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Concrete and the Barriers to Innovation in UK Housebuilding

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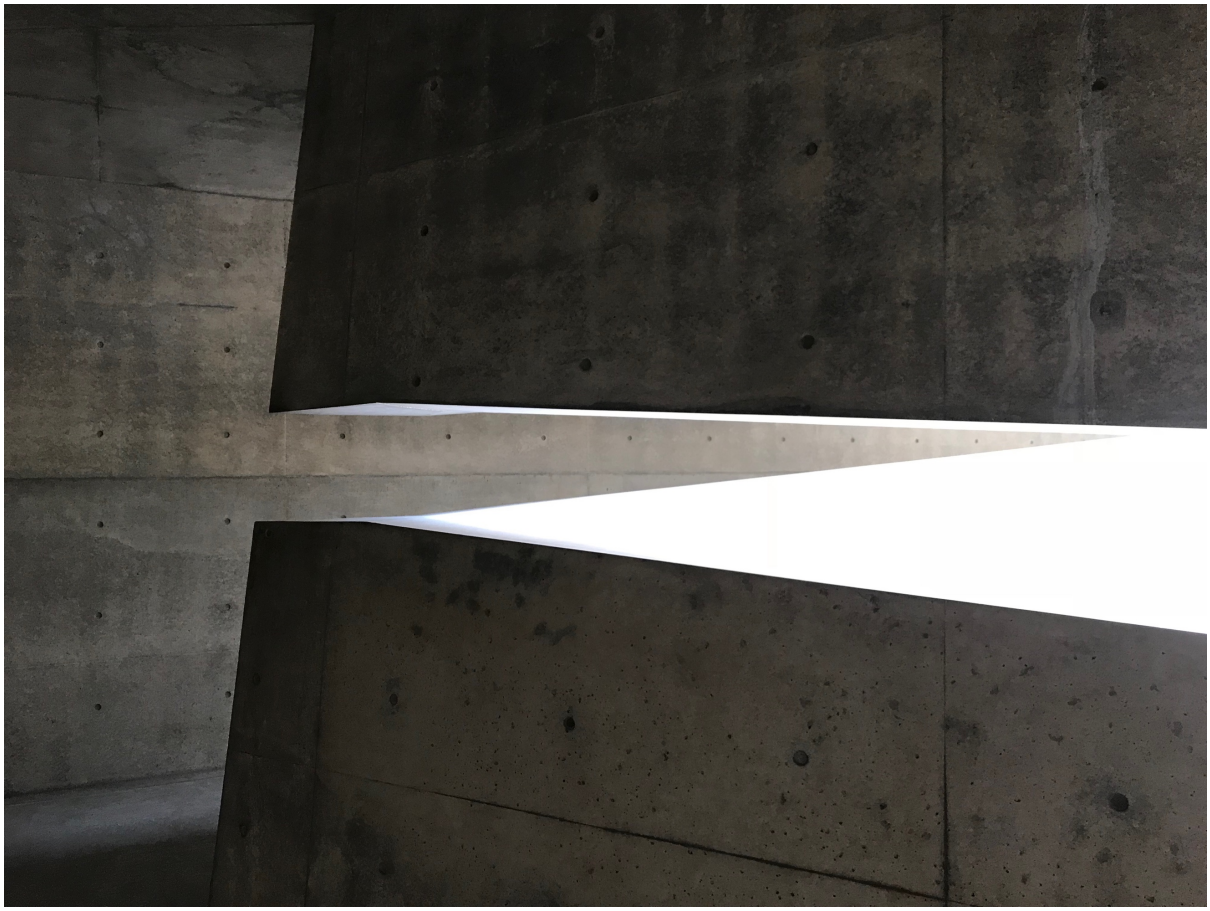

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ABSTRACT

It is widely accepted that our housing industry is in crisis. Like most crises this has not happened overnight but comes after many decades during which little progress has been made from within and the numerous government white papers calling for change have gone unheeded. The proposition put forward in this thesis is that too much attention is being given to the benefits to be gained from innovation within the industry, at the expense of understanding the barriers that are preventing those innovations from being adopted, or possibly even from being considered. That lack of understanding represents a gap in our knowledge that could potentially mean the difference between our housing industry continuing on its current trajectory and it transitioning to a more sustainable path which can provide us with more, better quality, truly affordable housing.

The initial aim of this research was to discover what those barriers were, by looking at the industry from all possible perspectives and capturing any influencing factors that might have been previously overlooked. The methods used to achieve this were a series of industry interviews across all sectors, together with on–line questionnaires and an analysis of government produced recommendations. By asking each sector in turn about their knowledge and perceptions of how the other sectors operated, a picture emerged of an adversarial, fragmented industry that was failing to understand the motivations and drivers of those it must collaborate with to bring about change.

From this stemmed the realisation that, more than anything else, it was a process that was needed to help the industry deal with the many complex, interrelated problems it faces, that not only have to be recognised as such, but also assessed for their comparative impact on the decisions being made. Through a series of twenty case studies, a set of decision making tools were therefore developed, tested and validated against known issues spanning the whole remit of innovation within housing, using the concrete industry as the vehicle for this process throughout.

There were many findings taken from this interrogation of the barriers to innovation, with relevance to the industry as a whole both from the perspective of those promoting and those wanting to adopt innovative solutions. By questioning what laid behind each barrier in turn, a model was constructed that showed a hierarchy of causes and consequences and exposed the true root causes that this process suggests must be dealt with. Whilst the practical lessons learnt from this exercise were strategically important, the more urgent message that should be taken from this is the need for a more holistic decision making process that can lay out the options available to the housing industry with greater clarity and allow decision makers to make their own, more informed choices.

FOREWORD

Eighty years is a long time to be making the same claims to no effect, but that is the reality of what has been happening, since the report 'Reaching for the Skies' was published in 1934. The industrialist Alfred Bossom, on his return from America, *"saw an adversarial and wasteful industry in which construction took too long, was too expensive and was not satisfactory for its clients".* He observed that the construction industry was just an industry like any other, and that if it were to adopt more organized, collaborative working arrangements this would lead to increased productivity, profits, investment and wages.

All of these observations are to be found in the Farmer Review, published in 2016, and in the many other government commissioned reports throughout the intervening years that have set out to tackle the complex problems within our housing industry. Increasingly, the language in these reports has begun to reflect the urgency of the situation we now face, culminating in the title for the Farmer Review, 'Modernize or Die'. But there is still a reluctance in any of these reports to analyse in detail the reasons behind the industry's collective failure to innovate, with a tendency to restrict the arguments to the acceptable discourse of what both the industry and government is prepared to consider.

Stepping outside the confined ways of thinking that exist within this industry introduces many alternative concepts and methodologies that might help resolve some of these seemingly intractable problems and allow some more innovative solutions to be realized. In other disciplines these are known as 'wicked problems'; complex, socially related issues that cannot be solved but only *resolved* at any one moment in time depending on the facts as they exist in that instance. Wicked problems require a more holistic, collaborative approach to be taken and a far deeper understanding of the issues being confronted. But they also require there to be a process to enable such a fragmented, adversarial industry as this to reinvent itself in a new light, something recognized by the Farmer Review as key to its survival.

There have been many calls for the housing industry to behave more like the manufacturing industry, held up as a shining example of improved productivity through collaborative working, but this has for too long been misinterpreted as little more than a call for a production-line solution to house building, regularly rebranded over the years as prefabrication, off-site manufacturing and now smart construction. The real benefits to be realized however, sit behind the manufacturing industry's success, and are to be found in the decision making process it has evolved, not the solutions that this process has developed.

That process, particularly familiar within the automotive industry, comes from a methodology known as 'Systems Thinking' and has been used to resolve some equally complex problems, not dissimilar to those confronted by the housing industry; more affordability, more comfort, better performance, less carbon emissions. This research looks to develop a similar process for the housing industry to enable it to innovate its way out of the increasingly dysfunctional status quo that now defines it.

PREFACE

Returning to architecture after a long absence, and at a time when the Code for Sustainable Homes was about to be introduced as a mandatory requirement for Housing Associations, I was able to research the solutions available with little prior knowledge to inhibit my quest. As a result I embraced the alternative approaches being proposed, but also interrogated them for their validity from first principles. Armed with the perfect excuse for asking basic questions, I soon became aware of the lack of true understanding that existed within the industry, together with a lack of inquisitiveness amongst those who had already build up a wealth of embedded knowledge that they were now being asked to set aside.

For many practitioners, engrossed in the demands of every-day business, it was far easier to comply with these new requirements and not consider in too much detail the principles that were used to arrive at the predefined set of solutions being offered. In my research phase, however, I was able to concern myself with this tick box approach, which seemed to encourage an abdication of responsibility by handing over that need to fully understand the problem being addressed to those who provided the choices we choose from. The inevitable outcome of this would be a lack of innovation, partly due to the loss of embedded knowledge that the tick box approach cultivates and partly due to the tick box approach not allowing for alternative solutions to be recognized.

The act of designing a building requires multiple factors to be considered, and their comparative importance to be measured before deciding which should influence the decisions that need to be made. All too often, however, this process is followed in name only, without unearthing the true level of information needed to make those decisions defendable. An individual failing to thoroughly research a problem will result in an individual mistake, but once decisions begin to be made based on principles decided by others, and those principles are no longer understood by those that follow, mistakes can propagate. Even appropriate solutions have a shelf life, and need to be reassessed as the ground shifts beneath our feet, which requires us to either keep abreast of the solutions being offered, or fully understand the problems that need to be solved.

That is the principle behind this research and what I believe needs to be reintroduced into the profession, the industry, the curriculum – even government policy making. It's not about learning the right answers, it's about understanding what the right questions are that need to be asked.

Define the question

Research the unknowns

Resolve the problem

Enact the solution

ACKNOWLEDGEMENTS

My stock answer when asked why I had decided to 'do a PhD' was that my wife had just done one and there no way I was going to be known as Dr & Mr Siebert. When I first met my funders, Tarmac PLC and they, not surprisingly, asked the same question, that was the answer they got. We all laughed, they said 'no, seriously' and I had to come out with my first unrehearsed elevator pitch, because I hadn't as yet verbalised exactly what it was that appealed to me about three years of destitution. The fact that I found it an easy pitch convinced me I had made the right decision. I do enjoy getting under the skin of a problem and to have three uninterrupted years to dedicate to something I already felt passionate about was an opportunity I couldn't turn down.

But, this would still not have happened if it were not for Penny, my wife, going there first, and showing me that it was even a possibility. As with many people in her life, she has shown the way by being prepared to 'just do it' where others would 'just talk about it'. How else she's been of use is hard to define because it's been a constant drip drip drip of knowledge, insight and guidance that I've had to take on board whilst pretending to already know precisely what I'm doing. That's been hard.

It's also hard to admit that if it weren't for my supervisors-to-be, Dr Lucelia Rodrigues and Professor Mark Gillott, convincing me that I should take their offer of a paid PhD for Tarmac seriously, I would have ultimately failed in my bid to go it alone. I've not been the model student, I think we can agree on that, but at this age I think that's to be expected. My broad understanding of the industry, whilst useful in one respect, has made me hard to manage in others, and I've had to learn to separate out my knowledge from my perceptions – something that is central to the process developed in this thesis. All in all, I think we've managed to find a route through that has beaten me into shape without beating me into submission, and our friendship, more importantly, has survived in-tact.

I've also been hard to manage because of my stubbornness over working from home. We all have our favourite modes of working, and mine is in comfortable isolation, from which I have emerged when I need to. I will be the first to admit that I have lost out in some respects because of this, and if nothing else would have been stopped far short of 140 000 words if there had been anyone around to notice, but I have not been in academic isolation, despite my absence from the campus. There are in fact many people I have to thank for their input along the way, all Doctors, although I had no realisation of this beforehand, such was their nonchalance towards their own abilities, but most importantly Martin Orrell, for falling into the trap of reading my thesis from beginning to end before enquiring about its length, Paul Windrum for steering my methodologies, and Puja Miles for making it look easy.

Lastly, of course, would be Tarmac themselves, with whom I should also include The Concrete Centre. The people I have met have, without exception, not only been a pleasure to work with, but incredibly constructive in their input and their openness to embrace the systems I have trialled on them. I've not had that much experience of working with businesses at this level, but I doubt I could have felt more included in any other organisation, so I thank you all for that, and in particular David Rich for his faith in what I was trying to achieve, and of course Emma Hines for being there from beginning to end, an achievement in itself.

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LIST OF ACRONYMS

BRE	British Research Establishment
CLC	Construction Leadership Council
CLT	Cross Laminated Timber
GWP	Global Warming Potential
MPA	Mineral Products Association
NHBC	National House Building Council
OSM	Off-site Manufacturing
RIBA	Royal Institute of British Architects
SAP	Standard Assessment Procedure
TRADA	Timber Research and Development Association
MHCLG	Ministry of Housing, Communities & Local Government
DCLG	Department of Communities and Local Government (now MHCLG)

INTRODUCTION

The UK Housing Industry today

Housing in the UK since the Second World War has followed a very different trajectory to that on the continent, to the point where making comparisons between our housing industry's issues and those of other European countries can be misleading. It is nevertheless a familiar refrain to hear comments about 'how much better they do housing' on the continent (Cutland, 2012), (Venables and Courtney, 2004), (RIBA, 2013), (Halman, et al, 2008), whether this be in terms of affordability, sustainability, comfort, size – on all measures, the public's perception is that we appear to fall short. There is also a readily accepted explanation for this state of affairs at a governmental level, which is that our housing industry is 'complacent' in the face of new innovative methods of construction and what is now seen as a national housing crisis, with implications for the whole economy (Farmer 2016, p8)

Whether or not either of these perceptions truly represent the current state of UK's housing industry, these are now well established points of view, but neither 'copying Europe' or 'just trying harder' are solutions that are likely to produce the improvements under any of these measures that we need to achieve. The purpose of this research is to consider whether or not the arguments as they stand, regarding the issues around the quantity, quality and the affordability of our housing are recognising the true breadth of the questions that need to be asked, not just of the house builders and suppliers of innovative solutions, but of the whole housing delivery system, the scope of which potentially reaches far beyond these two main actors. And the fundamental question that arises from the need to establish this is 'what are the factors that influence the decision making process regarding the adoption of innovative solutions?'

There are some pressing reasons why this research is necessary, most succinctly outlined in a recent government white paper, entitled 'Modernise or Die', where the UK housing industry is depicted as a dying patient exhibiting ten symptoms that need to be urgently addressed if a full blown housing crisis is to be averted. But despite both the prognoses given and the remedies proposed being well received, even within the industry itself, there is a very real concern that this report's recommendations, like those of others that have preceded it, will go unheeded. That concern is all the greater due to the threat of collapse that the industry now faces should the reason for its inaction not be complacency, as suggested in this white paper, but a more deep-seated and unexplored inability to act.

The fundamental proposition being made here is that the housing industry is failing to innovate for reasons not fully understood. The theory being posited is that whilst there is now at least a basic understanding of the benefits to be accrued from most innovative solutions, there is still little understanding of the barriers that are preventing those innovations from being adopted, and it is in a better understanding of these barriers that a more productive way forwards might lie. From that start point, this research has been led by its own findings, and the main output, a tool to help guide this decision making process, arrived at from a better understanding of the root causes that lie behind the

many symptoms already identified by others (Farmer, 2016), (The Edge, 2015), (Lyons, 2014). The structure of that tool evolves throughout the following chapters as more and more evidence is brought to bear, and the questions that need to be asked become more apparent. This process is very much about asking the right questions to ensure that all the relevant facts have been considered before making an informed choice, as opposed to choosing from a set of predefined solutions. Predefined solutions, it is suggested here are in themselves a barrier to innovation, as they limit what is seen to be acceptable whilst also limiting the industry's understanding of what the problems are that an innovation is attempting to resolve.

Before outlining how that objective has been approached methodologically, it is useful to provide some historical and geographical context to flesh out how our housing industry became set on what is now seen as such a dysfunctional trajectory after the Second World War compared to that of most other European countries. How it is, for instance, that Danish housing is now on average 80% larger than our own, our own being the smallest in Europe (Morgan & Cruickshank 2014, p.711), or why it is that German kit housing can be viably imported to the UK, with exports for some German companies now close to 40% of their total market (Venables and Courtney, 2004, p. 11), whilst it cannot be replicated here even for the same cost, let alone less.

It is also necessary to explain at this point the role that concrete plays in this research. Concrete has been used as a case study throughout the work, initially due to the industry partner funding this research being a supplier of concrete products. It has proved fortuitous, however, that perhaps better than any other material supplier, the concrete industry offers the ideal vehicle for this discussion about the barriers to adoption of innovative solutions. This is not only because of the reluctance of today's housing industry in the UK to adopt concrete as an innovative material for construction, outside of its currently defined parameters, but also because of the concrete industry's alternative role in defending its existing markets against the next generation of innovative solutions (Minson, 2016). This ability to see from experience the argument from both perspectives, together with the complexities of its own history as a provider of experimental solutions to housing after the Second World War and the degree to which that still impacts on the adoption of innovative solutions today, places the concrete industry in a unique position.

It is also appropriate at the outset to define what the housing industry really means by innovation, because compared with other sectors of industry, it is a relatively low bar to attain. For an industry wedded to existing ways of working, the introduction of any product or process that differs from the traditional building methods used since the Second World War, if not Victorian times, can be defined as innovative, but the changes being considered here are less those incremental improvements and more those relating to the introduction of alternative methods of construction. Even the use of concrete block walling with external insulation would, for instance, represent a break with our traditional cavity wall construction and constitute an innovative solution.

Concrete's claim to be a product for the future stems from a correlation that can be drawn between concrete, sustainability and innovation. Whilst these are far from interchangeable concepts, the sustainability agenda has become a major driver for innovation - albeit less so since the government's decision to abandon the zero carbon targets (Glover, 2015) - and the concrete industry remains keen to promote the sustainable credentials of its products, despite this being a complex and often counter

intuitive message to deliver. In all, many of the issues that confront the UK's housing industry today can be discussed through the experiences of the concrete industry in promoting concrete as a viable and sustainable alternative to traditional construction and the barriers that it is having to confront in doing so.

"When I spoke to Barratts and co - they were responding to zero carbon. If the government had just held good they would have delivered on that because they had to. They had no choice and they're not stupid. I mean some are and they will fall over, but the smarter businesses would adapt." (Ebbs 2017)

The UK Housing Industry in context

The twenty years after the Second World War saw a boom in housebuilding in Britain that has yet to be matched. Slum clearance, already underway before the war, combined with a need to rebuild a war torn country and resulted in an unprecedented urgency that produced at its peak 350 000 homes a year, allowing little time for reflection. Many generations on, perceptions from that era of mass housebuilding persist, inextricably linked to the use of new technologies, for which concrete, being the most visible, has taken a front seat in the public psyche. What was a moment of great change not just technologically, but socially and economically, has over the years been condensed down into a far simpler story than in reality it ever was. This serves as an interesting entry point into a discussion that is as much about our housing industry as it is about the complexities that sit behind established perceptions, not least those regarding concrete the material and the degree to which this recent history has impacted on the role of concrete, and by extension, all innovative solutions being promoted today.

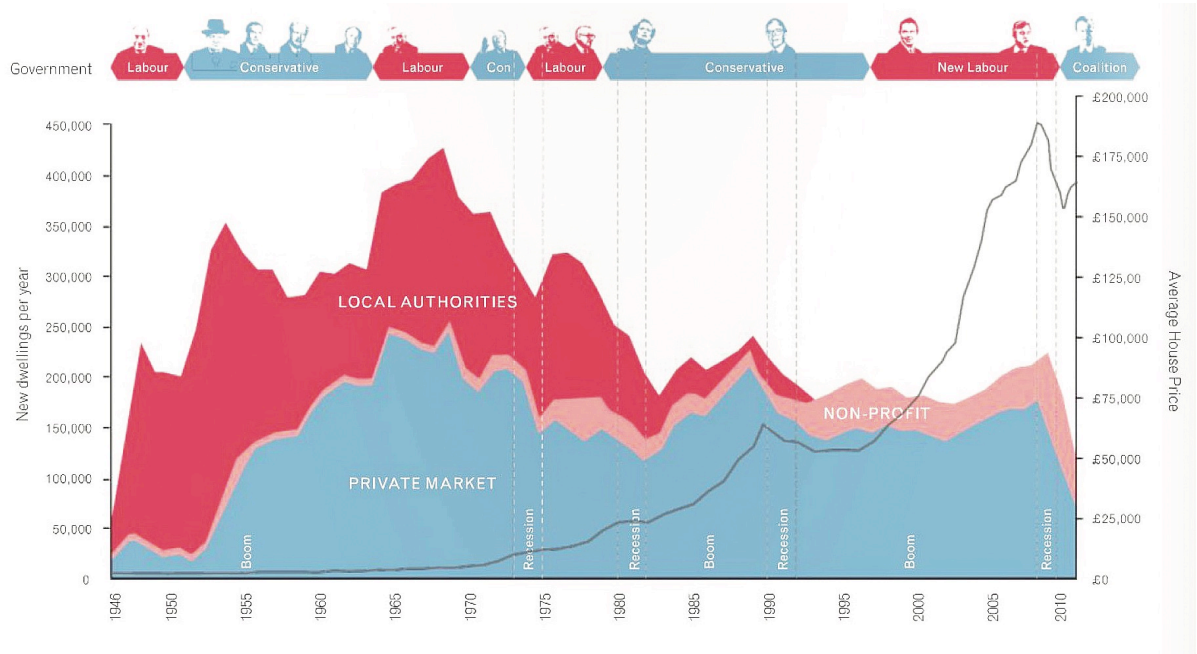


Figure 0:0-1 UK housebuilding rates since the 2nd World War (Bennett 2014, p.1)

There were three factors in play as Britain emerged from the Second World War. We had new construction technologies, born of the need to service the war effort and deal with the shortages of

labour that this had generated; we had a skills shortage that went beyond the building site and impacted on the continuity of ideas and knowledge felt right up to a governmental level; and we had a debt crisis. The resulting political and social upheaval let loose a period of experimentation that impacted upon an entire generation, not least in how that generation was to be housed. The physical role that steel and concrete played in this revolution cannot be underestimated, but this was also a period of social experimentation amidst a backdrop of economic uncertainty, and demographic and cultural change. Unpicking the benefits this brought from the mistakes that were inevitably made is not a straightforward exercise, but it is a necessary one if there are causal links to be addressed that continue to impact on our collective relationship with innovation today.

Prefabricated housing, the precursor of what we now call off-site manufacturing, was at the outset well received, but it would be wrong to take the often genuine love for these homes by its war weary residents at the time for much beyond relief at being rescued from the squalor of their lives beforehand. Tenants loved the 'mod cons'; the inside WC, the bath, the New World cooker. They did not appreciate living in what looked like a "row of pig sties" and set about personalising them in any way they could afford to (Grindrod 2011, p.27). Those still standing are a testament to their success, but at the time, mass, off site production was a necessary compromise, and seen as such by both the designers and the tenants.

The evolutionary process, when it came, came in the form of a growing understanding of what was good about the back to backs and tenement blocks that the 'temporary' prefabs and later tower blocks replaced. It was clear from the outset what needed to be improved - hygiene, in the form of running water, sanitation, clean air; and comfort, in the form of central heating, more space, both inside and out. But what was overlooked was the social needs of the communities that were often dispersed during the process, and even when kept together and rehoused in the same area, isolated by the physical barriers of vertical living. 'Streets in the sky' was the answer given to the loss of community felt by not having anywhere to informally meet with neighbours, but there was a limit to what could be recreated, even in theory, with this new way of living.

Many of the oversights however are harder to forgive, and suggest a glib approach to problem solving, clouded by the excitement of the time and the rush to experiment in an atmosphere of lax controls and an unshakeable belief in all things modern. The desire to replicate the works of Le Corbusier for instance, in particular his Unité d'Habitation in Marseilles, overlooked the climatic differences between Glasgow and the South of France. But much of the failure to deliver on the dream stems from the lack of resources, both in terms of finance and personnel, to design and build anything to the quality that would have overcome the shortfalls that were to be the demise of an entire era of domestic architecture. There was in fact, at least in hindsight, a very blurred line between what was meant to be a temporary housing solution in the form of the prefabs, some of which are still in use, and the experimental tower blocks that followed on from this first wave, some still utilising the factories and production line techniques developed during the war. The fact that even any of these temporary prefabs have outlasted what was meant to be the future of housing would suggest that something went terribly wrong, and that is what needs to be understood and learned from if we are to avoid replicating that era.

The era of tower block housing that swept the country during the 50s and 60s illustrated how little was learned from the Swedish point block model that our architects and developers purport to have emulated. Even in the 1950s, Sweden had evolved a housing solution that worked, financially, constructionally and socially (Architectural Review, 1943). By the time of the collapse of the infamous tower block, Ronan Point in 1968 (Jefferys and Lloyd, 2017, p. 42), we had transformed that ideal into something barely fit for purpose by doubling its height, removing the social and communal spaces, generally reducing the quality of the components such as the double glazing, and removing much of the structure that would have prevented the progressive collapse that killed four people and effectively brought to an end the UK's high rise housing programme.

Equally transparent in hindsight is the correlation between the decision to turn this new high rise housing into what are now called sink estates to cater for a new wave of immigration and those houses' fall from grace. It was not the new residents, but the tower blocks' poor design - something that very quickly became apparent when the tenants moved in – together with the termination of any maintenance agreements, that led to their association with failure, leaving only the visible face of concrete as the focus for discontent. In an era defined as much by private greed and political scandal as it was by the emergence of the social state, the fault associated with concrete in reality should have been of secondary concern. It is certainly true however, that much of the imagery that excited the architectural profession and to some extent a naive public desperate for the future being broadcast from America, was from climates more appropriate to the gleaming white edifices that the material promised. This 'perfect storm' of failure goes to show how broad the factors were that have led to the simplistic perception that has persisted, that modern methods of construction, specifically those that use concrete, are not to be trusted.

To bring this up to the current day, it is worth considering just how different a scenario we now face compared with that era seventy years ago. We are supposedly now in desperate need of a massive housing programme, with limited resources available. Much of our existing housing stock has been deemed unsustainable in our bid to reduce carbon emissions, and our labour force is collapsing through a combination of retirement, a lack of enthusiasm from the younger generation, and the loss of what has become our European backbone. On the surface, therefore, the resultant issues sound remarkably similar. What has changed however is the post war sense of 'we're all in it together'. Not for a long time has it felt that our country is so divided - economically, demographically, culturally – and with such a lack of faith in the future. So where does that leave us in learning from our past and from others' cultures, when moving forwards with a new wave of innovation?

This introduction has focused on one example, albeit an overarching one, of how the barriers to innovation can be rooted in unexpected places. The aim now is to develop a system for unearthing those connections through asking the right questions, and to do this in an efficient and systematic manner. If we could show a practitioner from the early 60's (preferably an architect) how our housing industry now operates they would no doubt give us some of the questions we need to be asking: 'Why are you still building little brick houses? Where have you moved all my beautiful tower blocks to? (You did what???) And what exactly does gentrification mean?' By now we were expected to be living in segregated housing zones breathing clean air and commuting with jetpacks in a very ordered world. For some, certainly in the developed world, there is more of our lifestyle in common with that

prediction than might be realised, were we to set aside the imagery. Industry has been segregated out, mostly to China, which is further than expected but the principle holds. The air is cleaner as a consequence and the jet packs have been demoted to a choice between Segways and the internet. But our housing has remained stubbornly the same, and it is the reasons behind this that need to be better understood if we are to be more successful in promoting, adopting and benefitting from innovation than we have been in the past.

Research Structure

Looking at the UK housing industry from an historical and geographical perspective has helped to set the scene for the debate that now needs to be had regarding our current relationship with innovation, specifically that driven by the sustainability agenda, and carried out here with concrete being used throughout as the denominator for that discussion.

The main body of this research has been founded on a series of industry interviews that were undertaken to establish the knowledge and opinions that exist across the whole housing delivery system relating to innovation within housing. That process, together with additional questionnaires and a public survey, provide the bulk of the information that has been gathered to investigate where the barriers to innovation are perceived to be. The issues that emerge from this, together with further research into the broader issues around behavior change, risk and complex problems, have been used to develop a decision-making tool that is this research's main output. This tool has then been tested through a series of case studies, chosen to examine the house building process from all perspectives. The tool in its final form as a relational database is then used to propose the most appropriate strategies for the concrete industry to adopt, based on the broader understanding of the industry as a whole that this has helped to bring about.

Because this work has been an iterative process, building off the evidence that has been gathered throughout the research, the thesis has been structured to reflect that progression of ideas. This decision has an added significance as the tool itself tends to reflect this process in the way it suggests issues need to be addressed. To that end, the methodologies and methods are briefly outlined here, and discussed in detail as they arise in the relevant chapters.

This structure, outlined in figure 0:2, shows the progression that starts with a review of the literature based around the relatively well-rehearsed benefits to be gained from the adoption of innovation, followed by the research into the barriers that prevent that adoption, and finally the approach being proposed to overcome those barriers. Methodologically, there is also a progression, from the 'deconstruction' phase, where the thinking behind the decisions being made is captured and broken down into a series of factors to be considered, to the 'reconstruction' phase where the discussion is had about how to then carry out a comparative analysis of those factors' relative importance. The final chapters then apply this process to the concrete industry and wider industry issues, and also discuss the further work that stems from the many questions that have been raised along the way.

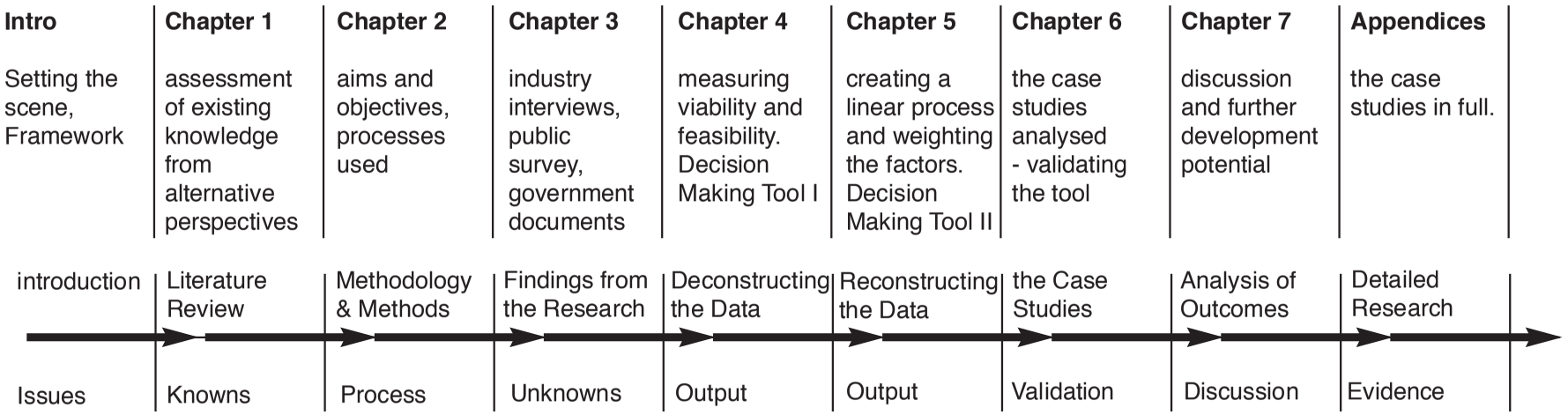


Figure 0-2 Structure of Thesis

Contribution to Knowledge

The inductive way in which this research has been carried out means that there are many occasions when theories have been formulated to make sense of the data being collected and the knowledge gained that later prove to be well established in other fields of research and across other disciplines. It was through this process that the later decision to return to the literature regarding theory of change, risk and complex problem solving came about. At that level of applied methodologies, it would be fair to say that much of the contribution to knowledge therefore comes from that application of a decision making process to an industry where very little process currently exists.

It would be wrong however to suggest that the process did not need to be developed and customised for the specific needs of that industry or that the many outcomes from applying that process were not in themselves of considerable importance, both to the concrete industry and the wider housing industry. It can be shown therefore that the contribution to knowledge exists in a number of forms. Firstly, from the perspective of the concrete industry and in response to their needs the tools developed have proved to be pivotal in the strategic decisions they have since made regarding how to engage with the housing industry. The Concrelator, discussed in detail in Chapter 4 provides a baseline measure for the amount of concrete used in any one housetype, which then acts as a comparator for any future proposition to increase concrete sales. The Decision Making Tool, in a broader context tests the feasibility of any strategy by considering the implications both internally and across the whole housing delivery system, something that can be of benefit to all sectors, not just the material suppliers.

The findings themselves have proved to be possibly of more interest to those engaged with the research than the processes used to deliver them, an ongoing bone of contention in the battle to get the process embedded. The key findings are discussed in Chapter 7 where they are linked to the further research needed to provide empirical evidence where assumptions currently prevail. Many of the case studies carried out to highlight the importance of understanding the housing market from all perspectives also expose the degree to which the entire industry operates at a level of 'unsubstantiated presumption'. This is in itself a key finding, and one that enforces the need for a more holistic approach to decision making whilst raising the importance of certain research areas to be pursued with some urgency.

Perhaps the most important from the concrete industry's perspective is the need to contest the presumption in favour of timber, now written into the Committee on Climate Change's recent paper (Holmes *et al.*, 2019, p. 9) and therefore legitimised in the eyes of the housing industry, despite there being no empirical evidence to back up this position. Since submitting this research there has been a paper published in Canada (IISD, 2019) that highlights the same concerns raised here in section 6.1.3 regarding the uncertainties that have been ignored by those keen to promote a shift to timber construction as a symbol of environmental progress.

More than any other finding, this exemplifies the need for a Systems Thinking approach in resolving these complex issues, and the futility of promoting innovation without first establishing the ground rules on which the benefits to be gained are founded.

Chapter 1

SEARCH OF THE LITERATURE

The first task was to establish the breadth and depth of knowledge held within the housing industry, which in turn required that industry to be defined. Who are the actors that define this industry, in terms of having a possible influence over the decision being made? How far does the net have to be cast to ensure that nothing is overlooked, and how can that be pre-defined without preemptively deciding where those influences might lie? The decision was taken to begin this search by looking at the industry literature in the hope that this might provide a better indicator for where the academic search should be focused, a search that was returned to on numerous occasions as new perspectives were uncovered.

1 SEARCH OF THE LITERATURE

Introduction

The purpose of this study stems from a brief provided by the industry partner that can be encapsulated in the sentence 'How can the concrete industry improve its understanding of the housing industry so that it can be more effective at optimizing the use of concrete within it?' The initial research undertaken to fully understand both the concrete and the housing industries led to this question being interpreted in a much wider context, in order to capture all possible influences beyond those directly between builder and supplier. In a similar vein, the concrete industry's ambition to promote the use of concrete above and beyond its use in foundations in ways not currently accepted by the mainstream housing industry was interpreted as an attempt to bring about change, and considered in this context. As a consequence, the role of the concrete industry within this research has become that of a case study exemplifying the broader issues facing all innovative solutions fighting for recognition within an industry that is undeniably difficult to influence (Farmer, 2016, p. 8). The actual research question is defined in full in Chapter 2 as a result of the findings from this review of the literature.

1.1 Approach to the Review of the Literature

The purpose of a literature review was to establish the body of knowledge already existing on and around the subject being researched. This is a fundamental prerequisite of any research to establish the need for further investigation and the direction that should take. Defining the scope of that search however, was in itself a challenge because of the subtext of the initial brief which suggested that many decisions within the house building industry were possibly being made without a complete understanding of the range of issues that ought to influence the questions being asked. Were this found to be true, it would suggest that a lack of understanding within the housing industry of its component parts might represent the most fundamental issue to be addressed.

1.1.1 Scoping the review

In order to avoid arbitrarily limiting the research, and thereby failing to address the role that some peripheral or 'perceived to be irrelevant' factor could have on the research question, the scope was initially defined as the extent to which any area of study could potentially have an influence over the housing industry as it has been defined (Section 1.1.3). It was understood that this made for an ambiguous boundary encompassing an already broad area of research, but the initial purpose here was not to attempt to understand all of these factors in detail – such as the impending innovations in any competing industry – but to define all those areas as possible 'influencers' and attempt to measure their potential relevance. Because of the need for this broad brush approach at the outset, it was decided that the search of the academic literature was not the appropriate starting point, but that the scope of the data available to, and used by the industry itself first had to be fully understood.

Defining the scope of the literature review presented here was an iterative process based on the findings made as the research progressed. An initial scoping exercise was carried out to mark the areas of interest before deciding which of these justified further investigation. Some of this initial research proved to be into realms of less consequence than originally thought, whilst others, initially set aside, later became more central, particularly as feedback from the industry interviews resulting from this review began to influence the direction of travel. In hindsight, what was originally seen as two separate linear processes, the search of the literature and the industry interviews, became intertwined as the evidence from each informed the other.

The body of evidence collected was categorised into four sectors that evolved to define the broader concept of the housing 'delivery system' as opposed to the housing 'industry'. Those sectors represent the material and component suppliers, the house builders, the legislative bodies and the end users, or general public. Within each of these there is an historical perspective, focusing mostly on the last 100 years, and a geographical perspective focusing mostly on northern European countries and ultimately on the UK Figure 1-1

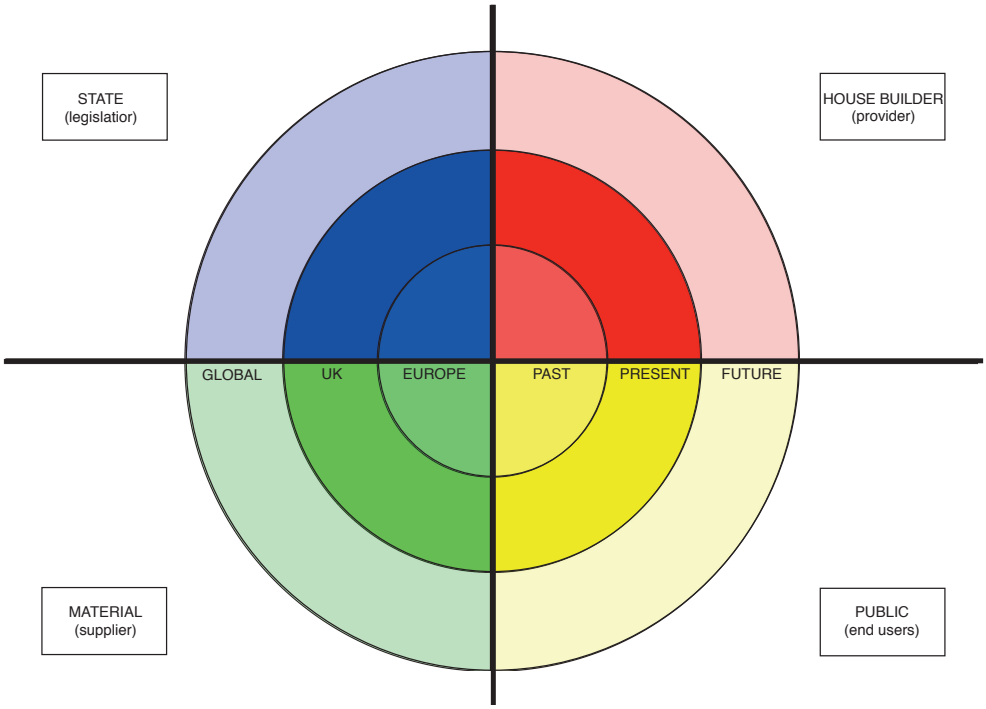


Figure 1-1 Scope of the research. Intensity of colours represents the main areas of focus

This model proved to be a robust starting point for the research, although it was constantly tested so as not to become a barrier in itself to any emerging ideas that didn't comply. Further subdivisions emerge as the research progresses, such as the variety of housing providers that sit alongside the volume housebuilders, defined as those that build over 2,000 units a year (Communities and Local Government Committee, 2016, p. 7).

The evidence gathered was from a variety of sources, ranging from academic papers to public surveys, with the emphasis in each case dictated by availability within the sector being researched. State legislation, for instance, represented the sector where information was most readily available, as it is

by law in the public domain. It is thorough, factual and, one would hope, free from bias in its content. At the other end of the spectrum, information gathered about the public, both in terms of their perceptions and how they themselves are perceived, was more a body of opinion than a body of fact, gathered by a variety of means ranging from the statistically reliable National Census to some less robust industry funded surveys. As a result of this variance in the availability of data, some of the sources used were more dependable than others. The important point here however was that for this research all sources and all opinions, if used by the industry, were deemed to be relevant whether they were factual or perceived, even whether or not they were verifiable or biased towards some agenda: If something is believed and acted upon, it has relevance in the real world. Clearly, the bias or the perception needed to be recognised to be able to understand the purpose and thinking behind it, but the author believes that all evidence is valid when trying to ascertain the true level of understanding within the industry of its own component parts.

1.1.2 Defining housing

Housing, for this research, was taken to mean all dwellings, as defined by the English Housing Survey, which is a comprehensive statistical report produced annually by the DCLG (Department of Communities and Local Government). Their definition was taken from the Census 2011 definition, which in itself has often been updated, but is the source used by the government's Office of National Statistics (Information Policy Team, 2014). This represents all housing as we conventionally understand it – bungalows, terraces, semi-detached and detached - plus low and high-rise apartments or flats, with a design life requirement of 60 years. The path that led to the decision to use this definition was less straight forward, with initial attempts to show where housing sat within the construction industry from the concrete industry's perspective proving difficult to quantify (Figure 1-2). The English Housing Survey, however is possibly the most reliable baseline resources available and for that reason a good comparator to use against other sources, despite it covering only England and not the whole of the UK. Outside of this statistical comparator, however, the research was undertaken at a UK level, and a clear distinction made between the two wherever necessary. The inclusion of all residential property was also considered, which would have covered student accommodation and care homes for instance, both growth markets and ones that lend themselves to concrete's credentials, but that too would have made direct comparisons with other data a more complex operation.

Within this definition was also a definition of affordable housing, an important categorization when considering where innovation is both needed and encouraged through government funding requirements. This is not a straight forward definition, as many of the published figures suggesting a figure of 240 000 houses "for the net increase in the dwelling stock required to meet new housing need" are based on a normative concept, or widely accepted ideas about what categories of the population 'ought' to have access to separate accommodation of an adequate standard. Effective demand, in comparison, is the level of demand made effective in the market by sufficient purchasing power from income, savings, and access to credit. (Holmans 2014, p.1) The relevance of this becomes apparent when the broader barriers to innovation are considered, with ability to pay for what is known to be both needed and desired enters the equation, both from the public's and the government's perspective.

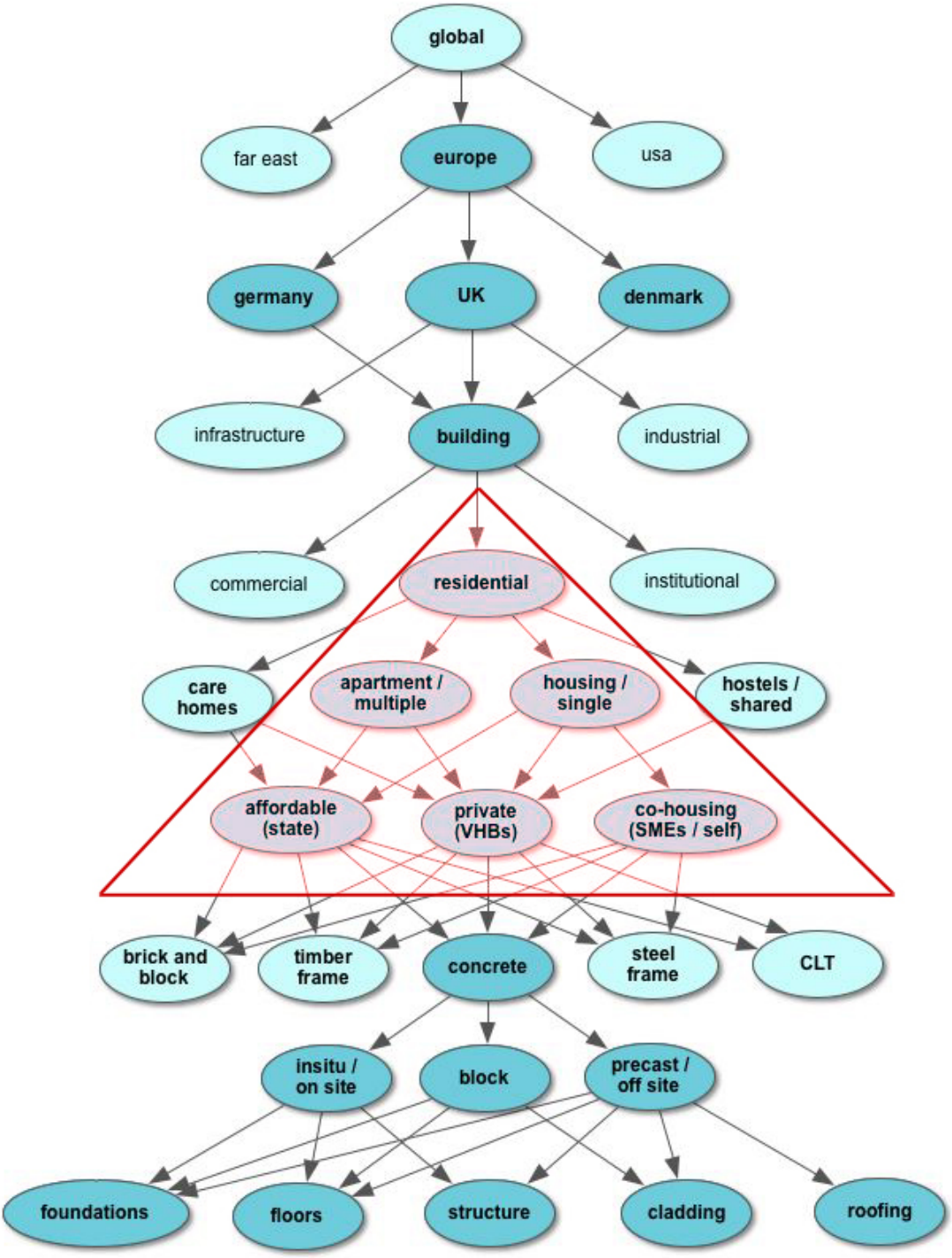


Figure 1-2 Positioning of housing in the construction industry as covered by the research scope.

1.1.3 Defining the housing industry

The conventional definition of the housing industry involves the planning, design and construction, buying and selling, development and management of property (Gorringe, 2011). The intention in this research was to look beyond the more immediate and obvious factors that define the physical aspects

of the housing industry, and consider what else might be influencing the decisions that are being made. The term 'housing delivery system' has therefore been used to refer to this more holistic concept, referring to all those actors who have an influence over the UK housing industry. The process of collecting data on these actors inevitably required that data to be categorised under some system, resulting in the four sectors now used throughout this research. Further on, other systems of categorization and sub divisions occur, but this initial division into the four sectors of material supplier, housing provider, legislator and end user proved to be an appropriate solution on which to structure this research at the outset.

1.1.4 Defining innovation

The other term used liberally throughout this research is that of innovation itself. A correlation has already been drawn between concrete, sustainability and innovation for the purposes of this study, but the broader relevance of the subject requires a fuller definition. In the more recent context of the white papers being referred to, innovation has been closely linked to the adoption of manufacturing style processes that it has been suggested might improve the housing industry's productivity. Innovation in other words, is never for innovation's sake. The ulterior motive is to improve the process, in terms of cost, quality, speed of production – to the benefit of one or more of the participants. The barriers to innovation are most apparent where those benefits are less immediate either in terms of time or direct consequence, hence the issues around sustainability. The need here therefore is to understand the drivers behind the innovations being proposed rather than the innovations themselves, which could be anything from a lighter concrete precast slab or a new form of collaborative contract allowing more uptake of offsite manufacturing.

1.1.5 The boundaries of the research

Defining the housing delivery system by the roles of its actors did not negate the need to also define its scope, or the point at which a factor's influence was deemed to be of negligible consequence. Because that level of consequence could not be pre-defined, however, it was necessary to register all factors for inclusion in the discussions for them to be either kept or discarded at a later date.

In addition to defining the contextual scope of the research, it was also necessary to contain the research both temporally and geographically. Again it was important to examine everything to a level of detail that was proportional to its relevance. Historically, concrete dates back to pre Egyptian times (Crow, 2008), with the Roman era clearly being a reference point, and its reinvention in the 18th century another. But for the UK, and for housing in particular, it was the last 100 years that encapsulated most of what can be defined as relevant to our current housing situation. Similarly, geographical relevance is arguably proportional to proximity, with northern European housing models having most resonance with our needs both culturally and climatically, beyond which the benefit of research becomes increasingly tenuous, but never irrelevant.

Figure 1-3 Barratt Homes – the pinnacle of Britain's aspirations? (Barratt Homes 2019.)

A point in case would be the Japanese, who build much of their low rise housing for a 20 year lifespan (Hashi and Linda Lombardi, 2013). The UK has a surprising amount in common with Japan (Farmer, 2016, p. 47), including some have suggested our future economic trajectory (Stephens, 2017) but should we be drawing parallels with a society that values modern living conditions above all other factors, when in the UK there is a strong correlation between the increasing age of a property and its value? The reality is that Japan has had a long history of building its housing for a 20 year life span, which has more to do with building light to limit the impact of earthquakes, resulting in a housing industry that makes most of its profit from the fittings and appliances, with the actual house becoming less an asset than a container of assets (McAllister and Yates, 2013). But even this is not the full story, with inheritance tax in Japan now also a major influencing factor in their decision making.

"In many cases, when someone dies with property in central Tokyo or Osaka, unless their heirs are incredibly rich (and sometimes even if they are), they have to sell the land in order to pay the inheritance tax on it." (Tsubuku and Brasor, 2014)

Learning from the experiences of our own past or from those of other countries brings with it the need to fully understand the context within which those solutions exist. Relevance is dependent on how similar those contexts are, but recognising where they differ can often be more enlightening. The overriding principle in this work therefore was to allow the research to define its own boundaries by the extent to which each area of research could be shown to have the potential to influence the decision making process within the UK's core house building industry. In this respect the research became self focusing, as the knowledge gained provided a better understanding of how to define the relevance of any factor, and thereby its inclusion or omission.

The following examples (Figure 1-4, Figure 1-5, Figure 1-6, Figure 1-7) show how all countries are prone to evolving housing solutions that reflect changes in their economies, cultures and climates, but not all of which are appropriate to their own situations, let alone those of other countries.

Figure 1-4 Morocco, past and present – climate and materials dictate changes in architecture.

Figure 1-5 Amsterdam past and present – cost limits a desire to replicate past achievements

Figure 1-6 Tokyo past and present - neighbouring new housing build to order

Figure 1-7 Guyana past and present – appropriate and inappropriate floodplain solutions

There are however, many examples of choice within the northern European housing market that reflect an openness to innovation that does not appear to be as prevalent in the UK. It is the explanation for this ability to innovate or the public's acceptance of it that is perhaps of more interest than the solutions themselves. Has this resulted in housing solutions more appropriate to the public's needs and desires, more affordable, more sustainable, or just a broader variety of visual house types?

Figure 1-8 Modern housing solutions from Denmark, Belgium, Holland and Germany

1.2 The Industry Perspective

In this section, a detailed search and analysis of those information sources used by the industry itself is presented, with the sources reviewed in order of impartiality, starting with the government documents. The information gathered from this initial search served as a signpost to those areas of the academic literature that would be most beneficial. The broader understanding of the housing

industry gained here led to a realization that the real issues were more about the acceptance of change in general than about specific products or solutions. They were issues about motivation, risk, and the decision making processes involved. Recognising this led to a far broader search of the literature based on very different parameters to those initially anticipated (Section 1.3).

1.2.1 Government papers

The most verifiable source of information for industry could be said to come from government sources, ranging from DCLG (Department for Communities and Local Government) policies, publications and statistics, to the many reports and reviews commissioned on all aspects of housing and the construction industry in general. The quantity of information available either directly from or commissioned by government bodies is voluminous and on-going Figure 1-9. It also covers many areas that are relevant to housing beyond the immediate planning and building regulation sectors, covering the sustainability agenda, productivity, supply of labour and innovation, to name but a few policy areas.

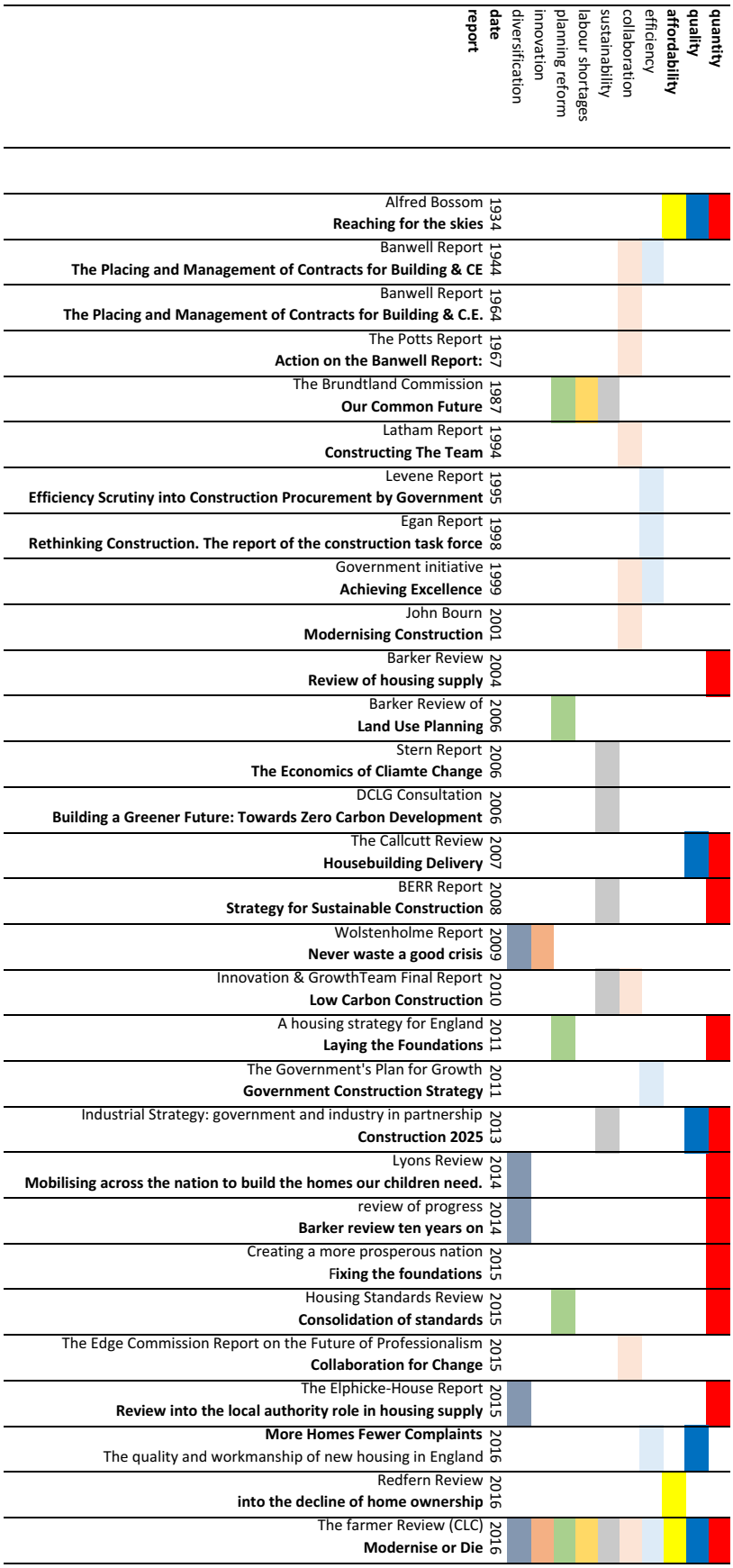


Figure 1-9 breakdown of objectives of government reviews of the construction industry

The purpose of this research is to understand the process by which each sector, in this case the legislative sector, can impact on the industry, and in turn, how the industry can influence those specific policies that governments enforce upon it. The government sector, for this research, more accurately requires a looser definition that covers all legislative and regulatory processes that may not be directly under state control, but are none the less predominantly dictated by government policy. The subdivisions within this section have been defined as areas under governmental control that influence the housing delivery system and include the economy, housing policy, and the regulatory processes:

The economy: Economic stability is seen as key to reducing the perception of risk which in turn encourages the adoption of new or innovative technologies (Biais et al. 2015, p.1353). Perversely, however, it is the very cyclical nature of our economy that often provides the opportunities that innovators need to get themselves noticed whilst established businesses are 'hunkering down' and waiting for signs of recovery (Lloyd, 2015). Any government decision that impacts on the national economy directly, or politically upon sectors within it, is therefore of relevance to the housing industry, especially considering the UK's history of boom and bust (Ball and Dosanjh, 2012).

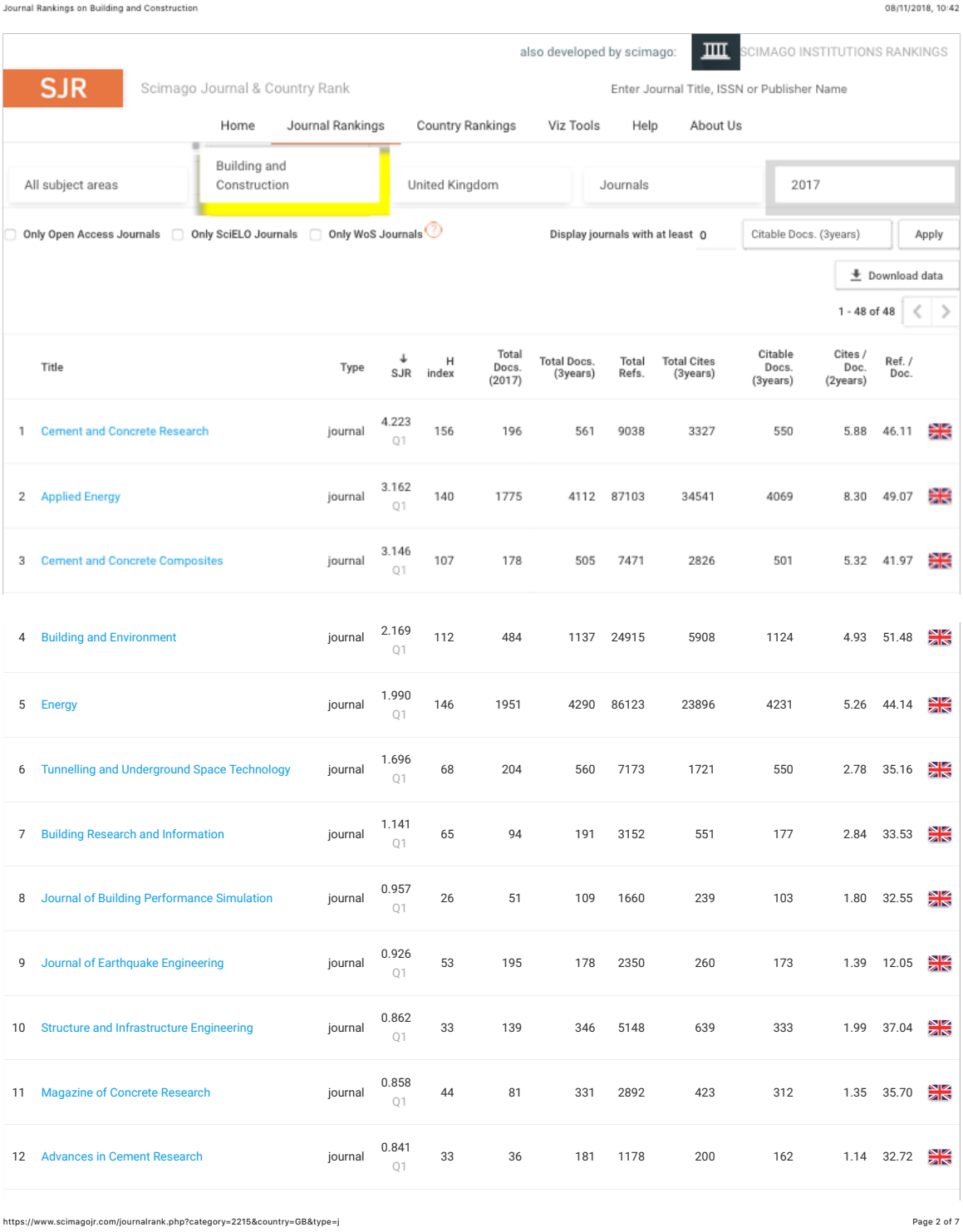
Housing policy: Papers relating specifically to the housing market are regularly produced and have given rise to an in depth study in themselves, discussed in Section 3.2. There are some regularly occurring themes within these reports going back over 80 years and also a tendency to refer back to previous papers in order to castigate the industry for not taking action on that occasion (Farmer 2016, p.46), but without questioning why it is that they have had so little impact over all this time.

The regulatory process: Government policy dictates the changes made within the planning process and the building regulations. Again, consistency is key to the housing industry's ability to plan ahead and innovate, particularly with respect to the Climate Change Act 2008 and the UK's interim targets for achieving its goals by 2050. Much has been written about the negative impact that the government's decision to withdraw from the 2016 zero carbon targets and to dismantling the Code for Sustainable Homes agenda is having on innovation (Harper, 2016) (Oldfield, 2015), not least for the concrete industry, but the extent to which this should be allowed to define the future role for concrete is what this research intends to put into some perspective.

1.2.2 Industry journal and magazine articles

Any information that is published will have been researched, but to what degree is often unknown. Even the discipline of peer reviewing academic papers is not fail-safe, a point raised in one of the industry interviews where it was suggested that time could be better spent discrediting the concrete industry's competition's peer reviewed papers, many of which were seen as inaccurate (Thompson, 2016, p. 14). If true, this requires a level of caution to be adopted together with a policy of corroborating 'evidence' by finding additional concurring sources, or tracing uncited quotes back to their original source. It is also necessary to always be aware of the agenda of any article, because most non-academic articles will have one. There are however many well respected industry journals that carry peer reviewed articles, the highest ranked of which are shown below (Table 1:1), but these are not necessarily the journals that the housing industry refers to (Section 6.1.1). What is of more

interest here, therefore, is how the information in these journals is disseminated through the channels more often referred to by the industry sectors that this research is focusing on.



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	Title	Type	SJR	H index	Total Docs. (2017)	Total Docs. (3years)	Total Refs.	Total Cites (3years)	Citable Docs. (3years)	Cites / Doc. (2years)	Ref. / Doc.
1	Cement and Concrete Research	journal	4.223 Q1	156	196	561	9038	3327	550	5.88	46.11
2	Applied Energy	journal	3.162 Q1	140	1775	4112	87103	34541	4069	8.30	49.07
3	Cement and Concrete Composites	journal	3.146 Q1	107	178	505	7471	2826	501	5.32	41.97
4	Building and Environment	journal	2.169 Q1	112	484	1137	24915	5908	1124	4.93	51.48
5	Energy	journal	1.990 Q1	146	1951	4290	86123	23896	4231	5.26	44.14
6	Tunnelling and Underground Space Technology	journal	1.696 Q1	68	204	560	7173	1721	550	2.78	35.16
7	Building Research and Information	journal	1.141 Q1	65	94	191	3152	551	177	2.84	33.53
8	Journal of Building Performance Simulation	journal	0.957 Q1	26	51	109	1660	239	103	1.80	32.55
9	Journal of Earthquake Engineering	journal	0.926 Q1	53	195	178	2350	260	173	1.39	12.05
10	Structure and Infrastructure Engineering	journal	0.862 Q1	33	139	346	5148	639	333	1.99	37.04
11	Magazine of Concrete Research	journal	0.858 Q1	44	81	331	2892	423	312	1.35	35.70
12	Advances in Cement Research	journal	0.841 Q1	33	36	181	1178	200	162	1.14	32.72

https://www.scimagojr.com/journalrank.php?category=2215&country=GB&type=j Page 2 of 7

Table 1:1 Top most cited construction industry journals (Scimago, 2018a)

1.2.3 Advisory bodies

Often reflecting government policies and agendas but from an industry perspective are the multitude of advisory bodies that inhabit the space between government and industry, although sometimes between government and the public or industry and the public. Their roles span research, lobbying for changes in policy, giving advice and assessment of performance, often combining more than one role to fund their existence through membership fees when not state funded. Most industry bodies have a voice that takes one of these forms, some being independent umbrella organisations, whilst others are openly acting as promotional mouth pieces for their market sector. Because of the sheer number of these bodies, all with a web presence, and many appearing to be superficially comparable, it was necessary to catalogue them in their entirety and investigate their structures, affiliations and in the case of umbrella groups, their shared knowledge through board members sitting on multiple boards (Appendix A) The relevance of these bodies to the decision making process is discussed in detail in the first of the case studies in Chapter 6.

1.2.4 Company literature

Possibly the last source to be taken at face value would be company literature, or any research carried out and funded by a company on their own behalf. The difficulty faced by many practitioners having to choose between two or more alternatives, all reportedly offering the most appropriate solution is what, it is suggested here, might lead to snap decisions based on incidental factors. An example of this in the insulation market would be the comparative sustainability of two products, one being promoted on its low carbon footprint in production, and the other on its high thermal performance. Both measures are relevant to the products' sustainability credentials, but neither are directly comparable. Part of the purpose of this research in creating a more robust decision making process is to reduce the ease with which wrong decisions can be made when selective advertising is the primary information source used. To what extent misinformation or selective advertising skews the decision making processes of businesses or the general public is an unknown which needs further investigation, but what should be accepted is that every company brochure will portray its products in the best possible light, and cannot therefore be relied upon to give unbiased or comparable data that can form the basis of any in depth research process.

Company literature might, nevertheless represent the main source of information used by much of the industry, with the lack of industry agreed denominators making comparative research almost impossible at this level. Any literature that claims theirs to be the best solution can erroneously be cited as proof of due diligence and become the justification for any future decisions that stem from it, making further research into the degree to which this occurs an important aspect of this study.

1.2.5 Opinion polls

Public surveys and opinion polls are a primary source of information about the general public with respect to housing. There is statistical data available in the public domain gathered from the national census (ONS, 2014) that can be accessed at source and there are opinion polls providing information gathered from samples of the population to make specific points (House_Builders_Federation, 2013).

These polls tend to be published as interpreted data, and it was here that the risks associated with using existing survey data become apparent. The further the interpretation had traveled from the original data source, the less likely it was to be free from bias, unintentionally or otherwise. A review of existing survey data was carried out in Chapter 3 which served two purposes. The first was to highlight the inherent dangers in referencing surveys without having access to information about the way in which they were conducted, the sample size, ideally the questions as asked and the raw data received. Secondly, it served to establish where the gaps in the knowledge existed with respect to the public's opinions about housing.

Much of the survey data found related to public preferences and was funded by either the housing industry as a promotional exercise or by lobby groups to raise awareness of the industry's shortcomings. A third category of survey came from estate agents and mortgage providers to help spot trends in the market, which could be said to be the least likely to suffer from any bias, but again of questionable validity. (Section 6.1.2)

1.3 The academic perspective

"I have yet to see any problem, however complicated, which, when looked at properly, did not become still more complicated." Paul Anderson (Morrell, 2010, p. 2)

The knowledge gained from the research covered in Section 1.3, as expected, raised more questions than it provided answers, but as the complexity of the housing delivery system became more apparent, so too did the role this complexity played in the industry's inability to adapt. The main focus of the search of the academic literature therefore shifted from what was originally looking at the potential benefits of concrete in terms of housing and sustainability to the barriers to adoption. The breadth of this issue took the research beyond the purely constructional arguments that usually define these debates and looked at the broader influences at work. It also recognized that to be of any worth to the industry itself, it must in some way try to measure the relative importance of these influences so that they could be given the appropriate level of attention.

The following section is therefore divided into three categories. Firstly, research into concrete, sustainability and house building, with searches based on combinations of these; secondly, research into motivation, risk, and barriers to change - either within the construction industry or elsewhere; and thirdly, research into the methodologies, including conjoint analysis and case based reasoning that were proposed as possible solutions to the problem of how to measure the impact of these disparate parameters in the decision making process. (Table 1:2 table of search criteria used in the search of the literature and papers found

The research by this stage was already becoming an iterative process, with the second and third category of searches being made as a result of the information gained from the industry interviews discussed in Chapter 3. The comments made against each paper are therefore often 'made in hindsight' and constitute part of the findings from the research.

Academic Literature Review

			general				drivers					material				legislation				house builders					end users						methodologies		
no.	paper	cited	concrete	housing	building	sustainable	motivators	barriers	failure	risk	decision	lightweight	fibre reinforce	pannelised	innovation	legislation	lobbying	boom and bust	warranty	off site manufa	MMC	modular	volume	BIM	survey	demographics	self build	communal	public	need	case based rea	conjoint analys	decision makin
	DRIVERS																																
3	Characteristics and performance of lightweight concrete for sustainable housing development	.	x	x		x																											
&	Is concrete construction as suitable for new domestic housing, as timber frame construction in the modern sustainable development environment?	.	x	x		x																											
0		.		x		x	x																										
1	Regeneration for Sustainable Communities? Barriers to Implementing Sustainable Housing in Urban Areas	.		x		x		x																									
0		.			x	x	x																										
1	Sustainable Supply Chain Management: Motivators and Barriers	.				x	x																										
14	Establishing sustainability: policy successes and failures	. 15				x			x																								
	MATERIAL																																
273		.	x			x																											
4	The advantage of natural polymer modified mortar with seaweed: green construction material innovation for sustainable concrete	. 0	x			x									x																		
&	Eco-friendly Concrete for Reinforced Concrete Structures - Technical Innovation for Sustainable Buildings	. 7	x			x									x																		
&	Sustainable housing using lightweight cellular concrete	. 0	x			x																											
153	Reusing concrete panels from buildings for building: Potential in Finnish 1970s mass housing	. 4	x	x																													
&	A model-based productivity improvement of reinforced concrete work in a multi-housing project	0	x	x																													
&	Marcel Breuer and Jean Barets in Bayonne (1964-68): the use of architectural precast concrete panels in large public housing schemes	. 0	x	x																													
&	Using dynamic model for determination of heat losses in cold weather from a typical house in Tabriz constructed by lightweight concrete blocks	. 1	x	x																													
0		.	x	x											x																		
5	Development of sustainable housing: an analysis of an innovation in three sociological dimensions	. 0		x		x									x																		
5	Lightweight Foamed Concrete for Prefabricated House	. 0	x	x								x																					
&	Lightweight concrete made with rigid foam, for prefabricated houses and sanitary ware	. 0	x	x								x																					
&	Sustainable housing using lightweight cellular concrete	0	x	x								x																					
1	Fiber reinforced-concrete and its potential uses in houses	. 0	x	x									x																				
7	Technical note: development of biocomposite concrete panels for low-	. 0	x	x										x																			
&	A study on designing mixed buffer production systems for manufacturing the components of prefabricated houses via precast concrete panels	. 1	x	x										x																			
&	Proposed ribbed panel system for precast concrete housing	. 0	x	x										x																			
	LEGISLATION																																
0				x												x																	
4	Housing Market Failure in a Booming Economy	. 6		x													x																
&	The impact of slow growth policies on local economies: Through housing boom and bust	. 3		x													x																
0		.	x	x														x															
	HOUSE BUILDERS																																
2	The environmental benefits of the Off-Site Manufacturing	.																		x													
0			x	x																x													
0			x	x																		x											
0								x												x													
0								x													x												
8	Experiential and project-based learning in BIM for sustainable living with tiny solar houses	. 0		x																			x										
&	Primary BIM dataset for refurbishing flood risk vulnerable housing in the	. 0		x																			x										
&	BIM Based Optimal Life Cycle Cost of Sustainable House Framework	. 0		x																			x										

Academic Literature Review

no.	paper	cited	general				drivers					material				legislation				house builders					end users					methodologies		
	END USERS		concrete	housing	building	sustainable	motivators	barriers	failure	risk	decision	lightweight	fibre reinforcec	pannelised	innovation	legislation	lobbying	boom and bust	warranty	off site manufa	MMC	modular	volume	BIM	survey	demographics	self build	communal	public	need	case based rea	conjoint analys	decision makin
566		.	x																					x								
1		.	x																					x								
1		.	x			x																		x								
22	A survey of need in a public housing project for aged	. 2	x																					x								
74		.	x																		x											
0		.	x																		x											
3		.	x										x								x											
0		.	x																		x											
0		.	x																		x											
54		.	x																													
0		.	x																													
	Understanding Residential Needs of Single or 2-Resident Households with a Focus on Communal Amenities of Multi-Family Housing Complexes	. 0	x																						x			x	x			
	MMC																															
27	Barriers of Implementing Modern Methods of Construction	. 1					x													x												
&	Modern selection criteria for procurement methods in construction A state-of-the-art literature review and a survey	. 0					x													x												
&	Automated cost estimating methodology for modern methods of	. 0					x													x												
&	Factors affecting the use of modern methods and materials in	. 0					x													x												
	Comparison of Low-Energy Houses Selected Parameters Made by																															
&	Traditional and Modern Methods of Construction	. 2					x													x												
&	Modern methods of construction as a challenge for energy efficiency	. 0					x													x												
	An embodied carbon and energy analysis of modern methods of																															
&	construction in housing A case study using a lifecycle assessment	. 91					x													x												
	Review of the multiple criteria decision making methods, intelligent and																															
&	biometric systems applied in modern construction economics	. 34																														
&	Prefabricated building units and modern methods of construction (MMC)	. 1					x													x												
46	Taking risks in the face of uncertainty: An exploratory analysis of green	. 0						x				x								x												
	The risk-reward nexus in the innovation-inequality relationship: who takes																															
&	the risks? Who gets the rewards?	0						x				x																				
&	Diagnosing risk in radical innovation projects	0						x				x																				
	Assessing the impact of risk allocation on sustainable energy innovation																															
&	(SEI) The case of private finance initiative (PFI) school projects	0						x				x																				
&	Dynamics of Innovation and Risk	2						x				x																				
&	How to make a decision - the analytic hierarchy process	344							x																							
	METHODOLOGIES																															
	A theoretical approach to the construction of technological output indicators																															
x	Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process																															
x	What to do instead of significance testing? Calculating the 'number of counterfactual cases needed to disturb a finding'																															
x	Theory and Design of Conjoint Studies (Ratings Based Methods)																															
x	Applied Conjoint Analysis																															
	A Bayesian model to forecast new product performance in domestic and international markets																															
	Product, process and customer preference alignment in prefabricated house building		x																											x		
	House or home? Constituent preferences over legislator effort allocation		x																											x		
	Integrated assessment of sustainability trade-offs and pathways for global bioenergy production: Framing a novel hybrid approach				x																									x		
	Neo-Rawlsian fringes: A new approach to market segmentation and new product development		(x)																											x		
	Stating preference for the ethereal but choosing the concrete: How the tangibility of attributes affects attribute weighting in value elicitation and		(x)																											x		

Table 1:2 table of search criteria used in the search of the literature and papers found

1.3.1 The use of concrete in sustainable housing

This was a broad search carried out under three main topic areas, the key findings of which are set out below. The core parameters used throughout were 'housing', 'concrete' and 'sustainability' to which were added a number of other parameters relevant to each of the four sectors. The results collected covered the full spectrum of factors that needed to be researched in more detail, and gave focus to the research question by highlighting a number of unpredicted avenues. The papers found and discussed in this first section were either around innovative housing solutions where concrete had a role to play, assessment procedures, the ways in which concrete could achieve more sustainable outcomes, or the impact of social changes and attitudes towards these issues.

Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice, (De Wolf, Pomponi and Moncaster, 2017)

This paper discusses the barriers to the effective measurement and reduction of embodied CO2e in practice. The authors recommend that "*governments mandate for improved data quality and support the development of a transparent and simplified methodology. Recent innovations and regulation have helped to reduce operational impacts, but a lack of comparable methodologies, data, and regulation still hinder the reduction of the embodied impacts, and in most Life Cycle Assessments (LCA) at the building scale, still only 20–40% of the life cycle stages are included, often the production stages*." This is detrimental to the concrete industry, as its worst figures (cradle to gate) are the only ones being considered.

The measurement of the impacts of embodied carbon in Life Cycle Assessments (LCA) are currently inconclusive and often misleading due to a lack of standardisation of the methodologies used (Hammond and Jones, 2008). Until this is resolved, the figures that will begin to appear from competing materials and product suppliers could be damaging to the concrete industry as they will tend to be using simplified results covering cradle to gate only (manufacturing of products to point of sale). The concrete industry will only benefit from the inclusion of LCA information in BIM (Building Information Modelling) data (discussed in Section 6.4.3) when these figures are inclusive of the whole life cycle, something for which there is little appetite elsewhere due to the complexities surrounding its implementation.

This is not dissimilar to the issues facing concrete over the SAP assessment procedure, where the dynamic modelling methodology that would benefit concrete's thermal mass credentials has been resisted for similar reasons (Todd and Fitton, 2016). The reality of both these situations means that the promotion of concrete's eco credentials will for some time be difficult on two levels: The message itself is complex and superficially counter-intuitive, and the systems of measurement currently in use will not reflect these benefits to their true potential. Fighting for these issues to be resolved is therefore a key strategy, but attempting to promote concrete's thermal mass benefits without drawing attention to the regulatory barriers denying it its mainstream acceptance will ultimately be ineffective. What this exemplifies is the need to either confront the underlying issues or recognise them as immovable barriers and look instead for alternative routes that bypass the problem.

The alternative course of action in this instance would be to seek out markets where the issue of paper compliance – a certificate of achievement - is of less interest than the actual built performance. This issue of how to deal with barriers to change, (confront and remove or accept and avoid, but never ignore) is expanded upon in Chapter 5 as part of the methodology behind the decision making process that is being developed.

Sustainable housing using lightweight cellular concrete (Mak et al. 2008)

"*Concrete is the dominant material used in the construction of many buildings, where it is used in various structural elements including external and internal walls. Depending on building type, up to 20% of the embodied energy of building materials may be attributed to the use of concrete. Based on comparisons with some conventional wall systems, the use of LBCM (load bearing cellular mortar) may result in a two- to six-fold reduction in both gross energy and greenhouse gas emissions*."

The use of concrete in housing is substantial, and in many situations, difficult to substitute with alternative solutions. If concrete can represent up to 20% of a building's embodied energy, any innovation that can reduce that embodied energy will have an equally substantial impact on carbon emissions within the industry. The use of load bearing cellular mortar, (LBCM) may result in a two to six-fold reduction in both gross energy and green house gas emissions, but it will also reduce component weights which as a practical benefit has been suggested might be a more powerful argument with developers and contractors than embodied energy (NHBC_Foundation, 2016, p. 2). Understanding that key motivating factor is critical to how a product is promoted. If for a contractor it is weight, and for the government it is reducing carbon emissions, the promotional message will need to be tailored accordingly. For government, lightweight concrete alternatives should be of genuine interest if promoted in the right light, an argument that is reinforced by the fact that as houses become more energy efficient, the percentage of their total carbon footprint over a fifty year period that is due to embodied carbon could increase to over 50% of the total (Hammond and Jones, 2008).

Neither of the previous two findings however are of immediate interest to the traditional speculative housing market, and the other picture that emerges from this literature search is that the benefits of concrete above foundation level are more apparent in non-conventional housing solutions. The next four papers are all focused on these alternatives from structural, social and economic perspectives, all of which need to be considered when building a case for a market based solution.

The revival of high-rise living in the UK and issues of cost and revenue in relation to height, (Kunze, 2005)

This paper discusses the recent revival of tall residential buildings in the UK as well as issues of costs and revenues for such projects. The history of tall residential buildings and its impact on the image of high-rise living is explored as well as some of the debate that surrounds the topic, before focusing on the economic drivers behind tall residential developments.

Tall buildings carry connotations for many people, especially when those associations are visually reinforced by the use of concrete cladding. But the economic reality of our housing needs together with increasing land values mean that tall buildings may need to be revisited, and the constructional case for concrete made. Historically concrete was recognised as providing the most cost effective solution for residential high rise, whereas steel became competitive as the open plan spans required increased for office and retail (Glendinning and Muthesius, 1993, p. 75). This is still the case today, depending on the fluctuating price of steel and global demand, but the arrival of CLT (cross laminated timber) as an alternative method of construction has meant that the 'sweet spot' for concrete construction has reduced. There is an optimum height to cost ratio for all methods of high rise construction and it will vary with location and many other time related variables, but that research still needs to be done – not to define a solution, but to scope out what those variables are. If CLT is limited to eight stories, possibly ten, by its compressive strength, the competition for concrete will be less above that. Similar equations exist for all variables once they have been defined as factors for consideration. High-rise is a core market for concrete and an understanding of the economic parameters is key to this research, and picked up in Chapter 6 as a case study (Section 6.2.5).

Modular Approaches in Dutch House Building: An Exploratory Survey (Halman, Voordijk and Reymen, 2008)

"In many European countries, changing housing policies are now offering clients more influence over the final building. Based on a cross-sectional analysis, the perceptions of architects, construction firms, suppliers and municipalities are compared."

An alternative angle to the UK's conventional housing solution is reflected in this Dutch research looking at the increase in client involvement in their housing solutions. Whilst custom build represents a relatively small percentage of the UK market, it is nonetheless an increasing market (Brown *et al.*, 2013), and one which the government is, for the time being, keen to support (Theresa, 2017). The question for the concrete industry, however, is what can concrete offer this market that other solutions cannot? And would that solution only be of interest to a sector within a sector that is too small to justify the effort involved in its promotion? These issues around viability of markets are picked up in Section 6.3.3 as a case study for further analysis, but the community perspective that is part of this alternative solution to affordable housing is also an area where much research is being carried out.

Two routes to affordability and sustainability that are not regularly considered, are size of accommodation and the sharing of facilities. Neither of these in isolation are appealing solutions and both carry connotations for some of relative poverty, but there is both the scope and the demand for quality affordable solutions that capitalise on a sense of lost community through communal living. (Hertfordshire, 2013).

Understanding Residential Needs of Single or 2-Resident Households with a Focus on Communal Amenities of Multi-Family Housing Complexes, (Lee and Lee, 2016)

In this research a survey was carried out to identify the general residential needs of small households, and their communal amenity needs. It was found that small households had clearly different residential needs compared to regular households; the needs were generally uniform among regular households, while small households showed significant differences according to socio-demographics, residential conditions, lifestyle and the continuation period of households. The aim of the research was to formulate residential conditions that the residents of small households want, based on the understanding of their residential needs rather than simple socio-demographic characteristics.

This research shows how submarkets can be defined that have specific needs which are not being recognised by current market providers. The drive to reduce space standards to achieve affordability could be more beneficial if combined with an understanding of what that space needs to provide, rather than merely reducing the size of existing formats to impracticable levels (RIBA, 2013). Providing packaged solutions for niche markets, an approach discussed in Section 6.3.5, requires a broad understanding of the needs of that market and for this information to be used creatively.

Volumetric housing providers, with their potential for offering mass customization solutions, need to capitalize on their ability to hone individual house layouts to offer bespoke solutions that work for these niche markets in a way that the mainstream market cannot. The concrete industry could potentially offer similar packaged solutions around the constructional benefits of concrete as opposed to housing layouts.

Experiential and project-based learning in BIM for sustainable living with tiny solar houses, (Wu and Hyatt, 2016)

The tiny house movement represents a unique building initiative that aims to reduce the environmental and financial impacts of modern living. This research looks at this in conjunction with using BIM as a training model for students. '*The average size of new single-family houses completed in 2014 was 2,657 square feet. A tiny house, which is a home of 400 square feet or less, may significantly reduce the ecological footprint and alleviate financial burdens of housing*.'

Research into the design requirements for communal living and also compact living can both be incorporated into modular concrete solutions that provide both private owned space and rented shared space in a way that re-invents the model for a new generation. If ownership in the UK is perceived as a fundamental goal by both successive governments and the majority of the public (Redfern Review, 2016, p. 2), then a solution that makes ownership truly affordable by incorporating a degree of rented shared space into the equation would seem to be a realistic solution – one that accepts the barriers to fully rented accommodation and to the cost of ownership. A potentially beneficial outcome for concrete in this solution, discussed in Section 6.3.3 might be an increased sense of a need for robustness and longevity in an owned asset, the smaller that asset has to become.

Conclusion

Taken together, all of these relevant factors combine to define markets that concrete as an innovative solution could be focusing on to differentiate itself from the competition, including traditional

housebuilding. With each additional factor that is considered, a more comprehensive picture begins to emerge of what might be dictating the decisions that are being made about what is built and how. These factors together help to inform the decision-making tool that this research will ultimately develop, and also the case studies, referred to here, that are used to test that tool in development.

1.3.2 The barriers to change

The next area covered by the literature review was researched some time later in response to the industry interviews, and used search terms relating to motivation, risk, barriers and failure, from within the field of construction where possible, but mostly from other disciplines. The use of these terms reflected the realization that the reasons for not adopting an innovation were where this research needed to focus its attention, as discussed later. This review returned a substantial body of work much of which was then studied in more detail and related back to the issues being addressed within the construction industry. In total over sixty papers were found that were of significant interest, of which about twenty papers discussed components of these principles directly relating to the area of study.

The message that came through from these papers was that in any situation, the 'status quo' holds a powerful position. In this instance, the status quo refers to the speculative housing market as it currently exists, and the term is used to suggest that it is change that is the hurdle as opposed to the alternative solution itself. There were nine papers here relating to barriers to change. These were analysed to assess whether or not the housing industry suffers any greater exposure to the perceived risks and uncertainties the papers look at, and if so, whether this would explain its apparent inability to improve productivity levels when compared with other manufacturing industries (DCLG (Department for Communities and Local Government), 2017, p. 14). The papers were broken down by their focus on risks due to disunity, complexity and uncertainty, which tended to relate in turn to internal issues, industry issues and wider more general issues. These have later emerged in this research as important divisions, as they also define a decreasing ability to influence an outcome, which is in itself a major component of risk. The following papers focus on these issues:

Internal (disunity):
The ambiguous risks of internal divisions; The fixed time available to make decisions

Industry (complexity):
The barriers to implementation; Hierarchy of decisions; Conflicting motivations; Complexity

External (uncertainty):
The disconnect between risk and reward; The role of uncertainty – political and environmental; Risk associated with a cyclical economy

<u>Internal (disunity)</u>

'Equilibrium and Disorder in Human Decision-Making Processes' (L Toma and Gheorghe, 1992)

Decisions often begin as an internal exercise based on individual research, even if the incentive to do so comes from some external event. In this paper, the authors demonstrate that there is an optimum decision making time based on information availability, but that in reality the time taken to make decisions is based on the inelastic attention span of the decision maker, resulting in complex decisions being poorly considered. The paper suggests that too much information becomes counter productive as the decision maker, unable to select the really important issues, becomes unable to reach a satisfactory conclusion within the time available, resulting in either inappropriate decisions or a reluctance to take any action at all.

"In short, there are many reasons to expect that, on their own, individuals (either lay or expert) will often experience difficulty making informed, thoughtful choices in a complex decision-making environment involving value trade offs and uncertainty" (McDaniels et al. 1999).

This is certainly an apparent phenomenon in the house building industry where the rate at which regulations change and building solutions are accredited to meet those regulations means that the evolutionary process of technologies being honed from experience over time has been replaced by a system of guarantees and indemnity cover. As suggested in this paper, the time available to decide upon, let alone trial a solution is seldom adequate, and the level of research carried out reflects this. *"information multiplies our connections and forges greater interdependence"* resulting in a pressing need *"to develop better monitoring systems and faster reaction capability"* and to *"develop a critical attitude toward disinformation and information manipulation."* Under our current system of operation , *"we are not able to accurately process the information we gather and to reach adequate conclusions because we gather these data from an informational 'environment' that seems familiar but basically is 'incomplete'."*

There is no solution offered in this paper in response to these observations, but it is something that this research needs to address in a realistic manner. If the assumption is made that the housing industry will continue to be a complex environment and the time available for decisions will continue to be limited, it is only the decision making process that can be improved to meet these challenges. This is a fundamental aim of this research and will be returned to in Chapter 5 as part of the process for measuring feasibility.

Diagnosing risk in radical innovation projects, (Keizer and Halman, 2007)

Also perceived as an internal risk are the 'soft' or ambiguous risks that relate more to how a decision to innovate is made and managed within an organization (internal divisions and a lack of collective buy-in), as opposed to the mechanics of its implementation (performance, deliverability and end user acceptance). Understanding the impact, real or perceived of an innovation to all those involved is critical to its success. An example of this can be found in the industry interviews undertaken where trials for large concrete blocks were carried out by Taylor Wimpy to assess the increase in speeds of construction possible. The trials were successful, but the bricklayers response was very negative. On further questioning this was found to be due to a fear that the speed of construction possible would result in less work and lost income, whereas in reality it would mean greater productivity and greater

profits, although not necessarily for the bricklayers. These risks can be easily overlooked if there is no initial awareness of their existence or their ability to disrupt the adoption of a new innovative solution.

Industry (Complexity)

This second category of risk relates to those that exist for the industry as a whole. This does not necessarily mean that they are shared risks, only that they require the additional input of others outside the company itself to overcome them. In that respect they represent greater threats to the implementation of an innovative solution than those over which there is complete in-house control.

Barriers of Implementing Modern Methods of Construction, (Rahman, 2014)

The barriers to the adoption of MMC is where the focus needs to be. *"The adoption of MMCs is low, despite their well-documented benefits. This led to the present study of examining the importance of common barriers to implementing MMCs."*

This paper recognises seven main barriers to overcome; poor interface and insufficient regulation, market limitations, inadequate coordination and cultural barriers, lack of skills and tools, high costs, suspicion about performance, and system barriers. These are all examples of what Halman (Keizer and Halman, 2007) would categorise as ambiguous risks – risks that require good communication channels with suppliers, legislators and end users to manage successfully, and part of that management involves recognising their relative importance. There is a hierarchy to risks which needs to be understood so as not to get diverted away from the more critical or core factors that must be dealt with by smaller more immediate issues that might seem less daunting. Ensuring that all the risks within that hierarchy are manageable at the outset is something that emerges as a key strategy in navigating the decision making process.

How to make a decision: The Analytic Hierarchy Process, (Saaty, 1990)

"Perhaps the most creative task in making a decision is in choosing the factors that are important for that decision." This paper serves as an introduction to the Analytic Hierarchy Process - A multicriteria decision making approach in which factors are arranged in a hierarchic structure. This is key to the proposition in this research that decisions are being made without the right questions being asked at the outset.

This paper is also rigorously concerned with the scaling problem and what sort of numbers to use when measuring disparate factors, and how to correctly combine the priorities resulting from them. This is critical to the process being developed for this research, where the factors being considered range, for instance, from individual and immediate financial benefits to long term collective societal benefits, or from material performance benefits to security of labour supply benefits. None of these

factors are directly comparable, but all need to be considered and in some way assigned a level of importance.

“The AHP technique thus relies on the supposition that humans are more capable of making relative judgments than absolute judgments”

Establishing sustainability: policy successes and failures. (Van Bueren and De Jong, 2007)

This paper recognises the need for all actors to be part of the sustainability agenda and that the barriers to adoption are often outside the debate on sustainability. *“Those involved must develop a common understanding of what sustainable building entails, and of how it can be achieved. This requires flexibility concerning goals and procedures. The sustainability concept falls short when decisions have to be made, and costs and benefits allocated.”*

A broader understanding of what all the sectors want and need from sustainability will ensure that the end goal is achieved in a way that does more than pay lip service to the original intentions. Conflicting motivations will always exist, but ignoring this factor will most likely result in compromised or ineffective change rather than genuine change, albeit limited to areas of mutual benefit. This concept needs to be investigated around the principle of financially viable sustainability measures, and what this means to different sectors of the house building industry.

Innovation and organizational networks. Barriers to energy efficiency in the US housing industry, (Lutzenhiser, 1994)

This paper looks at some of the features of industry organization that impede efficiency innovation in housing. Research to date strongly suggests that these entities [all actors in the building delivery system] both act in concert whilst also constraining one another's actions, slowing the transfer of more efficient technologies and building designs*. 'Understanding the functioning of these three sets of factors (markets, social and cultural factors, and organisational networks) and their interactions is a prerequisite for effective policy intervention'.*

One of the findings from this research is that the complexity of the housing delivery system acts as a barrier to innovations taking hold, and it is possibly this rather than an air of complacency that needs to be addressed. Lutzenhiser’s work also suggests that a far broader understanding of factors that impact upon the decision making process is needed to unlock the process of promoting change. But it is not just the range of factors, but how they can act together either distructively or constructively, depending on whether or not they were included in the argument from the outset. This ability for relevant factors to have either a positive or negative influence purely on the basis of when they entered the discussion is a strong message to take forward.

External (uncertainty)

The third category of risk due to uncertainty tends to focus on the impact of future events as opposed to risks that exist as measurable quantities in the present time. It is for this reason that these represent the least controllable factors in the equation.

Taking risks in the face of uncertainty: An exploratory analysis of green innovation, (Roper and Tapinos, 2016a)

This paper looks at how firms' *"perceptions of environmental uncertainty and their perceptions of the risks involved impact on their willingness to undertake green innovation". "The results reinforce the relationship between perceived environmental uncertainty and perceived innovation risk and emphasise the importance of macro-uncertainty in shaping firms' willingness to undertake green innovation".* If uncertainty is high and the associated risk unmeasurable, this constitutes a considerable barrier to the adoption of new technologies, but specifically with green technologies, it is seen as an opportunity for smaller companies to use disruptive innovation techniques to create new markets whilst larger corporates are retrenching. The message within this study is unclear, but would seem to suggest that uncertainty, if it can be read, can be used advantageously by those wanting to open up new markets, hence the use of the term perceptions of environmental uncertainty, as opposed to knowledge. Predictable fluctuations (a boom and bust economy) are very different from unpredictable policies (ideological mood swings) which feeds into the narrative that a greater knowledge of the industry – and government processes - can deliver an advantage over those depending on their perceptions.

Dynamics of Innovation and Risk, (Biais, Rochet and Woolley, 2015)

This paper looks at the correlation between innovation and risk in the economic cycle. *"Illustrated by the boom and bust of the financial sector, where innovations can spur rapid growth, as well as declining standards, accumulated risk, and finally crises."* Although this research was centred on the financial sector, similar cycles of declining standards during boom periods have been recognised in the housing industry, where unskilled workers are brought in to cope with the demand. This risk factor is entirely separate from the more widely recognised risks associated with our boom and bust economy and the consequential reluctance of those supplying the housing industry to invest in the plant and machinery required for off-site manufacturing. One solution to both these issues would be to ameliorate the impact of a cyclical economy, something that only governments can control through economic and social policies. For the housing industry the decision is whether to lobby for this or to accept the boom and bust scenario and work within the boundaries this imposes.

The risk-reward nexus in the innovation-inequality relationship: who takes the risks? Who gets the rewards? (Lazonick and Mazzucato, 2013b)

This paper offers a framework to study the relationship between innovation and inequality. What types of economic actors (workers, taxpayers, shareholders) make contributions of effort and money to the innovation process for the sake of future, inherently uncertain, returns? The authors make the point that the environment for the risk takers is created by the State and big business investing over a period of time, and that this needs to be rewarded too if the model is to be sustainable.

It is perhaps this role that risk plays in the innovation process that is least recognised by those commenting on the housing industry and how it could improve itself. Whether it is the government, the large housing companies or the many much smaller industry players who need to see a more direct correlation between the risk they take and the reward they directly receive, this research suggests that without that immediate or guaranteed return, many companies are unable to innovate, rather than unwilling or unconvinced of the need to do so. This is a proposition that needs to be tested through the industry interviews, but would appear to be corroborated by the many government white papers (Section 3.2) without them expressly recognising this as a key reason for the industry's inertia.

1.3.3 Appropriate methodologies

The overarching purpose of this research was to develop a system by which the concrete industry, and by extrapolation any supplier of innovative products, could assess the likelihood of a particular strategy being successful, based on as complete a set of information as is practically possible. The initial challenge was in establishing the full range of influencing factors to be considered, both in terms of the actors who could potentially have an influence and also what it was that was seen as influential to each of them, ie, their key motivators.

This final search focused on the next challenge, that of how to make sense of this data once it had been collected. Before any conclusions could be drawn from such a broad set of parameters, we first needed to know their comparative relevance. The data collected was very disparate in nature, with some factors being independent but most being interdependent in multiple ways. Of these factors, some represented nested or sequential decisions, whilst others represented decisions that needed to be made in parallel. Further levels of complexity were drawn from the degree to which perception could supplant or even override factual knowledge when making choices, all of which made these disparate factors very difficult to analyse.

The search criteria:

The initial searches in this section were carried out using the three core criteria of 'housing', 'concrete' and 'sustainability' together with 'conjoint analysis' and then 'case based reasoning', two methodologies often used in such circumstances when comparing a number of disparate parameters. The core criteria were then reduced until results were found. A total of twelve papers were returned that were of relevance, but only three that related directly to either housing or sustainability. Concrete

returned only two papers, but with concrete featuring as an adjective, although both still unexpectedly relevant.

A Bayesian Model to Forecast New Product Performance in Domestic and International Markets, (Neelamegham, 1999)

This paper looks at the 'subjective beliefs about reality', and the development of a Bayesian modelling framework to deal with changing levels of information over time and how opinions or the degree of belief in an event can be shown to change with increased knowledge. In the sustainability market, is awareness of a product driven by a motivation to 'be more sustainable' or does motivation drive the thirst for knowledge? Understanding how best to influence the market is important, as there may well already be 'information overload' on a factual level without there being the appropriate motive based information available to trigger that initial interest.

Neo-Rawlsian Fringes: A New Approach to Market Segmentation and New Product Development? (Giloni, Seshadri and Tucci, 2008)

This paper draws attention to the 'dynamic effects of competition' and how this is rarely factored in as a variable to be considered at the outset, let alone over time. In reality, any new innovative product is competing not just against the status quo, but against alternative solutions that are also constantly improving their offer. There is no prescribed solution to this phenomenon, merely a suggestion that it represents yet another risk to be overcome by those wishing to innovate. For it to become a manageable risk requires full knowledge of the competition's agenda, which also includes awareness of disruptive technologies that might not appear to be of immediate relevance. CLT for example is clearly on the concrete industry's radar as a threat to its market, but there is less awareness of the increasing threat posed by the educational campaign that TRADA (Timber Research and Development Association) are funding through the provision of on line information and standard details to all schools of architecture (Appendix E TRADA educational resources

A theoretical approach to the construction of technological output indicators. (Saviotti and Metcalfe, 1984)

This paper looks at the *"development of alternative indicators of the output of innovative activity in terms of measures of changes in the state of a technology",* using the three sets of characteristics, one describing the technical features of the product, one describing the services performed by the product, and one describing the methods of its production.

Output indicators are an essential measure of an innovation's success as they measure the impact that innovation has had as opposed to how well it has sold. Smart meters, for instance, through government initiatives may become a commonplace household appliance, but this does not necessarily mean that those households have become any more energy efficient as a consequence. The well publicised issues relating to 'the performance gap' between expected and realised energy

performance in homes are central to this and are addressed in Section 6.1.4, where the benefits of Dynamic Modelling are debated.

Discrete Choice Modelling of Urban Housing Markets: A Critical Review and an Application (Yates and Mackay, 2006)

This paper questions the limitations of the basic multinomial logit model and nested logit models, and their potential for producing misleading results because decisions are not always made sequentially and the order in which they are taken is therefore important. A study is carried out based on tenure, location and house type, proving that a simultaneous discrete choice model works better in situation where the parameters are inter-related.

Yates & Mackay's work is very relevant to this research as the decision making process being developed involves numerous inter-related but incomparable parameters that need to be given some form of relative priority.

Stating Preference for the Ethereal but Choosing the Concrete: How the Tangibility of Attributes Affects Attribute Weighting in Value Elicitation and Choice (Horsky, Nelson and Posavac, 2004)

The tangibility effect – *"the tendency for tangible attributes to be weighted relatively more heavily than intangible attributes in choice as compared to in value elicitation".* ie what someone actually chooses as opposed to what they say they will choose in a survey.

This research has relevance because of the need to use focus groups to gather information about the public's knowledge and perceptions of concrete and housing. The process will involve trying to establish the preferred living experience for each participant, but this paper suggests that the choices made in surveys differs from those actually made when the decision time arrives, with the interview experience promoting soft intangible issues above their actual value. This represents yet another consideration to be catered for in an already complex interview process, but one that it is important to be aware of. How this was addressed is discussed in Chapter 3. This paper also states the importance of using multiple methods to arrive at more robust conclusions, something also discussed in the following paper.

Combining Revealed and Stated Data to Examine Housing Decisions Using Discrete Choice Analysis, (Earnhart, 2002)

This paper discusses the issues around discrete choice analysis and how a combination of discrete choice analysis of actual housing purchases and choice-based conjoint analysis of hypothetical housing purchases can produce more accurate results.

The same principle applies here as in the previous paper in that a mixed methods approach is more likely to give robust outcomes that are not skewed by unintended factors or confounders. These findings will help inform the writing of the focus group questionnaire and how the results are interpreted.

Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process. (Brannen and Brannen, 2005)

This paper considers the benefits in combining quantitative and qualitative research methods in the drive to making research more accessible*. "Currently, there are external pressures, from national and EU funders, for researchers to inform policy and therefore to disseminate in lay language. Such emphasis upon dissemination may have the effect of increasing the importance of research which takes an action perspective, that draws upon actors' perspectives both in the interpretation and in the presentation of the data."*

The author's research is predominantly qualitative but it does include elements of quantitative research where necessary to provide a measurable baseline for the viability of strategies being discussed. This in no way blurs the distinction between the two methodologies, but recognizes the benefits to be gained from combining their strengths if this leads to more accessible and meaningful outcomes. There is also a strong emphasis on the importance of understanding each issue from all perspectives and the likelihood of there being many opinions based on widely differing ontological viewpoints.

Integrated assessment of sustainability trade-offs and pathways for global bioenergy production: Framing a novel hybrid approach (Acosta-Michlik *et al.*, 2011)

This paper discusses using trade offs in the sustainability argument as part of the decision making process between economy, equity and ecology based factors. The resultant combination of fuzzy logic feeding into a choice based conjoint analysis model provides a solution that takes both quantitative and qualitative data to consider all perspectives when assessing sustainability measures. This is what this research suggests the housing industry needs in order to reconnect the different sectors that are driven by conflicting motivations, as well as making new connections where similar motivations exist within very different lobby groups. Some of these opportunities are expanded upon in Section 6.4.2.

Product, process and customer preference alignment in prefabricated house building (Schoenwitz *et al.*, 2017)

This paper addresses the challenge of understanding how to make what buyers want, based on public preferences when choosing kit houses in Germany. The overall aim of the study was *"to develop a systematic approach to the alignment of customer preferences and the levels of customisation offered through the operational processes within the context of the prefabricated self-build housing industry."*

The practical implication was that companies need to avoid committing resources into customisation activates that are not valued.

The UK custom build market is small but growing, and as a niche market that has considerable potential for the concrete industry, would benefit from a better understanding of how to provide the right level of customisation to maintain profitability. Learning from the Continent goes beyond replicating housetypes or construction methods, and is more likely to centre around processes, partnerships and methods of promotion.

1.4 Findings from the literature search

As stated earlier, this review began with a search of the industry literature produced by either Tarmac or the concrete industry's advisory group, The Concrete Centre. It then broadened out into a search of the literature on alternative material solutions against which the concrete industry competes, before looking in some detail at the environment in which that competition is set, both in terms of their immediate clients, the house builders, and also the legislative environment that dictates what those house builders are required to achieve. This progression through the industry literature was necessary to first get a sense of what level of information the industry is currently operating from, and also to understand more precisely where to focus the search of the academic literature in order to be of most benefit to this research. The findings outlined here therefore are those that helped define the knowledge gap from both an industry and an academic perspective.

Collating these findings resulted in a system of categorization that in itself proved to be a valuable concept. That process was approached from the author'proposition that all change - such as the adoption of a new method of construction - requires a decision to be made, and that that decision comes with three principle prerequisites (Figure 1-10): the 'decider' needs to have knowledge of the innovation, needs to be motivated to consider that innovation, and needs to be in a position to be able to adopt that innovation once convinced. Knowledge, Motivation and Ability. All three of these criteria, it is suggested here, need to be fulfilled before any practical change can take place, so the findings from across the industry and then from the academic literature have been discussed in turn under those three headings.

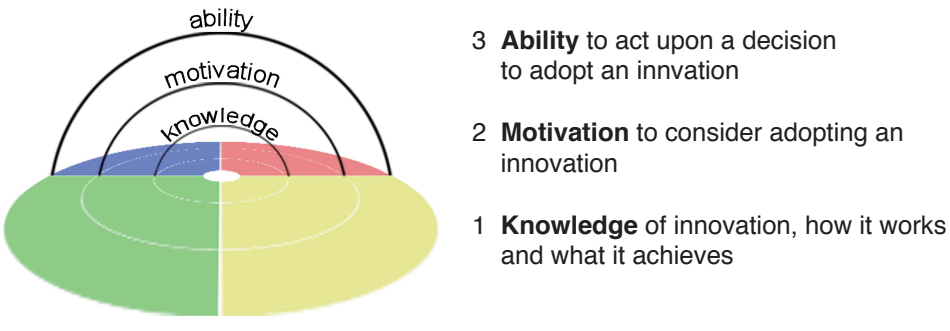


Figure 1-10 the three prerequisites for adoption

At this point, this research now enters into the world of compound probabilities. Not only is it being proposed that there are three conditions that need to be met, but that each of those conditions needs to be met by each of the sectors that are collectively involved in the successful adoption of a new technology or innovation. Without putting a figure on the chances of a positive outcome, it can be seen how important it quickly becomes to define not only the actors involved, but the parameters on which they are likely to make their decisions, and the degree to which they might influence that collective decision. For this reason, the three sections below relating to Knowledge, Motivation and Ability are further subdivided into the four sectors used to define the housing delivery system - and colour coded by the graphic used in Figure 1-1. Green: material supplier, Blue: state legislator, Red: housing provider, Yellow: public end user. The questions that arise from this process have been used to inform the industry interviews discussed in Chapter 3.

1.4.1 Knowledge

• Material Supplier: There is ample evidence of available information or advice within the housing industry with respect to this first sector, that of the material and product suppliers. What is in question here, however, is the reliability of that information. And if it can be validated, can that information from one material supplier be easily compared and contrasted with the statistics provided by a competing industry? Even on the relatively simple level of defining u-values for composite structures, the task of taking all information back to first principles in order to validate and compare is, in reality, beyond the grasp of this information's target audience, most often due to the lack of time available (Luigi Toma and Gheorghe, 1992). One of the aims of this research is therefore to evoke an awareness of the inherent dangers in relying upon company literature, draw attention to some of the most common pitfalls, and to in some way provide an alternative that is both effective and realistic.

• State legislator: Information from the government in terms of policy documents, regulatory procedures and statutory requirements is also widely accessible, and possibly in this sector presumed to be accurate and fair. But is that information seen as reliable in terms of its predictability when government policy can change with very little warning? And is there any evidence of this data being sourced reliably by governments in the first place – something that is discussed in the concluding chapter.

• Housing provider: The housebuilding sector, especially those companies within the private domain, have been found to be unwillingly to provide any information other than what they choose to use as publicity material. This is not surprising, but in the absence of factual data, is there a tendency for supposition to fill the void (Payne and Homes, 2012)? Even at a governmental level, policies were found to be formulated based on theories about the volume house builders' financial model. Speaking to the National House Building Council in November 2016 Sajid Javid, the then Communities Secretary said: *"Some of you have conceded to me, in private, that it [land banking] happens. Some of you still deny it's an issue. But there's clearly something going on.*" (Smulian, 2016). Is there perhaps a disconnect at a governmental level between the policies being promoted and the volume house builders that they are predominantly aimed at, and if so, does this arise from a lack of knowledge and understanding of their business model (Miles & Whitehouse 2013, p.16)?

• Public End user: Information about the public as end users of this housing was found to be available only through survey data that was periodic at best and driven by a variety of needs, making any detailed analysis over a period of time almost impossible. Questions relating to what and how the public think, and what the industry thinks of the public therefore formed part of the industry interview programme to address this gap in the knowledge. Clearly, industry decisions being made based on the industry's perceptions of the public's perceptions of their material solutions is not grounds for a reliable business strategy and highlights the need for establishing each sector's knowledge base as a foundation to any decision making process.

The fundamental question to come out of this review regarding knowledge as a possible barrier to innovation is 'what are the comparative levels of knowledge held within each sector?', and more specifically how complete is their own knowledge of each other's sectors – how they operate, what their motivations are, and to what extent they influence each other's decisions. These are key opening questions that went on to form the basis of the industry interviews discussed in Chapter 3.

1.4.2 Motivation

The emphasis put on sustainability in the concrete industry's promotional literature (The Concrete Centre, 2016) led to further comparative research into the sustainability agenda across the competing material suppliers. The question this raised was, to what extent was sustainability pivotal in the decisions being made to choose one material solution over another? Was sustainability, in other words, a major motivating factor amongst the concrete industry's clients? If so, for whom and in which specific markets, and if not, what were the key motivating factors behind the choices being made?

The findings here served as a reminder for how perception can differ from reality and also have the potential to be a more powerful driver than the facts. The sustainability credentials of any material can be drawn on many levels, and product literature can invariably find an angle that supports its own argument over any other. Consequently, when making a material choice as a practitioner, the concern is that these seemingly contradictory messages could result in the facts getting over-ridden by what is 'perceived to be right', resulting in decisions being taken on the basis of gut feelings and a superficial understanding of the facts. In the case of timber versus concrete as basic building materials, the concrete industry's stated concern is that timber will usually win through at this level (Burridge, 2016, p. 1) (UK Timber Frame Association, no date). In addition to this, research into the way sustainability is measured by the government approved Standard Assessment Procedure (SAP) confirms the inaccuracies in this system that favour lightweight timber frame construction over heavyweight concrete construction (Todd and Fitton, 2016).

One of the questions raised by the literature review was, if sustainability is such a difficult agenda for the concrete industry to promote itself under - despite the strength of its albeit counter intuitive argument - should the industry not first establish to what extent sustainability is actually a driver for deciding what material to use? The underlying issue here for discussion being, what are the main motivating forces for each of the sectors and how can a knowledge of these be used to focus the marketing message more effectively? Again, it is worth looking at the findings relating to motivation sector by sector, to highlight the extent to which they can vary, creating barriers to effective communication.

• Material Supplier: All materials suppliers are now heavily regulated, not least through ISO 14001, the international standard for environmental management systems. Whether this is seen as a driver for improved productivity and efficiency or just a necessary requirement to compete in the market place, most companies in the construction industry now to some degree have a policy for compliance. However, because this is a voluntary undertaking and there are differing degrees to which compliance can be achieved, it becomes very difficult to make direct comparisons between competing claims. This is an inevitable consequence of market driven compliance, and the uptake of EPDs (Environmental Product Declarations) is a prime example, discussed in detail in Chapter 5 in relation to BIM systems. Equally opaque however, is the motivation behind a company's decision to adopt a level of compliance. Is it driven by a genuine desire to be environmentally aware, a desire to appeal to an environmentally aware market, or a recognition of the direct financial benefits to be gained through changing internal processes? Ideally it will be a combination of all three, but one of these will always be the key driver, and this, it is suggested here, is important knowledge to have, as it could dictate the decision making process when dealing with other sectors within the housing delivery system.

• State legislator: The government possibly has the most complex and conflicted agenda, and when it comes to housing levels, preferred methods of construction, the sustainability agenda and home ownership, it should not come as a surprise when governments announce sudden and dramatic changes in policy, as was the case with the recent abandonment of the zero carbon agenda (Roberts, 2016). It is nevertheless uncertainty that helps create a perception of risk, that in turn represents a further barrier to innovation. To what extent this is a fundamental barrier is something the industry interviews hope to shed light on. Can the motivations behind government policy decisions be better understood so that those decisions become more predictable and thereby easier to factor in?

• Housing provider: The house building industry does not act as one entity. Research carried out in this sector has recognized some major divisions, both in terms of the markets being provided for and the motivations to do so (Miles & Whitehouse 2013, p.13). It is only within these subdivisions that any meaningful conclusions can be drawn about how to engage with the housing providers. The public sector for instance, being more heavily regulated, has historically resulted in it being the focus of new technologies and more importantly their use in a financially viable manner. In our current 'post regulatory' climate, however, it is becoming more apparent the extent to which both social and environmental 'motivation' now has to be built off an economically sound footing. The question this raises is, which sectors are now the most appropriate for the advancement of sustainability based innovations?

• Public End user: What motivates the public regarding housing is also shrouded in complexity, despite the mantra of 'location, location, location' supposedly being the sole driver. Research has been carried out that suggests that location is so important, it sits as a given above the true motivators that we need to be addressing (Samuels, 2005, p. 5). Location effectively dictates where we work, who we meet, who we are, but does not make the many other factors that dictate how we choose a home any less important. A number of surveys were studied as part of the literature review but the general trend was that they tended to be either too generalised or too biased to be of much academic value, certainly for the purposes of this research. Access to these sources also varied, and became particularly difficult when asking for the core data and information on sample sizes, denominators,

etc. as opposed to just the key findings taken from that data. How to gather more information about the public's true motivations therefore stands out as a key requirement to be addressed by this research.

1.4.3 Ability

The Farmer Review published in Oct 2016 and the subsequent white paper 'Fixing our Broken Housing Market' have both spelt out the urgency with which off-site manufacturing (OSM) or a 'pre-manufactured' approach must now be embraced as our most viable solution to the UK's housing shortage (Farmer, 2016, p. 11), (DCLG (Department for Communities and Local Government), 2017, p. 54). The proposition being made as to why this message is still going unheeded is that even when the change being proposed can be seen to be beneficial, if that benefit is not immediate, guaranteed and specifically beneficial for the decision maker as opposed to the industry as a whole, the ability to adopt that change might not be there. Off-site manufacturing offers a prime example of this, and demands an answer to the question, to what extent does risk play a role in the decisions taken whether or not to adopt this method of construction, and how can that be addressed to encourage the adoption of this and other new technologies (Lazonick and Mazzucato, 2013a).

• Material Supplier: When looking at this issue sector by sector, it becomes clear that for the material suppliers' sector, the decision whether or not to risk making a change to the status quo is driven by either the direct benefits that change can offer or a legislative requirement to do so. In either case, whether that change is in price, performance, appearance, or any one of a number of factors, the decision to change will be driven by a mutual and clearly stated need, not just a desire to innovate (Lutzenhiser, 1994). This would suggest that the material suppliers' sector is driven by events, and is rarely the instigator of innovations, making its need to fully understand the motivations and abilities of the other sectors all the greater.

• State legislator: Understanding the government's motivations and abilities is a case in point. They have no real agenda for promoting any one industry over any other, and in reality try to avoid any such scenario, making their potential contribution to change somewhat less than is often suggested. The current government's decision to turn away from ten years of sustainable development policy can only be seen as one based on short term financial benefit, and driven by agendas other than sustainability (Glover, 2015). It would seem reasonable to assume that those who made that decision were fully aware of the facts and were also motivated to enact the policies necessary to see us meet our statutory requirements under the Climate Change Act 2008, but their ability to follow through with such an agenda was thwarted by other conflicting requirements, which, whilst we can guess at, are not the main purpose of this study. The question to ask therefore, is to what extent can any government act as enabler, and should the housing industry perhaps stop relying upon them as the catalyst for change.

• Housing provider: As suggested earlier, the house building sector can be subdivided into markets that behave very differently to each other and this is reflected in their attitudes towards innovation and risk. The major volume house builders, who represent over 50% of the market (Miles and Whitehouse, 2013), are seen as the most risk averse, as are their clientele. This relationship of mutual indifference towards innovation has proved very durable, at least whilst regulations allow for it to

continue fundamentally unchallenged. The remaining sectors, categorized as the public sector (including councils and housing associations), custom build (including self-build and group custom build) and the new entrants (those from the construction industry but not conventionally seen as house builders), are effectively fighting for the remaining half of this market, and should in theory be more motivated to innovate to either differentiate themselves, reduce build costs or appeal to a more engaged public with stronger aspirations about how they want to live. But motivation does not translate into ability, and it is in defining that ability that the industry interviews need to shed more light. To what extent is that ability dictated by the risks involved, and how are those risks calculated by the housing providers?

• Public End user: Finally, the public end users, who, as the ultimate recipients of these dwellings, have to justify the expense of either a purchase or a rental agreement. How does risk define their ability to pay for something innovative or in any way out of the ordinary? Their concerns are accurately reflected in those of the mortgage providers whose remit it is to protect the public against those very risks that are associated with innovation (Ross 2002, p.12). For them, risk goes beyond the physical risk of poor performance or question marks over longevity and includes the impact of public perception on future house prices, with modern methods of construction being seen by the Council of Mortgage Lenders as untested until they have existed in an unchanged state for sixty years (BSA, 2012, p. 23). The question to ask therefore, is to what extent are the public even aware of these issues, and if they are can they really be blamed for holding back innovation when they have so little bargaining power, and there is equally little support being offered from elsewhere in the industry?

1.5 Conclusions

This literature review helped define the extent of the factors to be investigated that related to its inability or reluctance to adopt innovative solutions. Out of a need to assimilate all the information being gathered, a method of catagorisation evolved that has formed the basis of the decision making process being developed, and the structure of this research going forwards.

Within these categorisations, the areas where knowledge was lacking became clearer, and with that the areas where further research was needed. This was very much an iterative process, with the ongoing research both informed by the review, whilst at the same time resulting in further wider reviews as more areas of research fell under the microscope. The underlying principle was to continue to ask questions around the decision making process until those questions failed to elicit more questions or the questions became too peripheral to be of any likely consequence.

At this stage, perhaps the most salient point to come out of the review that influenced the direction of travel, was this quote from Mark Farmer in the Farmer Review:

"This is not just another 'must do better' school report where the industry and its clients shrug their shoulders and carry on as normal. This review warns of potential marginalisation and deterioration that might not be recoverable. I do not believe construction's perilous future state was so clearly evident at the time of Latham's Constructing the Team in 1994 or Egan's Rethinking Construction in

1998. If this review does only one thing, it must be to bring the likely reality into greater focus." (Farmer 2016, p.5)

Having read numerous other reports, all recognising that the industry as a whole is fragmented, suffering from a chronic lack of investment and a subsequent decline in its labour force, it seems that the Farmer Review, for all its dire warnings is not offering a cure, or even a diagnosis, but merely restating the symptoms. Even if complacency were the diagnosis and not just a symptom of some deeper malaise, it does not suggest what the cure might be, beyond 'snapping out of it'. The danger inherent in this approach, which this research aims to avert, is that the very real concerns raised in the Farmer Review and the equally reasonable calls to action that stem from it will not be acted upon because the fundamental reasons why all previous reports have gone unheeded has not been understood, let alone addressed.

Looking at the issues involved from the perspectives of the four defined sectors, and recognizing the need for knowledge, motivation and ability before any change can be expected to take place is a starting point for this investigation, and begins to shed light on why it is that the status quo can be so difficult to unseat, even when the consequences of not doing so are so well defined.

Chapter 2

METHODOLOGY AND METHODS:

RESEARCH STRATEGY

Within a constructivist framework, this research has sought to uncover the many viewpoints that exist within the different sectors that make up the housing industry. The methodology is fundamentally exploratory and has resulted in an iterative process whereby many questions have been revisited as more evidence has been gathered, creating a clearer picture of the different perspectives that exist. Each sector of the industry was found to have a different structure, requiring different methods to extract that evidence in as comparable way as it was possible to achieve. How and why those methods were adopted is discussed here, but the methods themselves detailed within each chapter alongside the findings and conclusion drawn at each stage of the evolving process.

2 METHODOLOGY AND METHODS: RESEARCH STRATEGY

Introduction

"The confused state of architectural research would be an interesting sidebar to practice and education if not for its impact. One consequence is the profession's collective shrug, which allows anything presenting itself as architectural research to be treated as such." Christopher Alexander, A Pattern Language. 1978

Christopher Alexander's comment on the state of architectural research, made over 40 years ago was in response to a still on-going debate about whether the 'normal' scientific rules of basic, applied and developmental research should apply to the built form (Buday, 2017). The counter argument centers on architecture's dilemmas constituting 'wicked problems', or ones that cannot be tested or measured for efficacy due to the issues involved being ill-defined and contradictory.

Entering this debate from the perspective of an architect, whilst recognizing the need for some structure to be introduced into the research methods used by the whole housing industry when considering innovative solutions, it is understandable why this debate still continues and why so much confusion still exists. There is clearly a conflict here that needs to be addressed in how the industry and the profession's approach to primary research can be 'brought into line' whilst still recognizing the centre ground that the design and construction of our housing inhabits between the arts and the sciences.

A very useful rule for students of architecture at the outset of a design project is to resist the temptation to conceptualize for as long as possible. The more information that can be gathered from the most perspectives beforehand, the less likely it is that time will be wasted on abortive solutions. The same rule applies to architects in practice, but for those practicing architects working to real time constraints, the most likely outcome is not dead end solutions but compromised solutions that become compromised realities. The relevance of this is twofold in how it applies to the current state of the housing industry which this research sets out to investigate – that of the dangers inherent in decisions being made based on a subset of the available information, and also the reality of time constraints that are so often purported to be the reason for those compromised solutions being accepted. There is also a relevance to the way in which this research has been carried out. The temptation to reach out for explanations whilst still assimilating the facts has been resisted throughout and that same mantra forms part of the methodology that has been developed into a process for the housing industry to follow.

In this chapter the research question is defined, based on the brief supplied together with an historical and geographical perspective gained from the literature review, and a better understanding of the existing knowledge base within the housing industry itself. From this basis, the aims and objectives are then established and the methodologies and methods that will be used to achieve these goals discussed in outline.

Initially, it was posited that there is a need for a better understanding of how the housing building industry operates in the UK. It is known to be complex and fragmented at many levels. It is also seen as a political football by the public and a hot potato by the government (Lyons, 2014). Public opinion is divided along lines of ownership and aspirations of ownership, an understanding of the need for public benefit and the strong instinct of individual protectionism, and long term quality against up-front cost. All in all, this work will show that the UK housing industry represents a morass of contradiction, made worse by layers of perception on all sides that often mask the realities that lie beneath the commentary.

The house building industry does, nevertheless, represent the customer to whom the concrete industry, just as any other innovator, needs to sell its products, so the customer's needs have to be understood. Hence the requirement for a better understanding of how the housing industry operates, and also of those actors who have an influence upon it. Only with that knowledge, it is suggested here, can the issue of how the concrete industry might increase its influence over that market be addressed. This in turn requires a better understanding of the benefits of concrete, the merits of increasing its use, in what areas of house construction that should be, and by utilizing which products. As stated at the outset, however, the issues confronting the concrete industry typify those confronting any supplier to the housing industry attempting to promote an alternative solution to the norm, and it is in that context that this research has been conducted, with the concrete industry's role being that of a case study within that framework.

2.1 Interpretation of the brief

Tarmac markets itself as 'the UK's leading sustainable building materials and construction solutions business, with expertise that covers aggregates and asphalt, readymix concrete, cement, lime and powders and contracting and building products'. Their brief contained a broad spectrum of areas where the company felt there was a need for a deeper understanding of how certain factors could impact on the decisions of others to use concrete products. It was agreed that this brief could be encapsulated in the statement '**How can Tarmac optimise the use of concrete within the house building industry?** The term optimize was used rather than maximize to reflect the understanding that to offer a sustainable solution, whilst the benefits and opportunities for the use of concrete could be maximised, the quantities used should never exceed the optimal requirements. Translating this into a concise research question was not straightforward, because it was not immediately obvious where the knowledge gap lay that would become the focus of the research. The initial theory posited, that it was a lack of understanding within the housing industry of its component parts that represented the most fundamental issue to be addressed first needed to be tested, and this became the initial undertaking of the research. Consequently it was only after an extensive search of the literature that the research question solidified into something that truly represented the area of study that most appropriately answered the requirements of the brief and the wider knowledge gap that presented itself as the fundamental flaw in our current house building system – that of the level of understanding that exists between the sectors about what each actually does and what it is that motivates them to make the decisions they do.

The final evolution of the research question came in the form of a broadening of the scope in terms of subject matter, whilst focusing in on what emerged as the real issue facing the housing industry, the barriers to innovation. Both for the concrete industry and the research itself, this decision to treat concrete as a case study within this broader context was seen as beneficial, as it grew the audience that could relate to the findings, and also grew the scope of the questions being posed in relation to innovation.

2.2 Aims and Objectives

This translated into a number of aims and objectives that were honed as the complexities of the whole delivery system became clearer. These now define the research that was undertaken, and the next section explains the reasoning behind them.

2.2.1 Aims

1. **To better understand how the housing delivery system operates and deals with innovation from all perspectives, and the role played by concrete within that.**

2. **To establish what knowledge exists regarding innovation and the use of concrete, in which sectors, and the veracity of the sources from which that knowledge was obtained.**

3. **To establish which factors influence the decision to adopt or resist innovation.**

4. **To consider how those factors relate to each other and how their comparative importance can be measured.**

5. **To ensures that any decisions made are based the full range of facts that need to be considered and an understanding of how they are interrelated.**

2.2.2 Objectives

1. **Create a model that encompasses all sectors within the industry and shows how they relate and interact with one another.**

2. **Gather the information needed to explain where and how the housing industry is failing to function as a collaborative whole.**

3. **Create a model that can hold that information in a way in which it can be systematically interrogated**

4. **Develop that model into a process for making complex decisions that can be referred to and adapted over time as situations change.**

5. **Test that model against known issues to validate the process and provide solutions to enact.**

These objectives encapsulate the need to better understand the industry from all perspectives before attempting to promote an innovative product within any specific market.

Objective 1: Create a model that encompasses all sectors that define the industry and shows how they relate and interact with one another.

The first task was to establish the scope of the research based on the extent to which external factors impact upon the house building industry. The literature review was conducted in a way that was exhaustive in that it did not set any preconceived boundaries, whilst only pursuing those areas where there was a clear relevance in doing so. To that extent, the research remained open throughout, as some areas of relevance only became apparent at a later date as the overall picture emerged. The purpose of this search was to gather all available knowledge that related to innovation within the house building industry from all perspectives. Focusing the search on concrete was a useful and necessary limiter, as it was not the innovations themselves but the process of innovation that was being investigated, so that the research, headed up by the industry interviews, could then be used to establish the extent to which this knowledge was held across the defined sectors.

Objective 2: Gather information from all sectors to evidence how each operates, using the most appropriate methods in each case

Once a picture had been drawn from the initial literature search of how the industry was structured to deal with innovation, the interviews could be used to look for the differences that existed between the sectors. Where the interview process failed to reach, other methods could be adopted, but the purpose throughout would be to establish what was known and by whom, and equally, what assumptions were being made about other sectors' knowledge, and about why they functioned in the way they did.

Objective 3: Create a model that could hold that information in a way in which it can be systematically interrogated

The evidence gathered would contain a wealth of information about the housing industry, how it operates, and how it approaches innovation, using concrete products and solutions as a focus for that discussion. That information would already be categorized by its source, but would need to be categorized much further before patterns of behavior or correlations between disparate issues would begin to emerge. Without knowing beforehand where the evidence would lead, the creation of a model that reflected these patterns and categorized the information gathered would be an inductive process, starting with the coding and analysis of the interviews themselves. The purpose behind this approach however, would be to establish the full range of factors that would need to be considered in any meaningful decision making process.

Objective 4: Develop that model into a process for making complex decisions that could be referred to and adapted over time as situations change.

Making sense of the data collected would require a comparative analysis of the many disparate and possibly contradictory factors involved, so that their relative importance could be considered in the decision making process. Ideally, such a model would also consider the relative importance of each sector in controlling that decision, and the feasibility of any proposition alongside its more immediate

viability. It would also need to be comprehensive in its ability to interrogate any issue from any sectors' perspective, whilst not becoming too cumbersome or inflexible in achieving that.

Objective 5: Test that model against known issues to validate the process and provide solutions to enact

Any model developed would need to be validated against known issues to prove its ability to deal with all circumstances and also its 'useability' as a tool. The data gathering exercise through the interview process should provide the necessary material to develop a number of case studies looking at known issues from all sector perspectives, both past and present. A combination of these looking at new or alternative strategies for the concrete industry should begin to show how taking a more holistic approach to complex problems such as these can result in far sounder strategies going forwards.

2.2.3 Synopsis of the objectives - Speed and Authority

The ultimate aim of this research is to achieve a better decision making process that allows innovation to be assessed in a fairer light against the status quo. The need for this is exemplified by the housing industry's continuing failure to evolve from its current state which has become dysfunctional on many levels – its inability to provide more housing, better quality housing or more affordable housing (Farmer, 2016, p. 5).

The first stage of this process is to understand what changes are needed, something that has now been well rehearsed for many years (the benefits of innovation). The second is to recognize why these changes have not been adopted, the main body of this research (the barriers to innovation), and the third, to consider how those changes, once proven to be worthwhile should be enacted (the procedure to follow). Establishing the benefits of innovation as a viability argument effectively defines the findings from the initial search of the literature, whilst understanding the barriers, and how to confront them defines the feasibility argument and the methods needed to support that proposition. The main output from the research however, the Decision Making Tool, will come from processing and interpreting that information in a way that allows the most appropriate decisions to be made with speed and authority.

Arguably, speed and authority are both conditions that are currently being met, but rarely together, and this is the crux of the problem being investigated. The solution currently being adopted is to simplify the increasingly complex decisions we are tasked with by providing a set of pre-defined options from which to choose – the tick box approach. This satisfies the first condition of speed, but abdicates responsibility for the second by handing over that need to fully understand the problem to those who are providing the choices we choose from. The inevitable outcome of this is a lack of innovation, partly due to the loss of embedded knowledge that the tick box approach cultivates and partly due to the tick box approach not allowing for alternative solutions to be recognized. Speed, nevertheless, is a condition that has to be met if this problem is to be approached with any degree of realism. The proposition therefore is to shift the box ticking process from predefined answers to predefined questions. In that way, the authority that comes from fully understanding the issues at hand is returned, together with an ability to consider alternative solutions beyond those currently on the table.

A number of concepts have been introduced throughout this research in response to the information being gathered. What began as a system for categorising this data – the division of the industry into four sectors and the division of the benefits to be accrued against the barriers to be overcome - evolved into a method for assessing the value of the many different factors found to be influencing the decision-making process, and the realisation that those benefits and barriers could be measured in different ways – benefits to the innovator, the client, society as a whole; barriers of knowledge, motivation and ability. At each step, these concepts have been put forward as ways to make sense of the information being gathered, at the outset from the literature review, but from here on in, from the evidence that has come from the research undertaken. The methods used have also evolved out of this process and for that reason are best discussed as their need becomes apparent rather than here at the outset. There is, however, an underlying principle that the concepts being proposed have followed, which is to deal with the complex issues being explored by deconstructing them through further analysis until eventually they represent manageable choices.

The interrogation of the benefits and the barriers, and this from the perspectives of the four sectors is the beginning of this process which continues throughout the research, with further concepts brought into play as a clearer picture emerges of how the industry operates. This analytical process that began as one of categorisation, then of assessment, finally becomes one of interpretation, as the component parts of the issues being addressed are reconstructed to form strategies, this providing the underlying structure of the decision making process developed as a tool for industry in Chapter 5. It is important, however, that this tool benefits from a knowledge of current methodologies that may already exist to navigate equally complex problems in other fields of business or industry.

2.3 Existing methodologies

As was suggested at the outset of this chapter, much of the research into existing methodologies in the field of complex problem solving has had to look outside of the discipline of architecture and the build environment. In the USA, the National Architectural Accrediting Board requires architecture school graduates to “build abstract relationships and understand the impact of ideas based on the research and analysis of multiple theoretical, social, political, economic, cultural and environmental contexts.” whilst recognising that “Investigative techniques and methodology are unacknowledged, and therefore, rarely taught.” (Buday, 2017). In the UK the RIBA (Royal Institute of British Architects) states that “In 2016 twenty two practices based in the UK, Australia, Bulgaria and Singapore responded to the call for submissions to the President’s Awards for Research: up from four the previous year and more than any year in the Awards’ eleven year history (Morris, 2017). There is a recognition here that the emphasis on rigorous architectural research in the UK and elsewhere has been overlooked, and that there possibly needs to be a re-evaluation of how the architectural profession approaches problem solving. The following three figures from Scimagojr.com, the journal ranking website (Scimago, 2018c), show how few publications relate to either Architecture or sustainability compared with other disciplines, notably medicine. To this end, a substantial part of the literature review carried out for this research was into the many studies from other disciplines that can be learnt from and their methodologies applied to the issues being confronted here.

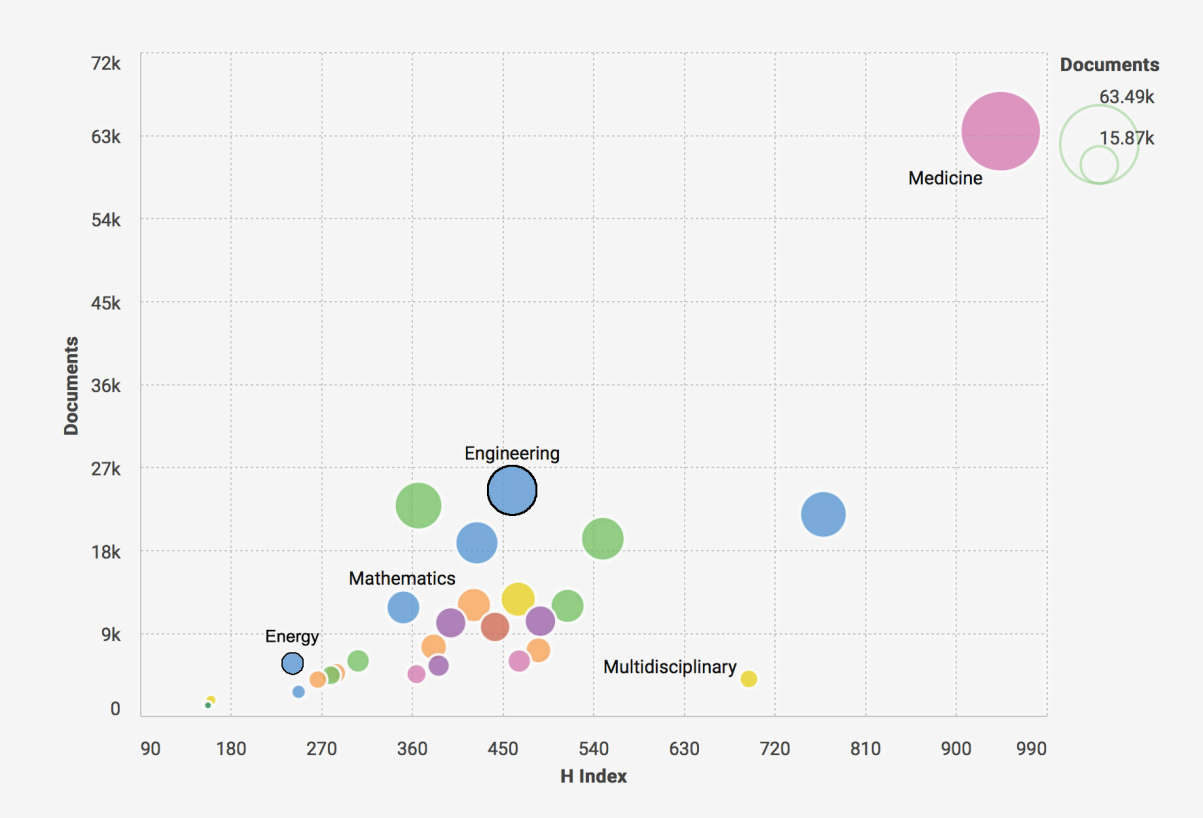


Figure 2-1 Scimagojr Bubble Chart of research areas (Scimago, 2018b)

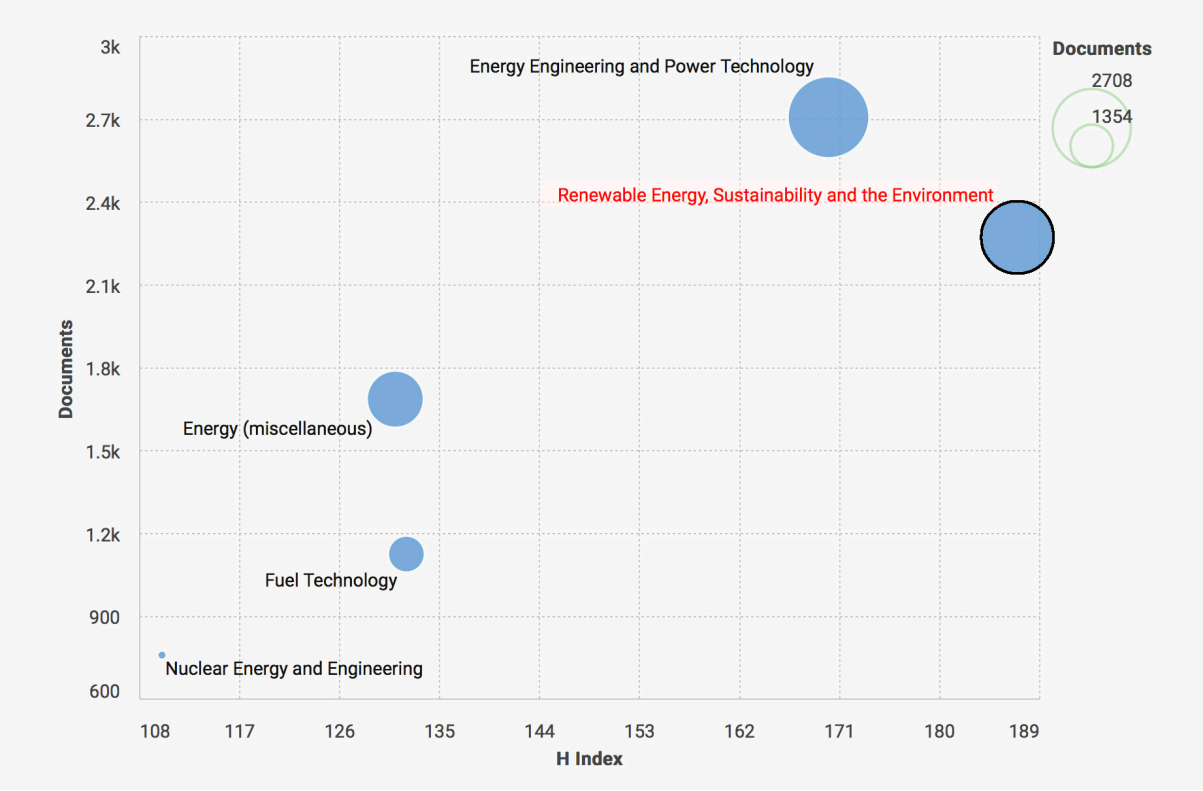


Figure 2-2 Scimagojr Bubble Chart breakdown for Energy (Scimago, 2018b)

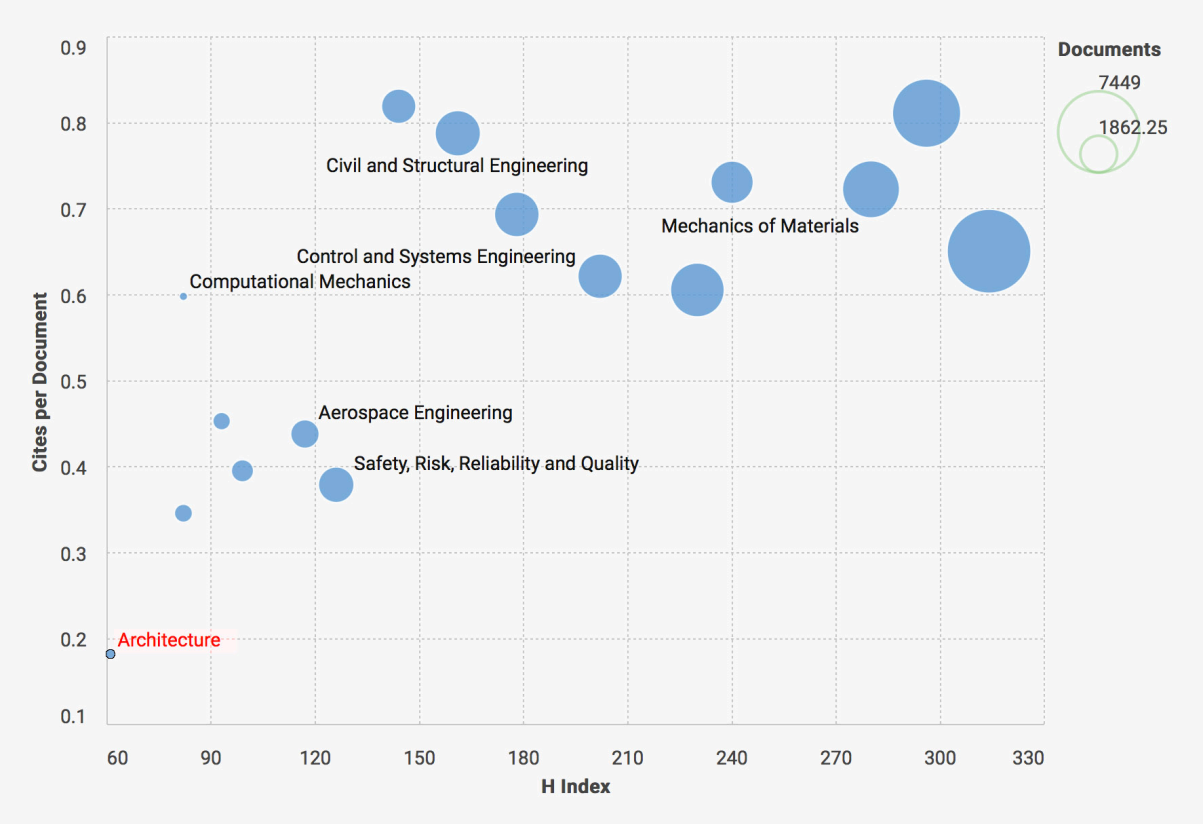


Figure 2-3 Scimagojr Bubble Chart breakdown for Engineering (Scimago, 2018b)

This is not to say that these are issues only being confronted within the construction industry. The extensive growth in the diversity of information required for decision making in general has been recognised as exceeding the capacity of common unstructured models to solve complex social problems, even at a governmental level (Cabinet Office, 2018). Conventional linear decision making processes often attempt to use intuitive approaches to simplify these complex problems until they seem more manageable, but in the process "important information may be lost, opposing points of view may be discarded, and elements of uncertainty may be ignored" (Bridges 2009, p1).

In response to this, there has been extensive research carried out since the 1960s into how to deal with complex, often social problems, that involve value trade-offs and uncertainty. The tools developed, defined collectively as 'Multicriteria Decision Analysis' (MCDA) tools, have been designed to deal with multiple sources of information that bear no direct relationship or commonality, as well as multiple, often conflicting ontological positions held by the various stakeholders involved. They tend to be matrix based and attempt to break down these complex arguments into simpler formats that can be more easily understood and openly discussed. The concept is very much about the process being effective than it is about arriving at any particular outcome, which has led to a proliferation of models to cope with many different categories of problem that exist.

"The purpose of MCDA is not always to single out the correct decision but to help improve understanding in a way that facilitates a decision-making process involving risk, multiple criteria, and conflicting interests"

In their simplest form these models rely upon quantitative measurements applied to each component part of a problem to create a score card for alternative solutions, known as Multi-attribute Utility Theory (MAUT). Another permutation, the Analytical Hierarchy Process (AHP) relies upon paired or binary comparisons within a matrix to ensure that each factor has been fully tested against all other factors being considered. The danger of such approaches however lies in the lack of a common denominator between the factors being compared, and the arbitrariness of any scoring system that is introduced into the process. For this reason, some models rely upon more qualitative approaches whereby binary comparisons are still made but on the strength of evidence that exists and the degree of dominance that any one factor or stakeholder holds over the decision making process (Outranking).

No matter which analytical decision tool is selected to analyse such problems, the implementation stage can still require complex, often impossible trade-offs, and the most appropriate solution can remain unclear or unattainable. The concept of 'Wicked Problems' introduced in detail in Section 4.4, is an acceptance that some problems, again, often social problems, are indeed unsolvable, and can only be 're-solved' time and time again when they are addressed, armed with the most current data available. This recognition of the uncertainty that broader events introduce into any complex equation has led to a further level of development of the tools needed to help navigate the decision making process.

'System Thinking' has developed as a way of understanding the circular causalities that make our conventional linear approach, and even a matrix based analysis of complex problems, ineffective tools for the problems being addressed (Challenges and Innovation, 2013). Dynamic thinking tools help to free up this process by introducing the concept of causal loops, which can be either reinforcing or balancing ("vicious" and "virtuous" cycles). Moving away from a linear perspective allows for the introduction of feedback mechanisms as a way for explaining how any decision taken today can have ongoing and often unexpected implications tomorrow or at some later date.

Many of the concepts that have evolved during this research, through the investigations made into how our housing industry operates, reflect the principles of System Thinking. They have shown how adopting an approach that allows for a constant re-evaluation of the facts based on an ever broader appreciation of the factors and opinions that need to be considered, can result in more appropriate solutions. As all of these tools recognise, however, what is needed is not only a method for solving complex issues, but a language for communicating that process. The role of the communicator (Section 6.4.1) is to translate the message into the right language for the right audience, and is a vital part of the process that allows innovations to advance.

The next section now looks at which of these methodologies could be applied to the issues being considered and what methods would need to be used if they were.

2.4 Establishing the Methods

The initial question of '**how can Tarmac optimise the use of concrete within the house building industry?'** evolved through '**what are the barriers that are preventing the advancement of concrete within the industry?'** into **'how can those barriers be either removed or avoided?'** This represented

a shift in emphasis that was brought about by a deeper understanding of the issues at stake: The problem appeared to be the barriers, and the barriers were often complex, sequential and recurring, leading to the proposition that sometimes, perhaps barriers might be easier to accept or avoid than they would be to remove, but what they must never be is ignored.

Reaching these conclusions has already required a level of exploratory research to identify and define the problems being faced. Testing the theories posited moves the research into a constructive phase where solutions can be proposed which in turn can be empirically tested for their feasibility. An underlying theme to this research has been that the evidence needed has had to include perceptions as well as facts. Differentiating between the two is clearly important, but so too is recognising the fact that many decisions are made based on gut feelings, presumptions and perceptions, and to ignore this 'fact' would be to deny the reality of the situation as it exists. Establishing the appropriate methodologies to use for this research was therefore a process that stemmed from a growing understanding of what the issues were that needed to be investigated. By this stage it had become clear that there needed to be a deeper understanding of how the sectors within the housing delivery system operate - what they know, how they think, and what drives them to make the decisions they do. The reality of how the industry is structured also impacted on what methods were available to the authors in following this path. The four sectors defined are in fact very different to each other in many respects and it became clear that the way to approach each would also vary depending on accessibility, sensitivity of information, levels of knowledge, etc.

2.4.1 The sectors and how they differed

The decision taken was that for the exploratory stage of the investigation at least, this research would be qualitative and would aim to uncover the full range of issues to be considered rather than attempting to measure impact in any statistical manner. This did not rule out the gathering of baseline information on the use of concrete, however, which whilst being a basically quantitative process should not have to be seen as conflicting with a predominantly qualitative approach (Brannen and Brannen, 2005). The more important definition of the approach taken would be around the holistic nature of the investigation and its attempt to provide an exhaustive list of parameters that could be said to have an influence over the decision making processes that take place within the housing delivery system. How this process has been conducted and the range of methods used varied across the sectors and followed a pattern based on the availability and accessibility of the material that was being sought.

The material (suppliers) sector: The authors found an abundance of promotional company and product literature relating to the concrete industry which was readily accessible through their trade body, the MPA (Mineral Products Association), but what was less obvious was how access to this material compared across the competing industries, and to what extent it was used by those within the wider industry. The search of the literature focused on the concrete industry and its direct competitors within housing, that being timber frame, steel frame and CLT (Cross Laminated Timber). The series of interviews which began within Tarmac and the concrete sector, were intended to then encompass these other material sectors, but there was an understandable reluctance for those companies to participate in research benefitting their competition. Information about these sectors

was therefore limited to literature sources and the knowledge and perceptions of those interviewed from elsewhere. Comparative advertising from all material sectors provided some interesting starting points, but no more than this because of the inevitable tendency for this material to use beneficial denominators which could not be easily verified or compared. Sources of training and educational material and their deployment were also compared as a measure of how well this information was disseminated across the industry and into educational establishments.

The government (legislative) sector: The bulk of the research within this sector focused on the published data from government sources, covering the regulatory process, housing policy and economic policy in general, where it could be shown to have direct consequences. Understanding the hierarchy within these sources and again, how that information was disseminated was a necessary part of this process, together with an understanding of the level at which that information was accessed by the industry (Section 6.1.1). The tree diagram of Advisory Bodies referred to in Section 1.2.3 gives a foundation to this process and clarifies the sources and their position within the hierarchy. Included in this are some government bodies that were reluctant to participate in the interview process due to their need to remain impartial, such as the BRE and the Council of Mortgage Lenders, but this in itself was an insight into the limited role these bodies were prepared to play in promoting any particular solution or innovation. The interviews that were undertaken within this sector and those undertaken elsewhere about this sector were nevertheless instrumental in establishing how legislation plays a part in the decision making process, and which bodies on the tree diagram were considered most dependable as information sources.

The house building (provider) sector: The interviews undertaken in this sector formed the basis of the research here both in terms of gathering data about the house builders and also their perceptions of the other sectors – and even how they thought they themselves were viewed. This was symptomatic of the way in which this sector operates with limited promotional literature made available to the industry or the public, resulting in little data on which to base research outside of this. One reliable source that was intended to form part of this study was the NHBC (National House Building Council), but this avenue was closed down shortly before it was due to happen over concerns about data protection, resulting again in only anecdotal evidence being available. Much of the written analysis used to either balance or corroborate the evidence coming from the house builders themselves has therefore come from government white papers, mainly focusing on the housing industry's shortcomings.

The public (consumer) sector: The surveys carried out across the other three sectors all involved people in positions of authority with an in-depth knowledge of their own sector, if not the whole industry. In this respect their opinions could be taken as representative in a way that a handful of interviews with the general public could not be. For that reason it was decided that some form of omnibus survey data would be a more appropriate method for gathering data across this broad spectrum of opinions. The alternative suggestion was to interview a selection of professionals with knowledge of housebuilding, such as architects, but from a user's perspective. The concern about this method was that it seemed to reflect the findings from the search of the literature that the public were often seen as a body whose opinion it was safer to assume on their behalf than to ascertain directly. To this end existing omnibus survey data was sought and its credibility considered before

embarking on the process anew. This became both part of the data gathering exercise and part of a further literature review (Section 1.3.3) to understand the requirements of a robust survey that could reliably gather the information missing from those surveys found, and discussed further in Section 3.3.

2.4.2 Methods used in response to the research needs established

By the completion of the research, with how it evolved in response to the knowledge gained during that process, the methods used had been adapted to suit many different needs. What began as a series of simple semi structured interviews grew into multiple processes to both gather the information and then comparatively analyse it from multiple perspectives. It was important that the underlying methodology was adhered to throughout to maintain a degree of comparability between the methods used, but it was necessary to return to the literature on two occasions as the goal shifted in terms of what was seen to be the most needed outcome.

The methods used both to gather the data and analyse it are explained here in the wider context of the research philosophy followed and will be enlarged upon in the relevant sections alongside the reasoning behind their adoption. The breadth of this research inevitably meant that it was going to involve a number of different strategies and straddle some of the purer definitions of research methodology. But this made it even more important that the research was based on a clear understanding of the decisions being taken at the outset.

The initial search of the literature, for instance, was not a systematic review, but a scoping review carried out systematically, in that it could be repeated. It was not exhaustive or its findings quantified statistically, but it served to establish the extent of knowledge within the industry and where it was located, both in terms of its sources and its take up.

The research philosophy used would be classed as Critical Realism, sitting on the continuum between Subjectivism / Constructivism and Positivism in its attempts to recognise from an objective standpoint how the situations being researched were understood, perceived and theorized by subjective observers. The methodological approach was therefore fundamentally exploratory and resulted in an iterative, inductive process, which aimed to seek out and understand different ontological viewpoints held across the different sectors of the industry.

The decision to take a constructivist stance for the research in terms of how it saw the industry, stems from the initial theory posited that it is the industry's sectors' tendency to actively construct or create their own subjective representations of objective reality that leads to powerfully held perceptions preventing the facts from being heard. In other words, the aim of the research was to find an objective reality that was informed by the many subjective realities existing within the industry, without itself becoming yet another equally subjective viewpoint held by an observer outside of that sphere.

"The primary function of Critical Realism lies in determining what is objectively real and what is subjectively accepted as truth" (Taylor and Taylor, 2018, p. 217)

Working from an initial theory might also appear to blur the line between an inductive and a deductive approach, and to some extent it does. There is, however, no evidence to back up this widely held presumption that the industry's sectors work from perceptions rather than reality, so the research was approached with an open mind rather than with the intent of finding data to fit in with an existing researched position.

The research strategy adopted to progress this inductive approach involved semi structured interviews, surveys and case studies, the need for each only becoming apparent as the research developed. The blending of a deductive and an inductive approach is again apparent in the way in which the interviews were coded based on initial expectations, but grown through the process to cover all issues that came to light. The initial coding headings were important because they reflected the perceptions already held, some of which were completely unsupported in reality, but the overall approach was an inductive one.

All of these strategies were qualitative except for one project undertaken early on to establish a baseline for the use of concrete in different housing types which was a quantitative exercise. The correct definition of this combination of approaches is multi method, as opposed to mixed method, as the methods were not used in combination to produce a single dataset, but independently for different tasks. The public survey in its pilot form cannot be used to infer any statistical evidence, with the data obtained from 150 surveys used purely to lend weight to the argument that differences of opinion exist that are not fully understood and need to be investigated further through a full omnibus survey.

Not surprisingly therefore, even the time framework within which the research was undertaken was not straightforward. The research was essentially cross sectional, as the data gathering exercise gave a snapshot of the industry's inner workings. But both the context within which this was set and the outcomes that were taken from it were longitudinal, in that they focused on changes that had taken place over time and cyclical occurrences that held important evidence to be learnt from. Many of the case studies took this approach, whereby the current evidence gathered was compared against historical evidence from both the UK and overseas to help explain outcomes in terms of causes and consequences.

In all, the decisions taken throughout have been guided by the purpose of the research and not dictated by an adherence to any one methodological approach. Because this has been done in an informed way and an overall cohesiveness retained, the resulting conclusions are delivered within an holistic framework appropriate to the subject matter being investigated.

"Critical Realist researchers have been criticized for not being rigid in their research approach and appearing as not being thorough [20}. However, as the research process involves identifying underlying causal mechanisms and structures these are not always obvious in the early stages of the research process [20]. As such, the researcher must adapt their approach to sift through the data and seek to identify the causal mechanisms and structures." (Taylor and Taylor, 2018, p. 220)

The final phase of the research was how to use the interpreted results to create a process to be followed by industry that would effectively replicate those used in the research. The starting point for this was the use of conjoint analysis as a methodology for comparing disparate factors in complex decision making scenarios. In principle, this approach was adhered to with each question posed being broken down into an increasing number of 'sub-questions' until those became binary questions. The sheer number of these generated however required an additional step in the process to be introduced. It was at this stage that a Systems Thinking approach was considered to make sense of the complexities associated with social issues and the realization that housing is not just a question of construction but represents a far more interrelated set of issues that cannot be dealt with in isolation. The outcome of this was the development of a system that categorized all those binary questions that were generated under a smaller number of binary choices, that could then be compared against each other to assess their comparative importance. In that way a clear picture emerged that allowed for some holistically defined strategies to be set.

2.5 Conclusions

The way in which the limitations of the interview process were recognized and dealt with through the introduction of further methods was very much in line with the inductive approach adopted throughout this research, showing a willingness to respond to the evidence as it developed. The issues of comparability resulting from the introduction of further methods however, were important ones to address. Opinions are easy to come by, but ensuring that they are valid, representative, and free from unconscious bias can be harder to ascertain, with each sector raising its own challenges. The issue of strongly held perceptions, often quite divorced from reality but no less relevant as decision making factors, also needed to be taken into account, whilst being carefully categorized as such.

It was at this stage that a link began to emerge between the way in which the research was being undertaken and the decision-making process being developed, with the realization that the template for the tool could legitimately mirror the structure of the thesis. The key elements in the approach taken for both were the need to let the boundaries be self-defining based on any one factor's relevance; the need to recognize the alternative realities of different sectors; the need to allow each line of questioning to find a natural conclusion within a simple binary choice, and the need to categorise that process in a way that would allow each parcel of information to be located within a structured system.

The structured system set out for the thesis in its objectives has been defined as a process that begins with establishing the question to be answered and collating the known information held by all the stakeholders, before establishing where the disconnects lie which might act as barriers to progress. Once that broader understanding has been established, a more informed discussion can be held

regarding the most appropriate strategy to pursue. That in essence is what the decision making tool needs to replicate if it is to be of any benefit to the innovator and to the industry as a whole.

Various models are used throughout this work to help visualise how that process evolves into the Decision Making Tool defined in Chapter 5. Without jumping ahead too far, it is useful to understand at the outset at least the intention behind how that model is to be structured. The concept so far is founded upon the following statements:

- There are multiple opinions within the housing delivery system that need to be recognised
- The barriers to innovation need to understood as well as the benefits, and from all perspectives
- Those barriers might be ones of knowledge, motivation or ability
- All barriers must be addressed prior to enacting any solution being proposed

Those statements have been condensed into the four basic steps being used to structure the process being developed:

Understand the Question → Research the Unknowns → Solve the Problem → Enact the Solution

The following chapters now discuss that development through the findings from the research, with each method applied dealt with in turn, complete with a more detailed analysis of the methodology used in each case, followed by the results obtained and the conclusions drawn.

The decision to segment the research in this way was taken because of the inductive way in which it evolved, requiring each stage to be discussed in turn, in order to explain the need for the stage that follows. As a consequence of this approach, the tool has evolved in response to firstly, the findings from the literature review (Chapter 1), then to the main body of the research carried out (Chapter 3) and finally, in response to the case studies (Chapter 6) used to test and validate the solution put forward. Components of the tool, dealing with different aspects of the overarching question being asked have therefore been put alongside each other, or nested within each other as their role within the whole becomes clearer. This model is shown here (Figure 2-4) as an overview of the structure that will now begin to emerge as the research progresses, consisting of three tools combined into one: The first, to help assess the financial viability of a product in terms of the straight material costs involved, the second to categorise the information gathered with respect to the benefits to be gained, the barriers to be addressed, and the options available within a specific task, and the third, to allow a set of tasks to be considered and weighted in relation to each other in order to arrive at a coherent policy of enactment.

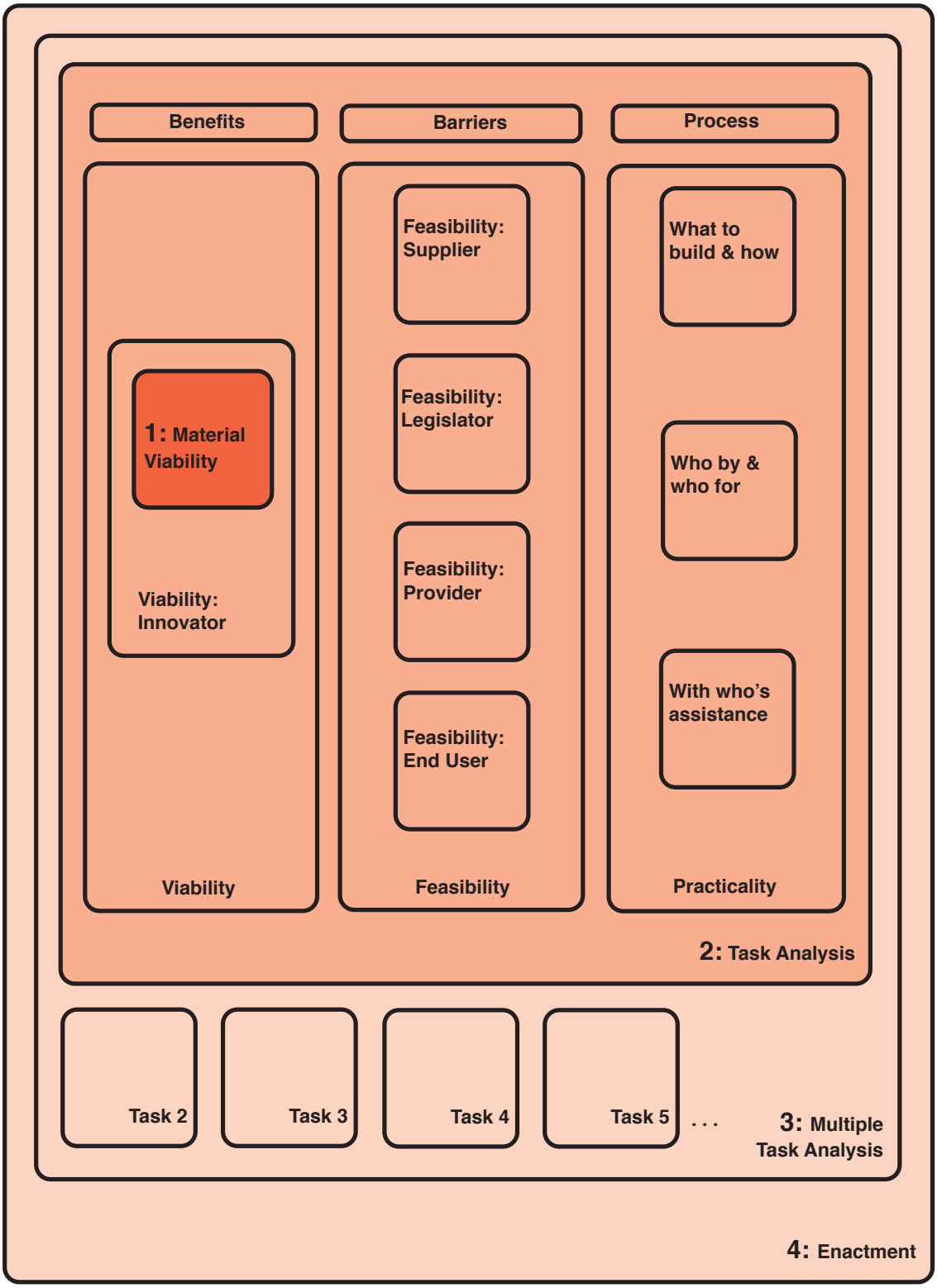


Figure 2-4 Basic structure of tools developed

Chapter 3

ESTABLISHING WHERE THE KNOWLEDGE LIES

Knowledge is defined as 'the theoretical or practical understanding of a subject'. The aim in this chapter is not only to gain a better understanding of the house building industry, but also to establish which sectors within that industry hold that knowledge, so as to shed light on where the gaps are that might be creating barriers to innovation. The first section of this chapter discusses the findings from the industry interviews and how this information then influenced the direction of travel for the research that followed, in terms of the additional studies that were then undertaken to compensate for the interview process where it proved to be an inappropriate vehicle for gathering the necessary information. Those next two sections cover the document review of the government white papers

relating to the construction industry, used to bolster the knowledge of that sector, and the public survey and how that was progressed to gain an insight into what was beginning to feel like the forgotten forth sector.

3 ESTABLISHING WHERE THE KNOWLEDGE LIES

Introduction

This data gathering exercise fulfilled the second objective (2.2.2) of evidencing how each sector operates in terms of knowledge held. The expectation at the outset was that a series of interviews would be carried out across the full spectrum of the housing industry to gather comparable data from all perspectives. Whilst that was certainly necessary to gather the information needed to examine the possible disconnects that existed, it became clear that the interview process was not the ideal mechanism for all sectors. This in itself constituted discovered knowledge, as the process of trying to arrange the interviews was a valuable exercise, exposing how each sector operated and saw its own role within the industry. It is worth briefly looking at these attitudes because they dictate how the research unfolded and also the different mechanisms used and discussed in this chapter.

The material suppliers:

The concerns raised by potential interviewees in problematic sectors were mostly relating to the sensitivity of information within a competitive marketplace, which made it difficult, for instance, to interview any material provider outside the concrete industry. This was clearly an issue as one of the fundamental hypotheses was that many decisions are made based on incomplete or incomparable data, and an understanding of the competition's perspective was therefore an essential element of the research. To some extent this was addressed by reviewing the many advisory bodies that have emerged to connect business to government and the public, although the reliability of this data was often questionable, and further research was needed to validate these findings in the form of a series of information based case studies, forming the first section of Chapter 6.

The legislative sector:

Government bodies on the other hand were not so much concerned with sensitivity of the content – as all their data is essentially in the public realm - but sensitivity over any perceived favouritism (Thompson, 2016, p. 5) something which had not been recognized by the authors at the outset as a major influence over their decision making processes. For this reason, the interviews that were carried out within this sector were supplemented by an in-depth study of all government reports relating to housing and the construction industry since the Second World War, discussed in Section 3.2. Whilst this gave an overview of the public facing message that governments wanted to portray, it did not provide much insight into government thinking, which was later pursued through a different route as part of Case Study 6.1.5.

The housing providers:

In comparison, the interviews carried out across the housing building sector were surprisingly candid, particularly amongst the volume house builders, perhaps reflecting an air of confidence in their position within the industry. These were valuable interviews as they gave an insight into a world about which very little is written first hand, outside of their own promotional literature. This assertion was

proven by the fact that even the other providers within this sector had little real knowledge of the volume house builders' business model, relying instead upon conjecture.

The public sector:

Lastly, the public sector presented a different problem. Whereas the interviews that were conducted across the other sectors were with representatives of professional bodies with an in-depth understanding, at least of their own roles within the industry, interviews with the public would have been of a far less informed nature regarding how the industry operates. At the outset it was decided to leave this sector until last so that a better opinion could be formed of their role and what questions actually needed asking that had not been covered by previous surveys and census data. The alternative option to individual interviews, that of an omnibus survey represented a considerable undertaking, but again, the need to gather reliable first hand information was central to the research, and if anything, corroborated by the responses from the other sectors that were at the same time both dismissive and opinionated about what they thought the public thought about housing. The findings from the public survey are therefore discussed as a separate section, 3.3, the content of which was based on the findings from the other three sectors, discussed below.

We now return to discussing each of the three methods used in turn, looking also at the results obtained and the conclusions drawn.

3.1 The Industry interviews

The following interviews were carried out over a 6 month period and generated over 30 hours of material to transcribe and code. Twenty two interviews were completed in total, by which point the information being gathered began to suggest that most opinions had been covered, and the inaccessible sectors clearly defined.

3.1.1 The Method:

The main objective of the interviews was to learn more about the level of knowledge held within each of the sectors, both about their own roles and those of the other sectors within the decision making process. The secondary purpose was to establish to what extent this knowledge was true, where that knowledge came from and whether it was based on factual evidence or perception and assumptions made over time. The questions asked were fundamentally geared around why concrete should or shouldn't be considered as a key building material for housing. The scope of the questions needed to allow for social, historical, economic, and aesthetic as well as practical reasons for why this might be so, to ensure that all aspects of the perceived problems as well as the actual issues were fully covered.

The actual questions asked were:

▸What do you see as concrete's biggest failing in housing that it needs to overcome? (weakness)

▸What do you see as the main threat to concrete's future as a building material for housing? (threat)

▸What would you see as the innovations in concrete most likely to re-engage the public / the construction industry / the government? (opportunities)

▸In what housing type would the benefits of concrete be most apparent? (strengths)

To ensure that all opinions were allowed to be expressed, the interviews were semi structured, using these four questions as a basis for direct comparisons but also a springboard for a broader discussion. The initial round of interviews were all 'in-house', ie: employees of Tarmac, with the intention being to gain a better understanding of the concrete industry's impressions of the housing industry they were supplying. Whilst this gave a valuable insight into their thinking, it also gave a better understanding of the line of questioning needed to either confirm of refute their beliefs.

The full extent of the interviews undertaken and the individuals involved cannot be included in its entirety because the data sources have to be protected, but the breakdown was as follows:

Tarmac PLC: 8 interviews across all material sectors and departments.

The Concrete Centre: 4 interviews covering employed architects and structural engineers

The Legislative sector: 4 interviews covering the NHBC, the Building Societies' Association, and lobby groups (Good Homes Alliance, Build Off-Site)

The House Building sector: 6 interviews covering the volume house builders (Taylor Wimpey, Barratts) Housing Associations (Nottingham City Homes) self build (NaCSBA) and the innovative sector (Blueprint, Urban Splash)

The first eight interviews undertaken were with Tarmac employees, who between them had knowledge of a wide spectrum of material solutions and management roles. These were followed by the four interviews at The Concrete Centre, the industry's promotional body. Interviews planned with the Concrete Centre's equivalents in other industries, namely timber, CLT (cross laminated timber) and steel frame, failed to materialise due to the sensitive nature of the questions from a business perspective. In fact, even within the concrete industry there was a reluctance from industry partners, such as Laing O'Rourke, to participate for similar reasons. With the knowledge gained from these 'in-house' interviews, the remaining interviews were carried out in an order that was mostly dictated by availability of the interviewees. In hindsight this 'randomising intervention' was beneficial as it allowed for information gained from one sector to inform the subsidiary questions asked in another, enriching the discussions as the interviews progressed.

Each interview was conducted under the strict guidelines of the University's ethical review panel, and recorded for later transcription (Appendix B). The analysis was carried out using Nvivo (Figure 3-1) and the coded data was collated to form a database of categorised responses (Table 3:1). The author's own thoughts were also added during this coding process as annotations, and used to formulate areas for further research. The entire process from beginning to end was recorded for future use (Appendix C). An example interview together with the action list generated after coding can be found in Appendix D. The following sections discuss the findings from each sector, one question at a time. The quotations have been coded and prefixed for each sector: M (material supplier) L (legislative sector) P (housing provider).

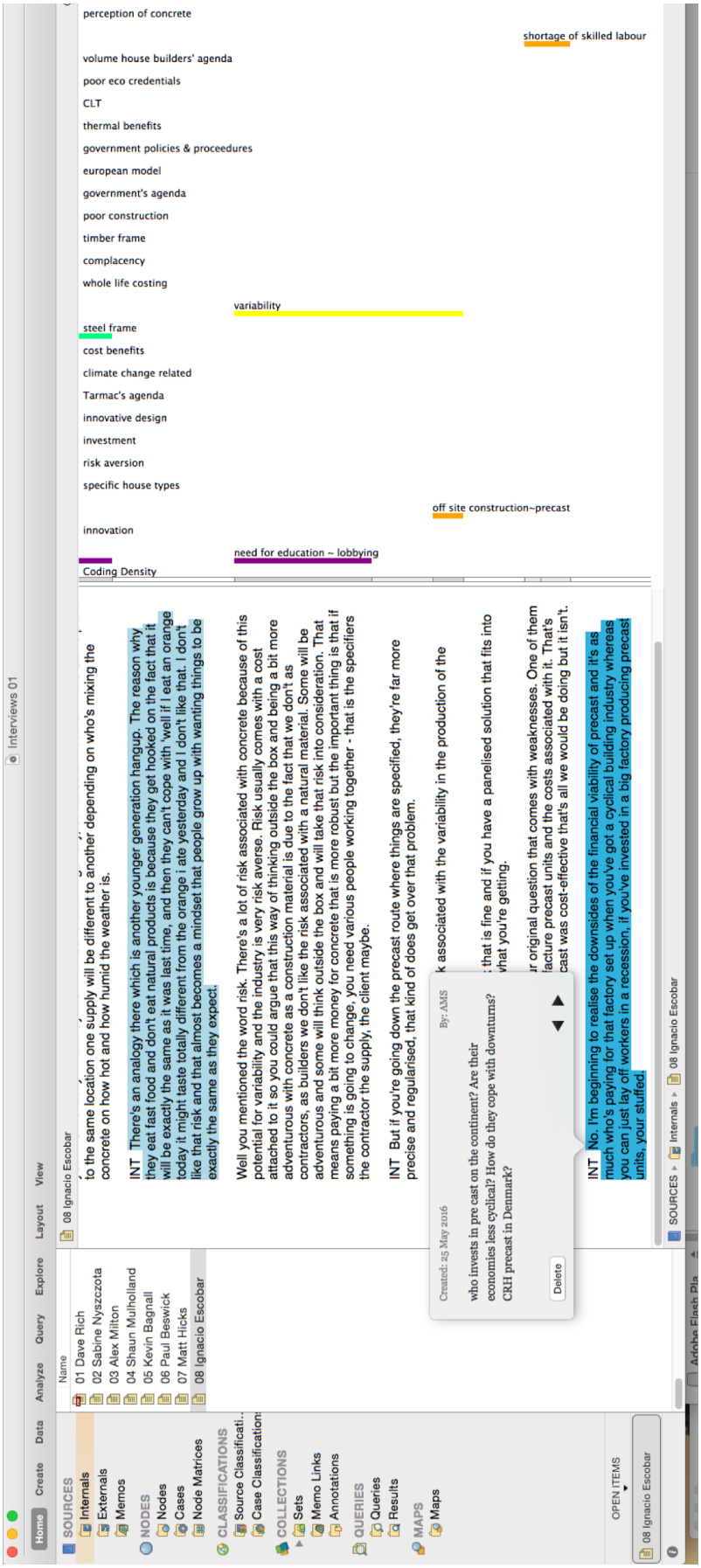


Figure 3-1 Sample Nvivo output

	Sect…	Intervi…	ann…	type	status	who	topic	annotation
	01	1.01	1	comment			03 house building	There are no UK examples of volume housing in concrete to showcase other than Grand designs houses where the concrete is 'in you face' It's hard to promote something you don't n
	01	1.01	2	to research	to do		04 public perception	Outside the housing market was there a fall and rise in popularity of concrete or did it just contiue and evelove / improve its image?
	01	1.01	3	comment			02 political / economic	government agendas require tangible solutions which it can shout about - OSM, NewTowns, planning relaxations on extensions, localism bills . . . all things with positive connotations.
	01	1.01	4	to research	to do	VHBs	03 house building	Is there any proof of VHBs competing with each other by providing something different? What USPs have they tried?
	01	1.01	5	comment			03 house building	The drive for delivering sustainability will either be a stick - from government legislation, public demand or competition between providers, or a carrot - it saves them money.
	01	1.01	6	to research	to do		03 methods of	it would be beneficial to categorise the benefits and the most appropriate building types for all OSM solutions, not just concrete's, even if only to help highlight the areas where there is
	01	1.01	7	comment			01 materials	self promotion by cherry picking science (timber frame industry)
	01	1.01	8	comment			04 public perception	People will make judgement calls based on very basic information, and once made, will seldom revisit the arguement, but just reapply the same solution. After that, detail will only be u
	01	1.01	9	comment			02 political / economic	Government policy can be seen as a threat to MMC if it robs it of one of its strongest USPs - sustainability.
	01	1.01	10	comment			02 political / economic	mixed messages from Government slow down the pace of change both in terms of buisness investment and public buy-in. The whole agenda needs taking outside the political cycle.
	01	1.02	1	to research	to do		01 materials	why was the concrete industry slower than the competition at promoting its eco credentials? Was it because it didn't believe in them itself even?
	01	1.02	2	question	to do		03 house building	how do you prove whether the VHBs are leading the public or responding to the public? Or do you just accept it as a symbiotic stalemate and add something new into the mix.
	01	1.02	3	comment			02 political / economic	The Government like OSM because it's a simple, radiacally different concept that sounds like it might work, and now it's got a new name it's no longer associated with prefabs.
	01	1.02	4	comment			03 house building	VHBs are driven by profit, but profit can be achieved in many ways - speed, less labour intensive methods, less materials, smaller buildings, housing density, different social solutions
	01	1.02	5	comment			04 public perception	Rather than promoting concrete as an alternative building material, try promoting a different (communal) housing solution that better suits MMCs from a constructional and an aesthetic
	01	1.02	6	comment			01 materials	Concrete industry needs to use facts to dispel myths, counter misinformation and explain the benefits. Stop apologising
	01	1.02	7	comment			03 house building	True, but are we not beyond this in the UK? We are more transient and no longer expect to buy a house for life.
	01	1.02	8	to research	to do		02 political / economic	How far can we push the earning to mortgage ratio before it breaks. How have got it from 3:1 to 9:1? Is there anything left to use up?
	01	1.02	9	comment			02 political / economic	Trying to find ways to fund 'affordable housing' only delays the structural change we know we need to implement to solve the housing shortages.
	01	1.02	10	question	to do	Tarmac	03 house building	how genuine are the cyclical benefits of Tarmac being involved in housing as a protection mechanism during a crash? Is that a good enough reason for being in this marketplace?
	01	1.01	0					
	01	1.03	1	question	to do	Tarmac	03 house building	Tarmac & Blue Circle's history of housebuilding and why they pulled out.
	01	1.03	2	question	to do	Tarmac	03 house building	Land value, section 106s, CIL - I still think Tarmac's policy on depleted quarry sites is part of this research
	01	1.03	3	comment			03 house building	Tarmac need to understand how the VHBs have optimised their supply chains before they can discuss alternatives with them
	01	1.03	4	to research	to do	NCH	03 methods of	Get info from NCH about remaining concrete prefabs for interviews - Bilborough?
	01	1.03	5	to research	to do		02 political / economic	Find post war housebuilding graph against governments
	01	1.03	6	to research	to do		01 materials	Check that internally rendered concrete works thermally just as well as exposed concrete.
	01	1.03	7	to research	to do		04 public perception	List all the ways concrete can be used but named in a way that the fact it's concrete isn't broadcast - stealth promotion. Brightly coloured cementitious concrete panels are not seem a
	01	1.03	8	comment			04 public perception	Prefabrication by any other name is not a problem in the UK. Look at Ikea.
	01	1.03	9	comment			04 public perception	"My perception is that on the continent they design with concrete whereas here we build with it." Is that the Grand Designs difference?
	01	1.03	10	question	to do	Tarmac	01 materials	Is the concrete industry up for comparative advertising? Whole Life Cost analysis can only be explained by way of example, and that enquires comparisons - importing costs for timber
	01	1.03	11	comment			04 public perception	Promote concrete through its success in non domestic UK construction - or European domestic construction.
	01	1.02	0					
	01	1.04	1	question	open		03 house building	is open plan here to stay?
	01	1.04	2	question	open		02 political / economic	do we need to take housing outside the political cycle?
	01	1.04	3	example				lobby groups cherry picking information to skew government policy decisions
	01	1.04	4	comment			04 public perception	blink - the first decision about which material to use will be the defining moment
	01	1.04	5	to research	to do		01 materials	can you make precast concrete pods? I thought they were injection moulded plastic
	01	1.04	6	to research	to do		01 materials	comparison of the thermal mass of concrete and CLT
	01	1.04	7	comment			04 public perception	my aim is to expose the questions concealed by the answers
	01	1.04	8	example				VikingHouse timber frame solution
	01	1.04	9	to research	to do		03 house building	why has timber frame dropped as a percentage of new build?
	01	1.04	10	to research	to do		02 political / economic	is there a generational shift away from ownership? - music, cars, yes. Houses - maybe not as they're seen as an investment, security, not a commodity
	01	1.04	11	question	to do	Tarmac	03 house building	What's changed? Was the loss of control over the marketplace not considered? Does being part of CRH make it a more viable option?
	01	1.04	12	question	to do	Tarmac	03 house building	Is there a public record of your land aquisitions? Land sales need to be sustainable, not a family silver sell off to balance the books / satisfy the shareholders for a few more years.
	01	1.03	0					
	01	1.05	1	question	to do	CC	03 methods of	who's going to drive piling? Not the concrete industry

Table 3:1 database of responses

The coding process itself was initially based on the four questions from the SWOT analysis with subsequent divisions based on the issues expected to be raised by the interviewees. For instance, reasons for seeing concrete as undesirable were expected to include 'poor performance', 'aesthetics', 'social connotations' etc. As the coding progressed, however, other categorisations were added as required until no new interview required a category that was not already present. Others that had been chosen at the outset, but never selected, such as 'weathering' in this case, were left in as this was felt to add a useful dimension to the author's own perceptions at the outset. The resulting list of coding categories, whilst representing an exhaustive list, were often very closely related to others and a further stage of simplifying the responses was undertaken until what felt like an optimum number of categories remained. The software used allowed for information held within any interview to be extracted on many levels to establish trends, comparisons and contradictions between interviewees and between sectors. The ability to return to interviewees for clarifications and follow up questions after subsequent interviews was also an invaluable part of this process and made all the easier by the coding process whereby all the data could be catagorised and searched by any number of parameters.

An example of how the data can be interrogated would be a simple word search across all Tarmac interviewees for use of the term 'perception of concrete' to corroborate the assertion that as a company there was a strongly held belief that this was an issue that constitutes a major barrier for the use of concrete in house building. This can be displayed visually but the phrases shown can also be easily traced back to the interviewee and the context of the statement (Figure 3-2).

By way of example, the follow up research that stemmed from this particular exercise was to establish if there was any actual evidence to this effect, and if so did it differentiate between demographics of age, race, gender, social status, affluence, geography, etc. Had the perception of concrete differed noticeably with age, for instance, this would have directly affected how and where the concrete industry marketed its products.

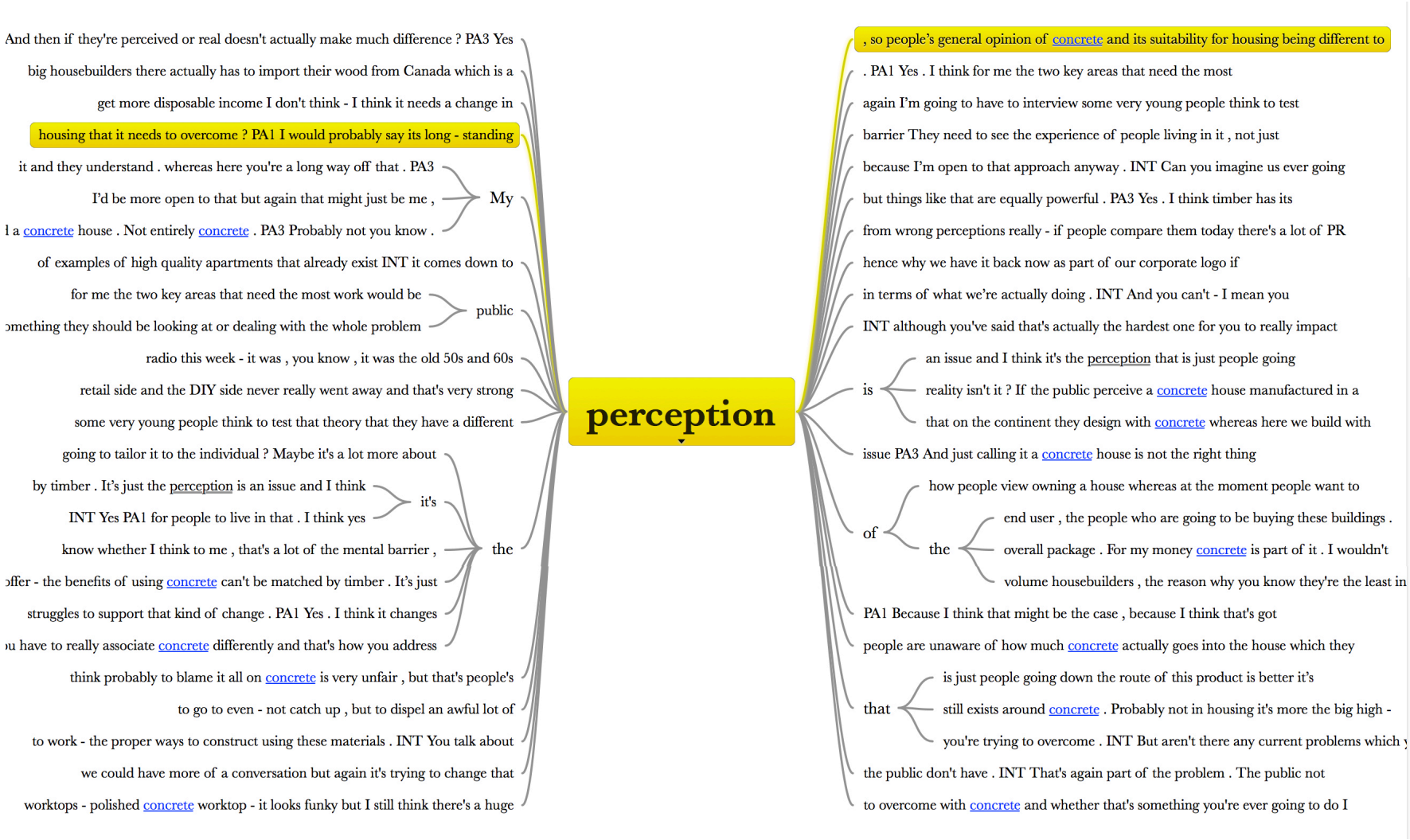


Figure 3-2 Word tree output from Nvivo

3.1.2 The findings: Categories for coding

A total of 22 interviews were carried out across three of the four sectors, many of whom were contacted subsequently with follow up questions to either clarify or add to the picture that began to evolve as more interviews generated further lines of enquiry. This was an iterative process in many respects with the coding criteria also evolving as more evidence came to light that was not being actively sought at the outset. Much of the interview data was therefore re-read after the full set of criteria was established and honed into those shown in the tree diagram below (Figure 3-3) to catch any comments initially missed or in hindsight categorized incorrectly.

The semi structured nature of the interviews, as intended, resulted in a broad range of responses that contained information and indeed entire areas of discussion that had not been anticipated. The two additional main categories added, 'Practices' and 'Agendas', reflected this shift in emphasis towards the reasoning behind the decisions being made rather than the decisions themselves. 'Practices' refers to the ways in which sectors within the industry operated and 'Agendas' refers to the reasoning behind the decisions made, both stated by themselves or perceived by others. The subject matter, such as comments made about off-site manufacturing, is therefore often split across a number of different categories, dependent on whether that information related to their knowledge, their perceptions or the consequential decisions this had led to.

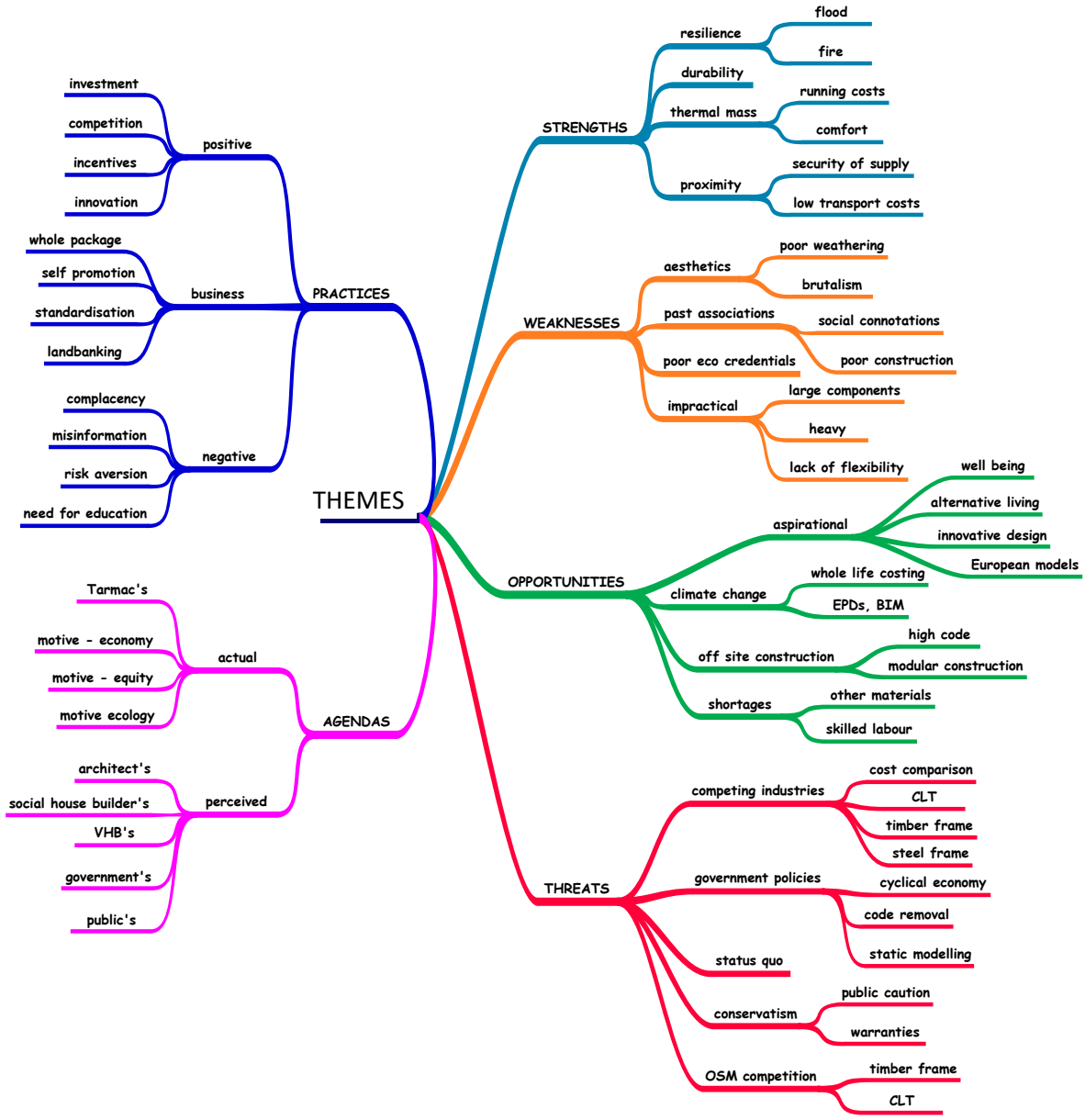


Figure 3-3 Coding tree diagram for industry interviews

Reporting on the outcomes from these findings was therefore a complicated process, with the software being used to code the interviews allowing for the data to be sliced and interpreted in multiple ways. Initially the information held in the data was categorized as either new information learnt from the interviews or information found in the interviews to corroborate previously held beliefs. This definition became blurred as the process evolved however, so alternative categorisations were considered. First it was suggested that the sectors interviewed be used as the main division, but because of the degree of crossover between answers relating to the interviewees' own sectors and their perceptions of other sectors, it was decided instead to discuss the findings by taking each of the four main questions in turn plus the additional two categories added, with the 'facts' from the sectors interviewed compared against the 'perceptions' from the other sectors when asked to comment on how they thought that sector operated. In the case of the public end user sector, the 'facts' are taken

from the survey data gathered in place of the public sector interviews, and are dealt with separately in section 3.3.

The first eight interviews undertaken were with Tarmac employees, who between them had knowledge of a wide spectrum of material solutions and management roles. These were followed by four more interviews at The Concrete Centre, the industry's promotional body. Interviews planned with the Concrete Centre's equivalents in other industries, namely timber, CLT (cross laminated timber) and steel frame, failed to materialise due to the sensitive nature of the questions from a business perspective. In fact, even within the concrete industry there was a reluctance from industry partners, such as Laing O'Rourke, to participate for similar reasons. With the knowledge gained from these 'in-house' interviews, the remaining interviews, including one with a public facing advisory group, were carried out in an order that was mostly dictated by availability of the interviewees. In hindsight this 'randomising intervention' was beneficial as it allowed for information gained from one sector to inform the subsidiary questions asked in another, enriching the discussions as the interviews progressed.

The following sections discuss the findings from each sector, one theme at a time. The quotations have been coded and prefixed for each sector: M (material supplier) L (legislative sector) P (housing provider) and E (end user).

3.1.3 'Concrete's biggest failing in housing that it needs to overcome' (weakness)

Findings:

This first question immediately elicited some very different responses from within the concrete industry to those from elsewhere. The expectation, however that the responses from within the sector being interviewed would be more factually based than those from other sectors was not always borne out by the results. All responses to this question tended to be based on personal experiences, intuition, and assumptions about how concrete is perceived by the other sectors, with a clear divide between the reasons given from within the concrete industry and those from without. With only two exceptions - who both, interestingly, were not British – the answers given by Tarmac employees all focused on the public's poor perceptions of concrete (M.01.3, M.01.6, M.01.7).

"it was the old 50s and 60s perception that still exists around concrete. Probably not in housing - it's more the big high-rise developments and the social stigma that is associated with that."

"I would suggest it's probably the perception of people that's led by what was done in the 1960s when there was an awful lot of concrete prefab housing built in the UK, and it wasn't built very well and it wasn't built using very good quality concrete."

"Well I guess its legacy perception caused by the 60s high-rise even when it wasn't high-rise, concrete cancer. There were ugly designs."

Clearly, eight interviewees cannot be taken as a representative sample, but on further discussion, the German and the Spanish interviewees agreed that they did not share the same historical connotations with concrete and therefore focused on answers that were more in keeping with the remaining ten

interviewees, even suggesting that the concrete industry itself was to blame in not recognizing the changes in demand that were taking place around it (M.01.2).

"people selling and using concrete, whose failings we're talking about here, have clearly missed a trick when, on what was important when decision-making changed, things like sustainability, efficiencies and speed of build became more important and they were blind to that."

The four interviewees from The Concrete Centre also gave answers that were more balanced towards the construction industry's perspective, reflecting their position as intermediaries within the industry (M.02.5).

"We were very good at putting up, building a lot of houses in the 60s and 70s. It's failing isn't the concrete, a lot of it isn't the concrete's fault, it's the social stigma associated with unmaintained sink estates."

In comparison, the answers from the house building industry were consistently related to the practicalities of construction (P.08.1), the comparative cost (P.05.1) and the performance of concrete (P.01.1)

"The traditional reputation of concrete is it's big, its heavy, it's difficult to construct."

"I think for me [the high] cost is the number one reason we have not used concrete frame in the apartment building or on the new apartments."

"it's biggest failing I would say is its inflexibility, and the bigger the panels the bigger problem. Cost, transport, erection. Its flexibility."

Throughout, no mention was ever made of public perception, and when pushed to comment on this aspect, the claim that the public had issues with concrete was often refuted, even from within the volume house building market. (P.01.1)

"At the moment I don't think public perception is an issue as far as we are aware."

Discussion:

This was certainly an interesting first foray into how opinions can vary between sectors and also the extent to which perceptions play a part in this. The belief amongst Tarmac employees that the public's perception of concrete was the industry's biggest failing, and that this stemmed from the era of 60s housing is effectively Tarmac's perception of the public's perception. It is not based on any verifiable data, and in fact raises some interesting questions about how any negative perceptions that do exist might vary across different demographics. It could be argued that the generation that should be of most interest to the concrete industry going forwards – those under 30 years of age – have very little knowledge of the 60s and are far less likely to hold those negative connotations that the concrete industry seem so keen to portray upon them. Similarly, there may well be significant differences in opinion between ethnic or social groups reflecting their varying exposure to the housing that for some has become so stigmatised. These were clearly areas that needed to be investigated though the public survey covered in Section 3.3.

Whilst this could potentially be seen as positive news for the concrete industry, the answers gathered from those within the house building sector were on the whole far less encouraging. Their answers focused on concrete's "lack of flexibility, its weight, transport issues and the associated costs" (P.08.1). The practicalities were seen as the real issues, showing perhaps the well-rehearsed divide between the professions of designer and of constructor as much as anything else, but nonetheless, very clearly defined and heartfelt. From the more informed perspective of the concrete industry however, it could be argued that none of the practical issues raised were either insurmountable or even factually correct if direct comparisons were to be drawn between concrete and some of its competitors.

3.1.4 The main threat to concrete's future as a building material for housing? (threat)

Findings:

One question raised early on in this process was whether or not the interviewees should have been allowed to see the questions being asked beforehand. The decision was taken in this instance not to give them prior knowledge, the argument being, other than the fact that the questions were straight forward and benign, that it was more insightful to get both an immediate and a considered answer rather than just the latter. In response to this particular question, a number of possible interpretations were thought of, with answers such as 'the status quo' or 'changes to government policy' being expected, but the spontaneous answers given were on the whole the same answer across the board: The main threat to concrete was seen to come from its direct competition, that of timber frame and more recently, CLT, cross laminated timber. (M.01.7, M.02.1, L.03.1, 04.02.1)

"Things like CLT. Any of these modular timber based methods, because they're so light, they are pretty quick to construct, they are easy to adapt."

"the main threat is timber off-site and that's because of the initial superficial understanding of timber as green and the move towards wanting to have more off-site and the fact that it's light, and transport costs will be less than for concrete."

"I think timber will play a big part. We've seen a resurgence of timber frame again. And we see quite a lot of current interest in CLT which hasn't really played a big part in the housing market yet."

"Well it's going to be the engineered timber frame that Legal and General are doing."

A comprehensive list of reasons for this were given, including timber's weight, ease of use, flexibility and (perceived) sustainability credentials. CLT in particular, the 'new kid on the block' was seen as the disrupter most likely to infiltrate concrete's 'defender markets'. But as the interviewee from the NHBC (National House Building Council) pointed out, CLT had yet to make any serious in-roads into the industry, and at the time of the interview, none of the major companies looking at CLT as an option had "made any advances to the NHBC regarding certification". (L.03.1) Even the Structural Timber Association (STA) were yet to produce their own guidance on good practice.

"They've been very shy about bringing information to us to assess."

It was also pointed out that the timber frame industry had, on the other hand, only recently recovered from its demise at the hands of the 1980s World in Action programme (Ross 2002, p.10) that exposed the poor practice of some companies (L.03.1)

"We've seen a resurgence of timber frame again. Back in the 80s prior to World in Action it was up to about 25% of the new build market but almost overnight collapsed to around 6% if you want to talk about perceptions. We're back up to about 24% now."

A more detailed interrogation following on from this initial question uncovered some more complex issues that the concrete industry needs to face up to, beyond those of weight, its carbon footprint and its inflexibility, highlighted in the previous section (P.08.1): Off-site manufacturing, the current panacea for increasing our national house building potential, was raised as a concern because of the likelihood of it being comparatively more beneficial to the competition than it would be to the concrete industry (M.02.3).

"But quick build is the other thing which is not quite so good for us. I mean it could be. You could do off-site concrete, but people tend not to think about it. They think about timber and light weight steel as off-site construction. Concrete is actually quite heavy to cart around on the back of a lorry."

This raised further issues about where the concrete industry should be focusing its resources, since the timber frame and CLT industries have no on site presence in the way concrete has – their business models are almost entirely predicated on off-site manufacturing - and can therefore only benefit from its resurgence. The concrete industry on the other hand, has a more complex model to consider, with on-site defender markets that could at best only be replaced by off-site alternatives, and possibly even lose out to alternative material solutions. (M.02.1)

"84% of housing is masonry currently and therefore that's something we're defending. We're at risk of losing that. Now we don't actually mind if we lose that to off-site concrete solutions because it's all cement aggregate, but we do mind losing that to timber frame."

This conundrum was put in sharp focus by one interviewee, through the example of mass concrete foundations, very much a defender market, and the possible promotion of mini piling as an 'eco' alternative. Whilst this might fit very comfortably with the concrete industry's sustainability agenda, and provide a viable solution to many tight brownfield sites with contaminated soil issues to consider, it not only considerably reduces the total volume of concrete sold, but it also opens up the market to steel pile alternatives. There was a very real concern, recognized by some within the concrete industry, that this might be symbolic of a larger threat facing their industry were off-site manufacturing to progress as intended. (M.02.1)

'Whilst foundations is a big market for concrete, it's going to be concrete anyway, so we could spend a lot of effort saying keep using concrete in foundations and piling is a different way you can do it - to protect ourselves from penetration from the steel market, but we don't actually fear the penetration from the steel market enough to prioritise that work."

Other secondary concerns stemming from the concrete industry's recognition of timber and CLT as a major threat were around the public's perception of timber as a more sustainable solution than

concrete, combined with the government's increasingly unpredictable sustainability agenda. On the one hand the concrete industry was seen as trying to convince a skeptical public and housebuilding industry that concrete can provide a genuinely sustainable solution (The_Concrete_Centre, 2015) whilst on the other, the government is retreating from enforcement, making concrete's benefits even harder to justify than they already were under a system that favours lightweight / timber / PassivHaus solutions (U K Green Building Council, 2017).

The threats that were not mentioned were the less tactile concepts of conservatism - risk aversion, and the power of the status quo to keep innovation at bay. Again the only interviewee to consider this question on the level that perhaps this needs to be taken to, was not British, and seemed capable of stepping outside the constraints that our housing industry is so often accused of working within. (M.01.2)

"I don't see our [the UK's] traditional methods of house building changing very quickly, any time soon. The only other driver that might change is if the housing market itself changes and the fact that affordability just isn't there. So we might look at different ways of living. Living with our parents longer, having bigger households, maybe people share more. If the UK housing market changed to a structure where we were more reliant on rented properties. Different drivers for someone who builds a house to rent than for someone who buys a house as an investment to sell on."

Discussion:

Overall, the question of 'threats to concrete' could be said to have been seen as more future focused whereas the 'weaknesses' question was looking to the past. What was noticeably different however was that on the 'threats' question there was far more of a consensus about where the issues were that needed to be addressed, namely CLT, not that how this threat should be dealt with formed part of that answer.

From the perspective of the warranty industry, however, in this instance the NHBC, this threat was far from imminent, suggesting that the reality might be very different to the perceptions held within the house building sector, something that is investigated further in Section 6.3.2. But the same interviewee's comments about the recent resurgence of timber frame also suggested that the concrete industry should have recently been through a relatively competition-free period of house building, which it clearly has not. The inference being that whilst the timber frame and CLT industries may well now begin to encroach on what could have been concrete's territory, it never actually was concrete's territory, and the reasons for that must lie outside the timber industry's influence.

This is not to underestimate the threat of timber to the concrete industry now however. The concerns raised about timber's unchallenged supremacy in the sustainability argument are well founded, with strong counter arguments going unheard:

SAP uses the kappa (k) value to determine thermal mass. 'k' is the measure of the heat capacity per unit area in kJ/m2K of the 'thermally active' part of the construction element. The 'k' value is a relatively crude way of determining thermal mass. It makes assumptions about the extent of the thermally active volumes of a material and ignores the effect of thermal conductivity in calculating the period over which heat is absorbed and emitted from the material. (Greenspec, 2014, p. 5)

Whilst these might have come across as secondary concerns for those considering concrete as a solution, they are not necessarily secondary concerns for the concrete industry itself. Unravelling these interrelated issues and recognising which represent causes and which consequences is a critical part of the decision making process being developed. (Section 6.1.4)

It is perhaps not unusual for an element of 'groupthink' to settle on an industry that has been wrestling with the same issues for a considerable length of time, and this would certainly seem to be true from how this question has been addressed, certainly from within the concrete industry. Research into how innovation in housing is both approached and received on the continent, specifically in Belgium (Minister of the Brussels-Capital Region for the Environment Energy Urban Renewal and Welfare., 2016), shows how it is the more fundamental concerns of affordability and social cohesion that have driven innovation, rather than a specific material's credentials (Bridger, 2010). This is picked up in more detail in Chapter 5 when the drivers for change are defined from the total evidence gathered.

3.1.5 The innovations in concrete most likely to re-engage the industry? (opportunities)

Moving on to more positive ground, the next questions were asking the interviewees to consider how and where innovative solutions could be used to the benefit of the concrete industry. This was basically approaching the problem of promoting concrete from the markets' perspectives and asking what it was that they wanted from concrete rather than telling them what concrete could do. Again, the ulterior purpose of the question was to differentiate between responses from each sector and also their perceptions of each other.

To re-engage the pubic:

Findings:

Taking the public first, whose own opinions were not part of the interview process, the responses gathered from the other sectors formed an even three way split. The public were either perceived as wanting their concrete housing to look radically different, wanting it to look as if it were built traditionally or not having any interest or say in the matter. These responses were equally split across the sectors interviewed.

If there was any consistency to be found in the answers given to this question it was in the slight air of negativity in what was after all the first opportunity in the interviews to debate the positives of concrete (M.01.1, M.01.7, M.02.1).

"I think the housebuilders could be convinced to go down the route of concrete if it doesn't affect their ability to deliver what the market [the public] wants."

"So that first home that you buy, are you as a buyer going to have a care in the world about it? About whether it's sustainable, the heating bills, or is it just that first step on the ladder that you want to get the hell out of? So why would you care about the quality of the construction of your first-time home?"

"I don't think the public have any real say in how things are built. They're more interested in the location, affordability the local schools are like, where their jobs are, what the kitchen is like what the garden's like, what the neighbours are like - and finally they might think about what it's built from, but they never do, so discount them."

In this respect, reasons given for why the public might not be interested in concrete housing went beyond the more obvious aesthetic arguments. The 'risk averse nature' of the British public was given as a (perceived) reason for house builders not wanting to invest in anything untested

"The volume house builders tend towards twee and retro in their hideous way, mock Tudor."
INT: "And they blame the public?"
"Yes." (P.05.1)

And the way in which we buy and sell properties to move up the ladder was given as a reason for us not paying too much attention to the running costs of our first home (Hicks, 2016, p. 6), a market often seen as one that the concrete industry should be focusing on.

The Good Homes Alliance, a body supporting sustainable housing and communities, suggested that "a concrete housing estate" would be the most positive intervention the industry could make to 'excite' the public (L.02.1). This, it was suggested would go to the heart of the problem the industry faces, that the public have very little at this scale to actually compare against the status quo that wasn't built in the 1960s and discredited shortly afterwards. (M.01.2)

"I honestly don't think people really care an awful lot what it's made of. They allegedly care a lot about what it looks like? I don't know as to how much that agenda is driven not by the public really but by the housebuilders, because we are not actually presenting an awful lot of attractive alternatives. How hard have we really tried?"

Discussion:

What could be taken from the broad range of opinions recorded about the public's desires was that there was a need to get a better understanding of what the public actually think and want themselves, rather than relying upon the presumptions of others. All of these perceived opinions could no doubt be found to exist amongst what is obviously a sector that spans an entire population, but the vital information that the concrete industry in particular is missing, is how these opinions break down demographically. It would perhaps be expected that the housebuilders themselves would have a better understanding of their own markets, but whilst there continues to be an undersupply of housing, their position tends to be that any public preferences are outweighed by their need to settle for what is available over what is desirable, and therefore does not constitute a primary driver.

A breakdown of the public by demographics might also show which sectors of the public are more likely to be risk averse in terms of innovative housing, and what type of housing that demographic

would be most likely to need. The comment made about our disinterest in the performance levels of our first property was also something that needs further investigation regarding the thought processes behind adopting that position. Is it due to a lack of knowledge of the financial benefits, an inability to invest at an early life stage, or a structural issue around recouping future benefits from prospective buyers? The solution to this may fall outside the gift of the concrete industry to affect, but even that is important knowledge to hold when deciding where to focus future campaigns.

Underlying all these issues, however, is the undeniable fact that there is very little modern day built evidence of what concrete can deliver the homeowner that is either modern or positive, and that needs to be addressed to give any argument some credibility.

To re-engage the Government:

Findings:

A similar situation of vicarious information existed here in that the answers given were predominantly about the government rather than from the government. To categorise this as information based on 'other peoples' perceptions' supplanting more reliable first hand, factual evidence would presuppose that government bodies, had they been willing to participate, would have been totally candid in their responses. The fact that the BRE (British Research Establishment) and the CML (Council of Mortgage lenders) for instance, both refused to take part would perhaps suggest that they would rather avoid having to answer the kind of questions that might expose their true motivations, or a preference for any one industry solution over another. Had the authors been more persuasive, however, it would certainly have been unlikely that this sector's opinion of themselves would have matched those gathered from the other sectors: (M.02.1, M.01.7, L.03.1, P.10.1)

"Well the government, to re-engage the government is anything off-site. I don't think they go any further, any deeper in their thinking than off-site."

"Well for Government it will be speed of build. I'm not convinced by their commitment to an eco-agenda,"

"Yes I think the real push now is volume, volume, volume, and certainly we have had our Chief Executive meetings with government and by the way we need to lean quite heavily on you, the NHBC, to make sure quality stays where it should be."

"I think Government seems very keen not to govern in this area not to contribute in this area."

The overriding comment about the government's agenda and how to re-engage them was to offer more houses faster and for less money. Quality was barely mentioned, and only in as much as it was off the agenda, along with sustainability, which was now seen as being, at best, fixed at current requirements. Almost as universal was the recognition of the government's belief in off-site manufacturing as the route to achieving their agenda – more than a belief in off-site manufacturing itself. (P.03.1)

"I don't think the government are bothered. They know what they want by modern methods of construction, but they're not bothered whether you do it in concrete or timber or steel."

Less universal was the realization that off-site manufacturing would surely benefit all material solutions, and possibly all others more than concrete. Not surprisingly this denial was mostly coming from the concrete industry who were reluctant to admit that the government might be shifting its focus away from sustainability, or that the benefits offered by concrete through off-site manufacturing that they were very keen to point out, might be of equal benefit to their competition – precision, standardization, performance. (P.03.1).

"I think generally there's a sense that there's more of an appetite for modern methods of construction now than there has ever been and I think certain modern methods of construction like timber frame are now compatible with conventional as it has ever been so I wouldn't expect to see timber frame fall in terms of market share during the next recession."

As with the comments made about the public sector, getting the interviewees to translate these thoughts into positive suggestions for how to re-engage the government was equally elusive. There was an acceptance rather than a frustration with the fact that the government was not actually that engaged with the debate beyond the basic short term goal of more housing faster, and a realisation, voiced by a number of interviewees, that until housing was dealt with as a cross party issue, this short termism would continue. (M.01.4)

"My feeling when I engage and talk to government is that it goes in the too difficult tray. If housing became part of the infrastructure plan I could see then it could be outside of party political interest and then it would become in the interest of the country."

Discussion:

The comment that housing was all too often placed in the 'too difficult tray' because of the impossibility of seeing a positive outcome from any policy initiative within a five year period was telling. An analogy for these answers is that of an almost abusive relationship between industry and government, where industry recognizes what the government ought to be doing to save the relationship, but out of a sense of hopelessness, allows the government to continue to behave in a way that is damaging for all those involved. The government, on the other hand, has decided that the housing industry is incapable of change, cannot be reasoned with, and is no longer deserving of its full attention. A similar perception of the construction industry as the complacent schoolchild underlies the Farmer Review:

"This is not just another 'must do better' school report where the industry and its clients shrug their shoulders and carry on as normal." (Farmer 2016, p.5)

To re-engage the construction industry:

Findings:

This last sector was seen, if this is possible, as even less engaged with the possibilities offered by innovation than either the public or the government (M.01.7).

"I'm not sure at the moment there's enough of a need for them to change. And the them being the traditional housebuilders."

In fact they were seen as hostile towards it, but 'they' are not the whole house building sector, whereas the answers given were almost entirely focused on the 50% of the housing industry represented by the volume house builders. Even the volume house builders themselves were quite candid about their own agenda and what part innovation needed to play if it were to be of interest to them, especially in relation to the sustainability agenda (P.01.1).

"Running costs from what I've gleaned over the years, if you say to someone - I mean all of us are governed by the latest standards that the government imposes so there's an equalisation there, so do you offer something better that costs more? People welcome that but they won't pay a penny for it. They are not interested in paying any more for something that will save them money in the future."

"[If] our return on capital invested is less than our competitors, it affects our share price and market perception as a business, and then presumably the salaries and bonuses."

For the volume house builders, profit was key, and this should not come as a surprise. How that profit can be achieved is where the discussion needs to be focused, as this can be through more than just a cheaper product at the gate. (M.01.2)

"for housebuilders, I mean profit is one word, but it can be translated into many things. Having less labour on-site. Time doesn't seem to be as big an issue as many people say."

Some of the larger volume house builders were keen to point out their willingness to investigate the alternatives on offer, but this did not change the principles by which they were prepared to consider investing in those alternative solutions, or the reasons why they would rather not (P.01.1).

"we've got an industry where a lot of the people who work on sites aren't the most thoughtful of people, but when they first do something the preponderance of mistakes its higher than when they are doing it for the 10th time in a row. So the more choice you give on-site the more cock-ups you get and the more cost is involved and the more the cost of organisation increases."

A further consideration for them in this decision making process was the opinion of their site workers. As has been witnessed by one interviewee, the viability of an alternative solution can often falter at this level even after the house builder as a company has been convinced of the benefits (M.01.6).

"We're going to meet some resistance if we're going to start talking concrete. I think if we look at the construction industry and the housebuilder as one thing, the housebuilder would be receptive to concrete housing but the people who work for them building those houses will not."

And in the case of large format concrete blocks, an innovation halted by a basic misunderstanding of profit at the coalface:

"It's not a good thing for them [the bricklayers] because they get less money per house, so they see it as taking money out their pocket and they don't like it. But things like that hold back the technology very easily."

The only other building sector that was mentioned other than the volume house builders was that of the 'new entrants' who were singled out by one as the sector that was most likely to be open to both innovation and concrete as a construction material, coming as they do from the non-residential end of the construction market where the use of concrete and standardized components was more commonplace. In this market, there was genuine hope for concrete as a solution, especially if the industry could offer complete solutions rather than just products. (M.01.7, M.02.1)

"I think the use of concrete will probably come through non-traditional so your contractors who are more used to using concrete in the commercial world, whether they see the housing crisis and the requirement for homes as being too big a carrot to ignore, and start expanding into that and putting through their methods of construction into the sector."

"Well I think it's got to be solutions led, not product led so the concrete industry needs to provide solutions, for example delivering something from the ground slab to the top roof tile that is airtight, that's got all the insulation, perhaps also got the acoustics completed so it's got obviously the glazing the installation external finish, internal finish all done."

Discussion:

The house building industry is undeniably driven by profit, but this can be achieved in many ways - through having less labour on site, less need for skilled labour, faster construction times (on occasion), even through proximity or greater reliability of procurement. Further down the priority list comes improved quality and sustainability issues but unless government or the buying public are demanding or in a position to demand increasing performance levels, which currently neither are to any great effect, profit would seem to be about making these immediate monetary savings and little else.

This lack of demand just adds to the enormity of the task of promoting innovation, and goes to show how necessary it is for all parties to understand the benefits of innovation and also to be benefitting directly from that innovation's adoption.

But what of the other 50% of the housing industry that is not controlled by the volume house builders? The fact that so few interviewees considered that half of the market as worthy of discussion was an interesting finding in itself and seemed to be due to a lack of knowledge more than a lack of interest. The irony here is that there is possibly more information sources relating to these other markets – social housing, HAs, council housing, custom build, self build, than there is about the volume house builders, but the answers given throughout were on the whole relating to that one sector and based on perceived knowledge**,** not on verifiable research.

The main conclusion drawn from the answers given in relation to the house builders is that there is an overwhelming tendency to focus on the monolithic 50% that possibly represents the market where there is the least interest in changing the ways in which housing is delivered. This is nevertheless an understandable policy, since the remaining 50% was seen as so fragmented that the possible gains, whilst potentially greater, might seem harder to win. This symbolizes the need for a system that can measure both the physical impact in terms of the quantities of concrete required, but also the effort and risk involved in achieving that particular outcome. Effectively this means comparing the small 'per property' gains associated with, for instance, convincing a volume house builder to replace a timber floor with a concrete floor, against the much larger per property gains to be had by convincing a small market player to build a complete concrete system house.

3.1.6 In what housing type would the benefits of concrete be most apparent? (strengths)

Findings:

In a final attempt to seek out the positives in what had become a fascinating but overwhelmingly critical set of perspectives on the role of concrete, this question was aiming to discover where the path of least resistance could be found - What housing type would represent the best fit with the benefits that concrete could offer? Interestingly, despite the concrete industry's understandable obsession with cracking the 'volume house builder nut', there was a broad consensus across all the sectors that their mainstream, speculative housing solution was not actually where the further use of concrete would be most beneficial. Regardless of whether the question was approached from the perspective of methods of construction, material benefits or social need, the answers given were always looking towards modular apartment style housing solutions (M.02.1).

"It would be multi-occupancy or multi-story".

In addition to a modular solution, the additional benefits of building above five stories was mentioned, making better use of the strength of ICF (Insulated Concrete Form) or precast concrete units, as were the cost benefits of concrete over steel for domestic developments, where spans were less than in commercial properties. (M.02.1)

"one of the drawbacks of ICF, is that it could be used if you need a sufficient tolerance to the reinforcement, it can only be a certain thickness which means it can go 5, 6 stories, so why do it for a two-storey home? It's just over-engineered".

Also mentioned as a positive for concrete in this form of housing was the reduced floor depths that were possible, with all the incremental benefits that brought regarding number of stairs, area of finishing materials, and on occasion, an additional floor within the height limits (UK Construction, 2010).

But these were just the constructional benefits. There was also a recognition of the compatibility between concrete solutions and the need for low cost dense urban living solutions where durability, low maintenance and low running costs are all prerequisites (Toogood, 2016, p. 9).

Discussion:

Putting all the observations together generated specific marketplaces where the majority of the individual criteria coincided to add strength to a package solution being collectively defined. The type of housing, aspects of which were almost universally described by those interviewed is effectively the model being pursued by the 'new entrants'. it would appear they are increasingly being seen, not least by the government, as representative of the intervention that was needed to solve our housing crisis, as they are open to new methods of construction and are working to a completely different financial model, often based on long term profits from rental incomes (P.10.1).

"the model for L&G [Legal & General], they are interested in two things, because they have got yours and my money for our pensions et cetera they've got to put it in a safe place and get a long-term return on it."

From the concrete industry's perspective, they also represent a potentially large, un-fragmented percentage of the remaining 50% of the housing market, and are coming from a sector of the construction industry where concrete in its many forms is a regularly used material solution.

3.1.7 Additional themes – Practices

Findings:

Whilst coding the data gathered, other themes emerged due in part to the semi structured nature of the interviews allowing the interviewees to stray into areas of particular interest to themselves. Business practices, and how they differed and whether they were seen as beneficial or detrimental to the issues being discussed was a theme that was recognised as cutting across the questions being asked and one that held some valuable insights into where the disconnects between the sectors might lie.

In terms of competition, for instance, not only were the interviewees' answers very 'speculative housing centric', there was very little differentiation made between those companies occupying that ground, whereas the volume house builders interviewed made numerous references to the competition between themselves. What was interesting here however was that these references were equally lacking in evidence. (P.03.1, P.03.3

"but return on capital is considerably lower than Taylor Woodrow and Persimmon, which causes angst to our board, and we can't quite understand why"

"If we offer something that the public don't put a value on, that costs us more than our immediate competitors who don't offer it, it just puts us in a worse position in terms of the return on capital."

"Well their profit is 15% whereas ours is just shy of 21% so our profit would be almost a third greater." INT "Why is that?" "More strategic land, maybe more cost efficient model. I don't know what their overhead structure is."

"what we want to do is be the best of the volume housebuilders, to look at what people like Berkeley Homes are doing and offer 90% of that, but not spend the money that is necessary to get right up there. But to put a gap between us and the other major housebuilders."

Whilst Berkeley Homes were generally seen as providing a superior product, Persimmon, whose profits were regarded as the highest amongst the volume house builders were seen as providing the poorest product. (E.02.1)

"I remember living in a dot and dab house once and drilling a hole and as I was drilling it all the dust was blowing out because there was a gale behind it. That was a Persimmon home. Never again."

The negative aspects of business practices were captured under terms such as 'complacency', 'misinformation', 'risk aversion' and the 'need for education'. Complacency was an issue that all sectors were in agreement over, in that it was recognized as being endemic throughout the housing industry. A lack of incentive, competition, oversight, interest in the bigger picture, interest in evidenced knowledge – all collectively painted a picture of an industry failing to come together to improve itself. (P.01.1), (M01.8), (M.02.7), (E.02.1)

INT "How long was it before windows came as metric?"
PA "They don't. The windows a still on imperial sizes."
INT "So why don't volume housebuilders go to a window manufacturer and say make them metric?"
PA "I wish I could answer that."

"We've got a lot of cowboys doing a lot of different things and that is a reflection of just wanting to get money without doing very much."

"It's also the way industry is set up, in terms of how people are employed and the fact that main contractors don't really know how to build. All they do is manage a bunch of subcontractors who have a bunch of subcontractors."

"The NHBC Foundation used to put a lot of money their [Zero Carbon Hub's] way and they did some very good work. Unfortunately, as I indicated earlier some of their good work is just sitting in documents and publications and there is no real follow-up, there's no action based plan to try and address some of the issues they managed to uncover."

"The industry doesn't have to comply - let's put it this way, the way the building regulations are complied with in this country is full of cracks."

3.1.8 Additional themes – Agendas

Findings:

Leading on from the comments made about the range of business practices that existed within the industry was another layer of information relating to the mostly perceived understanding of why those

businesses chose to or were able to operate in such a way. In contrast to this was the information gained from the concrete industry itself about its own agenda and how it saw its role going forwards.

There was a range of opinions within the concrete industry reflecting the conflicts felt within different departments championing their own agendas, such as over the importance of sustainability as a leading promotional message, the potential of in-house land assets and how that ought to be realised, and the need to engage other sectors by becoming an active participant – even a housing provider - rather than remaining a 'dumb supplier' of concrete. Even more fundamental, and central to the brief originally provided, was the importance of the housing market in relation to other markets for concrete, with one of its main appeals being its counter cyclical demand. (M.01.2), (M.01.3), (M.01.5), (M.02.1)

"If you look at Tarmac's exposure to the different sectors of construction, housing is very significant and it's not just in terms of size, but it's significant because it goes on a different demand cycle to most of the other construction sectors."

"we restore it [quarry sites] and then traditionally building material companies like ourselves have just sold it to balance and make the budget at the end of the year so you just get agricultural land values for it so two grand and acre." "Volume housebuilders, they build out houses to realise the value of the land, so is it the land that's more valuable than the concrete? It's not the hard core materials, but maybe it's a land play as much as it is a materials play, like it or not."

"I think if you're a partner more than just trying to say that you're innovating you're actually understanding what the customer wants and then your innovation's driven by opportunity and I think that's what we miss out on."

"because we are trying to defend in that marketplace, the fact that it's a closed door and habits die hard is something that works for us. So to protect the masonry side of things there are lots of our perception that there are lots of housebuilders who are wanting the information to justify the status quo and so it's important that we provide that information because they're being bombarded with information from elsewhere from the timber sector and from the offsite sector saying change."

Opinions from other sectors were also collected and compared to show how much these agendas can be in conflict without there being any real appreciation of the differences to be bridged.

Architects:

"Cross laminated timber? It's an architect's dream" (M.01.4)

"Which is why the Concrete Centre invested quite a lot of effort on trying to win the architect's mind conceptually to using visual concrete because once you've done that and that's embedded as a fundamental architectural concept for the whole project, you've won the project for concrete." (M.02.1)

"if I am confident that I can get a similar performance using a variety of materials, why am I making that decision early and not leaving that down to cost and procurement later on?" (M.02.5)

Government:

"you want to be pushing - for the regulations to be pushing our attempts to make people improve. Also not moving so quickly that it leaves people behind. But you kind of want people to know there is a direction of travel that benefits and encourages the innovators to actually start going over and above that minimum ceiling and that will actually give them a strong foundation as the market moves on." (M.01.1)

"It was interesting how that was such a U-turn on sustainability by the government in terms of standards of insulation, standards of all things that they put in place and then they dropped that when they realised the housebuilders were saying it was making it difficult to meet affordability targets" (M.01.4)

"It is a political issue and it's treated as a political football kicked from one end to the other".
INT: *"That's the problem, because it is something they're never going to see a quick return for within a five-year period to take the glory for".*
"Absolutely. I think that's why it has to go cross-party. If it doesn't go cross party it will never work." (M.01.6)

"What I've seen is that the Government and the HBF (House Builders' Federation) have actually concocted a way to calculate the number of houses being built to allow the Government to claim their million homes." (M.01.7)

"But they [ministers] are constantly changing. You can think 'right we have told them that', and then the next thing you know there's a new minister in charge who hasn't got a clue." (M.02.3)

"Homebuilders Federation, the Federation of Master Builders, NHBC. They all recognise that these problems are out there but they don't have to do anything about it because they have successfully persuaded the Government not to regulate." (E.02.1)

"The home information pack. HIP. Another governmental disaster. Thousands of people trained up and spent money on courses. It was criminal and they got away with it. I think at the end of the day the industry and I include estate agents in that, just didn't want to know." (E.02.1)

Volume House Builders:

"If you think of a kitchen designed for wheelchair use and a bathroom designed for wheelchair use you then say to a non-disabled person look this this million and a half house you will really love it - it's huge and look at that shit kitchen. They are not aspirational." (P.03.1)

"You see to my mind concrete has huge uses in the housing industry but not necessarily to any great extent in two-story houses in the envelope. The size of houses and the best use of space is possibly more important than working to someone's module and how big my block is going to be." (P.03.1)

"I don't know what the delivery times are on concrete but obviously from our end when they get planning permission they like to be on site at midnight if not they've gone on a few days before and risked it. They don't want to say hey we've got our consent, now place an order." (P.03.1)

Social Housing:

"In many councils, not all councils, they are risk averse. It's all about audit trails, not getting into trouble, covering your back so they are not inherently entrepreneurial and they're not encourage to be, so if they pull something off they say you were lucky, whereas if it goes wrong you lose your job." (P.03.5)

"when I sat last year with virtually every local authority in the Midlands when we came to give Sir Michael Lyons an overview of his report, and one of his additional sources was local authorities building houses again, as well as one or two other ideas, I didn't see much, I looked around the room and I didn't see many local authorities buying into that. They haven't got the expertise." (P.03.3)

"The challenge we have is to deliver it on a cost neutral basis to what we are delivering now, the old code 4 standard, brick and block. So no it's not happening. I've spoken to the Beattie Passive Trust and asked how much do you expect me to pay for your solution above traditional build and they said 30% but it's a good investment. It's not going to happen." (P.03.8)

"The timber frame guys with the offsite manufacture said, because we pursue the Nottingham pound so we go for local labour to reinvest our wages locally, and I said I wanted our joiners to put that up and they said no." (P.03.8)

"The last recession what happened to the construction industry? It collapsed, first of all the first one to go but you look at social housing, it kept going. We didn't stop. The spec builders did so you look at us - we are smaller than the big boys but we are constant." (P.03.8)

Discussion:

These two themes captured a different aspect of the information held within the transcripts, as it was focusing on how and why the industry operates in the way it does rather than the more practical influences anticipated by the original line of questioning. Much of the insight that this process was hoping to uncover is held within these two sections, as the answers given were more broadly based upon experiences that were specific to each sector and less likely to be commonly held opinions. There did, nevertheless seem to be a similar reliance upon perceived knowledge over evidenced knowledge. As a very basic test of this, a count was done of the instances of "I think" over those of "I know" was done across all the interviews, giving a ratio of 10:1 (679:70), rising to 20:1 (389:22) when restricted to these last two themes of practices and agendas.

3.1.9 Conclusions from the industry interviews

These observations represent a comprehensive analysis of the information held within the interview data. Many of the findings corroborate information gathered through the literature search, but there are also some insights, specifically from the private sector interviews, and to some extent, the government bodies that could be persuaded to participate, into areas that are less openly discussed or accessible through official publications. It was in the comments made about these sectors in particular that the differences between perceptions and reality were most pronounced, since

perceptions, not surprisingly, take the place of the factual information when that information is hard to come by.

Other than this, there was rather more consensus than expected, although not necessarily any more factually dependable for this, and more likely to represent a consensus of perceptions. Neither was there much evidence that where there was a mutually agreed picture, it was being acted upon in any clear way. What emerges in fact is an industry that on the whole understands its own internal issues, sometimes the bigger picture issues too, but seems no less able to deal with them as a collective whole.

Specifically from the concrete industry's perspective, there was a wealth of information gathered from these interviews that shed light on their markets and how to address them more effectively. Interestingly, for example, unlike the interviewees from the concrete industry, very few of the other interviewees raised public perception of concrete as a negative. Their concerns were far more practically based, and not generally issues that the concrete industry had historically prioritised. More often than not these findings have led to the need for further research, in this case into a breakdown of the public's true perceptions and the construction industry's true concerns.

Part of that further research was in the re-examining of the interview responses through the lens of 'working practices' and 'agendas' to get a better understanding of what was behind the answers provided to these key questions. There were definitely some areas where mixed messages existed between sectors that were trying to communicate at a business level, but there were also as many examples of where at a fundamental level 'the right thing to do' was quite clearly understood on all sides, but for whatever reason it was still failing to be enacted. To what extent this was due to a lack of detailed knowledge, or a genuine inability to follow through with these changes or just due to a lack of motivation to make the first move was what now needed to be investigated.

The need for this further analysis tied in with a separate exercise carried out during the period of the interviews, looking at the many reports and government white papers relating to the housing industry that have been published over the years. What was being looked for here, and discussed in detail next, was whether these reports would reflect a similar underlying theme, of an industry that needs to reform, become more efficient, adopt new technologies and better serve its customers, but is failing to rise to the challenge. The story that unfolded in these reports also helped to fill the gap left by those government bodies that were unwilling to be interviewed, and helped shed more light on the possible causes for this inertia.

There was a danger at this stage of the research of overlooking the full extent of the findings that had been made and the further questions that those findings had raised, which in turn have led to further research into these less understood areas. Those key findings have therefore been listed here:

The housing industry operates in silos with little meaningful communication or co-operation between the sectors defined at the outset, outside the promotional literature made available.

All sectors nevertheless have strongly held beliefs about how the other sectors operate and the reasons behind their business models

There was relatively little variance between the sectors over these beliefs, but equally little evidence offered as proof of their veracity.

The availability and reliability of factual information varied considerably between the sectors as did the importance put on gathering that information by those interviewed.

The consensus opinion about the general public was that their opinions were understood, but of minor relevance to the debate about housing needs.

The consensus opinion about the government's role was that it was important, but lacking in vision and consistency.

The root cause of the industry's reluctance to consider innovations appeared to be the level of individual risk involved in the face of uncertainly, with only a possible collective gain at some point in the future.

3.2 The Government Reviews

In October 2016 the Farmer Review was published, the last in a long line of government reports on the state of our construction industry stretching back to 1934. Over the intervening years there have been over twenty major reports and many more subsidiary papers (Figure 3-4), often lamenting the lack of attention paid to the preceding report, whilst all making similar observations, and suggesting similar remedies. Reading them all with the benefit of hindsight, this becomes quite apparent, as does the fact that not one of them has made any attempt to question why it is that they have all failed to deliver to the degrees expected. If they had, the recommendations might have differed over the past 80 years, but on the quantifiable measures used such as the proposed increases in productivity, invariably put as a percentage increase over a carefully calculated time period (Egan, 1998, p. 16), (HM Government, 2013, p. 5), (HM Government, 2017, p. 7), they have without a doubt, failed to deliver.

This systematic review of government white papers relevant to the housing industry was to some extent an extension of the literature review, recognized as a necessary undertaking in response to the limited number of interviews that could be arranged in this sector. The analysis of these papers however, went beyond a review of their intent and looked also at their actual impact and whether there were any underlying reasons for why this was consistently less than intended. Was it also due to a lack of understanding of how to motivate the sectors that were being addressed, and if so, was this tendency to prescribe solutions that would benefit the industry as a whole without recognizing the need for individual benefits still prevalent in the Farmer Review's proposals?

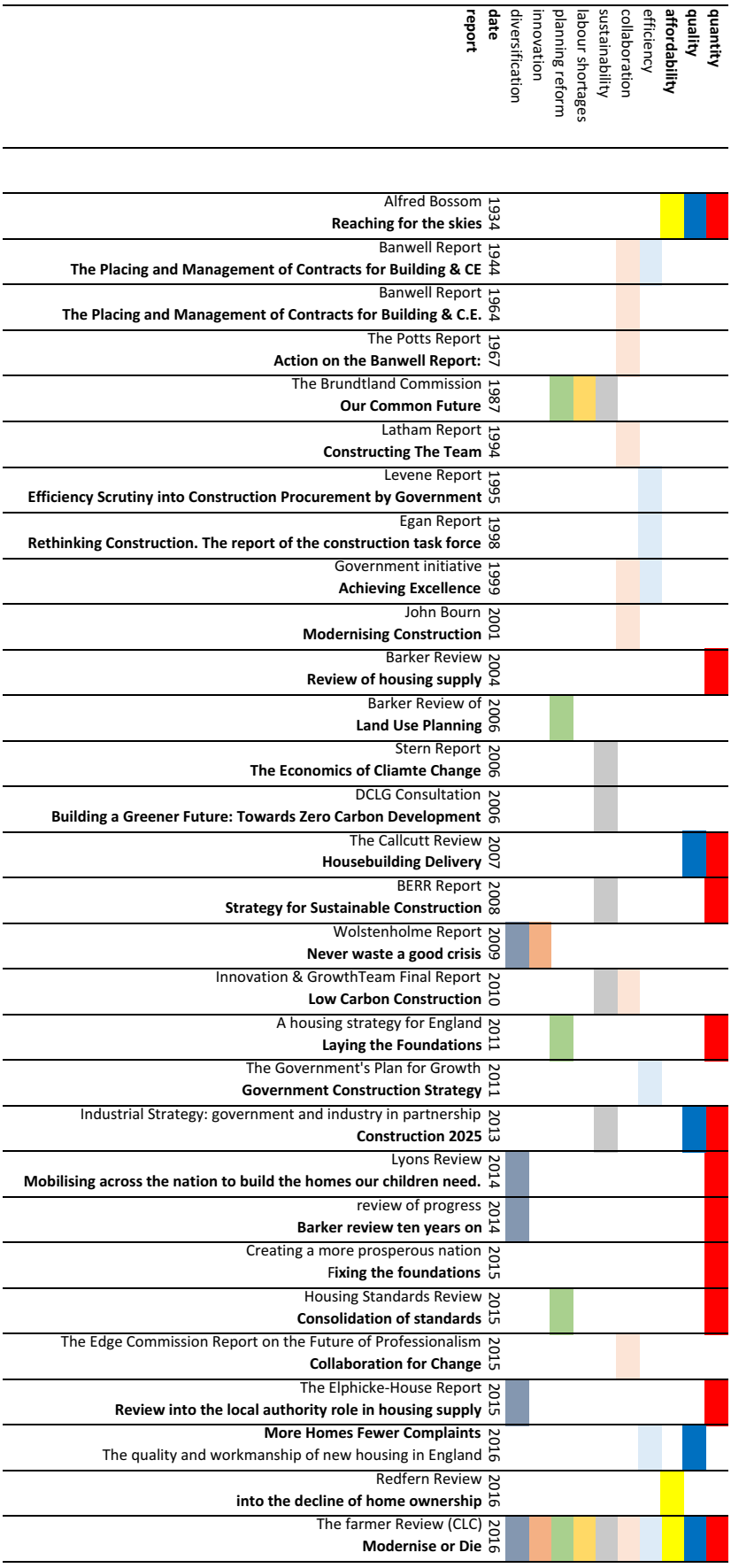


Figure 3-4 breakdown of objectives of government reviews of the construction industry

This table shows how the Farmer Review has attempted to take a more holistic view of the problems facing the housing industry. It also differs from the many preceding reviews in one other respect, in that its title, 'Modernise or Die' suggests that the house building industry now finds itself very much at the end of the road, and this is spelt out in blunt language, heralding this as the last in a long line of reports in more ways than one:

"The prognosis for the industry, if action is not taken quickly, is that it will become seriously debilitated. It is facing challenges that have not been seen before, which create an absolute imperative for change. Previous calls to arms have not been acted on by the industry or its clients at any real scale and somehow the industry has continued to 'muddle through'" (Farmer 2016, p.8)

The ongoing reality is that there is no obvious reason for the industry to believe it will not 'continue to muddle through' for many years to come. The housing industry could potentially continue to invent more and more ways to perpetuate the status quo through the power of vested interests, through a very real fear of the risk associated with change, and through credit in its many forms - as it has been doing for many decades now. The report's claim that *"we could see a 20-25% decline in the available labour force within a decade"* and that *"this scenario has never been faced by UK construction before"* is not altogether true, as our first major drive for prefabricated housing was due to the far higher decline in our available labour force after the Second World War. On that occasion, we did more than just muddle through, building new homes at a rate that we have never since emulated, but we still reverted to conventional methods of construction as soon as that labour became available again (Matthews, 2015, p. 46). Whilst it is dangerous to look for direct comparisons across these time scales, it would be wrong not to analyse the reasons behind these past events. Throughout our postwar history we have been wrestling with a concoction of issues that define our housing solutions today, and without a full understanding of those issues, it is unlikely that we will be able to have any influence over the housing industry's future.

Eighty years is a long time to be making the same claims to no effect, but that is the reality of what has happened, or not happened, since Alfred Bossom's 'Reaching for the Skies' report of 1934. On his return from America, Alfred Bossom *"saw an adversarial and wasteful industry in which construction took too long, was too expensive and was not satisfactory for its clients".* He observed that the construction industry was just an industry like any other, and that if it were to adopt more organized, collaborative working arrangements this would lead to increased productivity, profits, investment and wages.

To take some quotes from Mark Farmer, eighty two years later,

"The construction industry is chronically underinvested due to a combination of economic, market and behavioural factors."(Farmer, 2016, p. 10)

"there appears to be very low usage of more collaborative and integrated design, procurement and construction delivery models"(Farmer, 2016, p. 24)

"One of the critical features of the industry is its extremely poor level of productivity."(Farmer, 2016, p. 13)

"Low profitability is a long standing problem for the industry."(Farmer, 2016, p. 23)

During the intervening years there have been numerous reports, commissioned by either the government of the day or one of many industry funded advisory groups, many of which have continued to spell out the same concerns. Most reports make reference to at least the preceding report, if only to drive home the fact that not enough progress has been made, but rarely do they ask the question why this is so. The emphasis is on how this time there is no room for choice, no option but to enact the report's recommendations immediately and in full. The aims of the more significant reports range from contractual inefficiencies (Latham, 1994) to the lack of skills training (Egan, 1998), the dependency on traditional methods of construction (HM Government, 2013), the need to respond to climate change (Stern, 2006), and the failure to diversify to meet volume targets for housing (Lyons, 2014), all of which are picked up in the Farmer Report under its key headings defining the industry's ten '*critical symptoms of failure and poor performance*'(Farmer, 2016, p. 7). Aside from acting as a synopsis for the past 80 years' reports, the Farmer Report differs from those that have gone before in the bluntness of its message, analogised as the diagnosis of a dying patient. But the diagnoses themselves still contain little that hasn't been said before, and still fail to go to the root of the problems that the industry as a whole now recognises as real, but still seems unable to confront.

These reports' underlying opinions of the construction industry corroborate Bossom's findings that it is 'ineffective', 'adversarial', 'fragmented' and 'incapable of delivering for its customers'. Comparisons are often made between the working methods and productivity levels in other industries and those of the construction industry. Even Alfred Bossom was raising these issues, but we now have over 50 years of statistics to bear this out, as Farmer conveys, and the solution given is that the construction industry needs to learn from these more successful innovative industries by adopting modern methods of construction, less adversarial working relationships and by being more driven by its customers' needs. Whilst this may be a fair representation of the problem, and also constitute a reasonable set of solutions, it still fails to ask or understand why the construction industry might be different to manufacturing industries, but rather chooses to accept that it's just the 'lazy child' that needs to try harder:

"If you buy a new car, you expect it to have been built in a factory to exacting standards, to be delivered on time, to an agreed price and to a predetermined quality. This needs to happen more in construction, so that the investors, developers or building owners hiring construction firms increasingly dictate the use of modern methods of delivery and invest appropriately in the skills agenda to grow this part of the industry. There are more similarities between manufacturing and construction than many people are led to believe and this perception needs to change, starting in the housing market." Mark Farmer (*Farmer review recommends prefab push and CITB overhaul Those Farmer Recommendations In Full*, 2016)

Farmer puts forward that there clearly are similarities with manufacturing industries, and that the housing industry needs more skilled labour. He also suggests it is true that offsite manufacturing would appeal more to a younger labour force than traditional on site laboring, but none of this is new knowledge, and those searching for solutions it is suggested here, should be looking at why these changes have not been adopted rather than continuing to find more and more reasons why they should. Taking the labour issue as an example, the construction industry is an unappealing career choice because of many factors, the symptoms of which can be seen in low investment, high self employment and systemic fragmentation. But the underlying cause of all these ills is increasingly seen as our cyclical boom and bust economy and the exaggerated impact this has on construction.

"Many of the current behaviours in the industry … reflect the history of cyclical boom and bust, with its inevitable risk to those who get the timing of their investments wrong."(Lyons 2014, p.35)

If this represents a high risk for businesses, it's an even higher risk for those employed within it.

"The wide-scale incidence of self-employment is a reflection of a desire for flexibility, with little confidence in long-term employment prospects and a feeling that opportunism around inflated market labour rates in booms offset risks of low utilization, poor wages and no employment benefits in a downturn.."(Farmer 2016, p.27)

Suggesting therefore that modern methods of construction and off site manufacturing are the solution is failing to recognise the root causes behind our labour shortages, as the UK has a proven record of withdrawing from off-site manufacturing running up to every recession since the Second World War (London Assembly Planning Committee 2017, p.8).

"The cyclicality of construction demand is difficult enough to navigate for low overhead flexible businesses, but that fluctuation is amplified if you have not even managed to secure client confidence in a new product or approach [OSM] which has been invested in and has to compete with more traditional solutions" (Farmer 2016, p.35)

Callcutt, in his 2007 Review of Housebuilding Delivery, gave a more nuanced view of the housing industry and how it differed from other manufacturing industries, recognizing that *"the 'current trader' business model of housebuilding is very different from manufacturing, with quite distinctive opportunities and risks"* (Callcutt, 2007, p. 29).

A full synopsis of these government white papers is given in Appendix F Government White Papers but the focus here is less on their recommendations as it is on the reasons why they have not been addressed. To this end the quotes provided are to show the extent to which this is true, which still leaves the question of why it is that change has proved so difficult to enact within the house building industry. The Farmer Review, as stated earlier, does provide a thorough synopsis of these previous reports' findings, and does spell out in some detail what needs to happen now to prevent an imminent collapse. These recommendations are discussed in section 3.2.1 alongside the symptoms that they are aiming to address, but it is an understanding of the root causes behind these that is of most interest here. The approach taken has been to try to put these symptoms into a hierarchy that can begin to suggest where the fundamental problems lie. Farmer suggests that there are ten in total to be addressed and that they stem from three root causes, which he defines as a lack of a strategic

framework, a non alignment of interests across industry and the industry adopting a 'survivalist shape'. Even at this level, however, it is possible to assign a hierarchy to Farmer's 'root causes' (Figure 3-5), as the adoption of a survivalist shape, for instance, is clearly a response to some other factor at work.

Figure 3-5 Farmer's 10 symptoms (Farmer 2016, p.7)

Figure 3-6 suggests how the many symptoms defined sit within a hierarchy of causes and consequences, and could be shown to not only stem from one fundamental root cause, but also all result in the same manifestation, that of inaction.

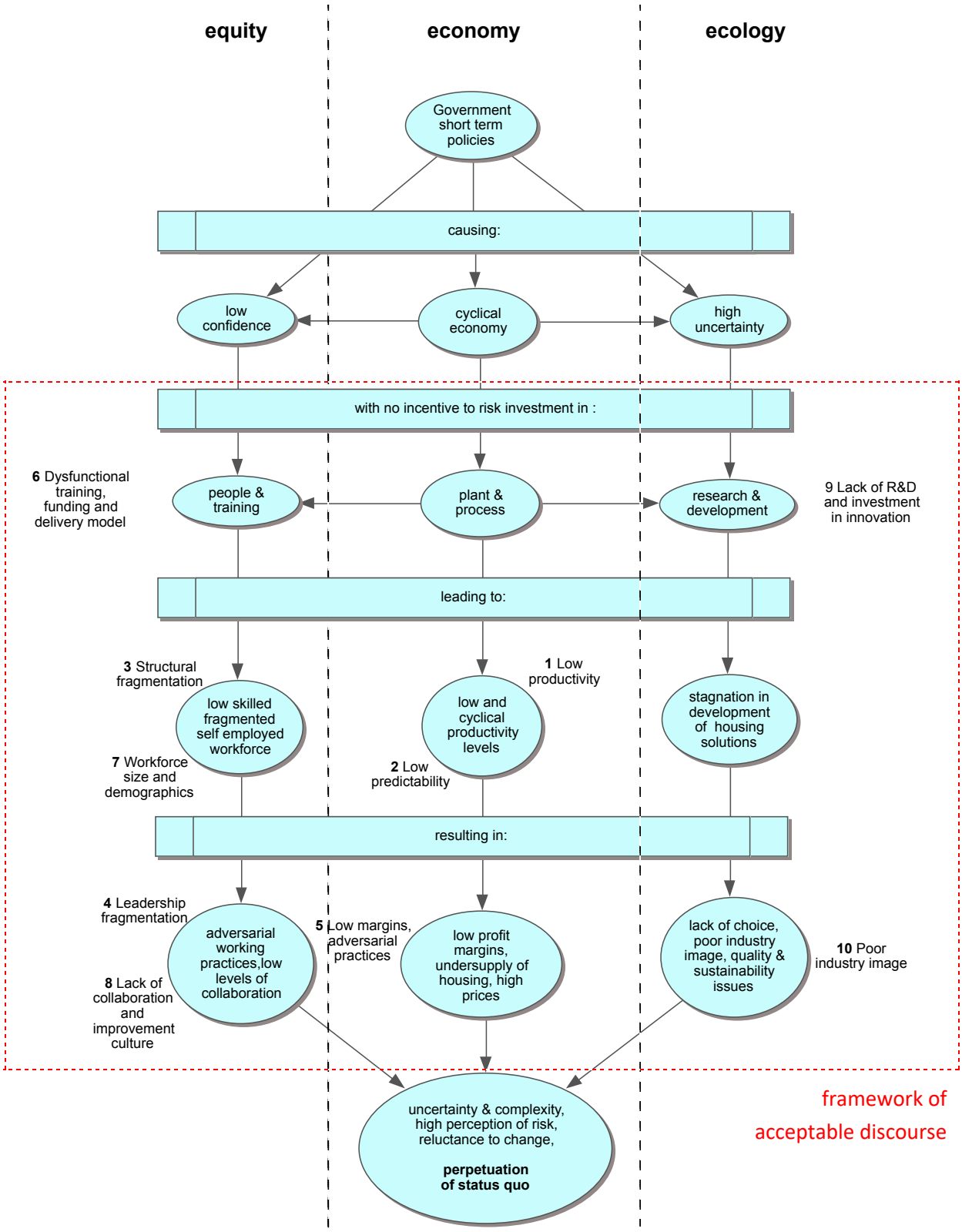


Figure 3-6 Suggested root causes of inaction, linked to Farmer's ten symptoms of poor performance.

Whilst the Farmer Review sets out how the industry must deal with these ten symptoms, the proposition made here is that the root causes are the critical factor, and that they must either be addressed or accepted, but they cannot be ignored. Eighty years of white papers failing to resolve the issues they set out to address would suggest that not only are the root causes a constant in these equations, but that they will continue to be so, and should possibly be accepted as factors 'outside the bubble' that cannot be influenced. Re-evaluating the Farmer Review on this basis leads to some interesting conclusions, as there is an element of this pessimism / realism to be found in many of the review's findings, and this is very much the approach that this research suggests should form the basis of the decision making model that is being developed – i.e. to focus on the areas where effecting a change is at least a possibility, and treat those that are outside this sphere of influence as realities or constants, no matter how undesirable that may be.

Fundamental to this approach is accepting that our form of government results in a number of predictable outcomes that would require systemic changes to our political system to influence. This is not a political discourse, and these statements are therefore outside the scope of this research, but in principle, as already suggested in Section 1.4.2, they are accepted realities and also areas where there is little likelihood of change occurring through any industry scale intervention:

• The need for governments to be impartial when promoting a specific option within any sector of the economy results in an inability to dictate the direction of travel for any meaningful period of time (Thompson, 2016, p. 5).

• Bold, easy to understand policy directions, such as New Towns, off-site manufacturing, the Localism Bill, etc. will tend to be used to placate the voting public so as to avoid confronting the underlying issues (B. W. Mann, 2017).

• The reality of the public's voting habits means that collective benefits, whilst easy to incorporate into manifesto pledges, do not necessarily guarantee electoral success.

• Our democratic five year cycle encourages short term policies, that to some extent accentuate the economic conditions that lead to our boom and bust economy (HM Government 2015, p.512).

In addition to this, specific political parties can be expected to behave in their own predictable manners, and these too need to be taken into account.

The proposal now is to follow the framework of the Farmer Review, and to re-assess its ten defined symptoms (Figure 3-5) for what they are – symptoms, not causes. In doing this a hierarchy begins to emerge of causes and consequences alongside a better understanding of which can realistically be influenced and which should be seen as unchangeable aspects of the industry, based on eighty years of Government White Paper evidence. By way of example, the volume house builders are businesses and have always behaved as such. Their terms of reference are very clear and do not involve solving the nation's housing crisis through the adoption of new innovative solutions that, whilst they might increase the quality of their product or their output potential will not necessarily grow their profit margins. To this day, governments still seem to find the speculative house builders' business model difficult to come to terms with (Smulian, 2016). Again, the Farmer Review begins to recognize these

truths and there is evidence in its recommendations of how this particular issue should be worked around rather than tackled head on.

"More tenure diversity would immediately imply different supply chain and delivery models that may better promote innovation. In time, this may in turn influence core housebuilder delivery models but it is considered unlikely that large scale innovation will start in the volume housebuilder market." (Farmer, 2016, p. 9)

The following assessment of the Farmer Review is therefore undertaken to establish to what extent its recommendations do accept that whilst there are some areas where influence can be had, there are others where alternative solutions need to be found. This thorough analysis is necessary as it is attempting to prove that the decision making process that is needed to find a way past the barriers to innovation - and on which this research is predicated - requires a deeper level of understanding of those barriers than this or any of the preceding reports have expressly realized.

3.2.1 Analysis of The Farmer Review

The Farmer Review starts out by commenting on the need to step outside the boundaries of the construction industry to pick up on the many influencing factors that impact upon it. This recognition of the need to take a far more holistic approach is no doubt a reflection to some extent on the failure of previous reviews' piecemeal approaches to result in any meaningful change. To that effect the review encompasses much of what has been focused on before under the ten headings that represent the 'prognosis of the patient'. These are now discussed in turn, with all quotes taken from the Farmer Review, suggesting in each case how the underlying causes, highlighted in Figure 3-6 are not being addressed.

Low Productivity

Productivity has increased substantially in all other industries other than agriculture in the past 50 years whereas in construction it has fallen. Previous reports have reprimanded the industry for this and suggested that it should behave more like other industries, by adopting more automated processes (Egan 1998, p.11). A more profitable approach might be to look at how the construction industry differs from these other examples and to understand whether or not it can be automated to the same extent. The labour element is clearly a component in the low productivity measures, as it is with agricultural industries, but the cyclical economy also impacts on this more so than in other industries with unskilled labour having to be brought on line during boom periods with a consequential drop in productivity (Farmer, 2016, p. 14). A move to off-site manufacturing, the standardization of components and also of the finished product would all move the housing industry in this direction, but the root cause of many of the issues that have led to the industry's current low productivity levels, i.e. the cyclical economy and the exaggerated impact that has on housebuilding, will still beset the industry and potentially prevent off-site manufacturing becoming fully established, as in the past.

[Low productivity tied to the cyclical economy]

Poor Predictability

Two fundamental differences between the housing industry and the other manufacturing industries with which it is so often compared are the un-predictabilities of both site conditions and the weather. These variables make the manufacturing of houses by conventional means a very different proposition to any factory based manufacturing process. But statistics for low against high rise construction show that another factor might also be at play, as the successful on-time completion rates for low rise, much of which is housing, are far higher than for high rise (Farmer, 2016, p. 16). Poor quality of work, budget overspends and missed completion dates are more often than not put down to skills shortages, the effects of which are more pronounced in complex constructions than in conventional housing where temporary low skilled labour can be brought in when necessary. So the root cause, it is being suggested, beyond the un-predictabilities of site conditions and the weather, is the cyclical economy and the associated problems of long term investment, employment and training of its workforce. If the hope is that off-site manufacturing will reduce the problems associated with poor predictability, it will also need to address the underlying issue of a cyclical economy.

[Poor predictability tied to the cyclical economy]

Structural Fragmentation

The construction industry is known for its lack of collaboration and complex transactional processes. To some extent this is due to the fact that construction is a complex multi-disciplinary process, but it is exacerbated by the high levels of self employment that adds to the introverted nature of its component parts and poor levels of communication between them. This long tail of SMEs making up a large albeit declining proportion of the housing industry (Communities and Local Government Committee, 2016, p. 13) has resulted in the UK housing market being hard to penetrate by overseas markets, keeping innovative European methods of construction at bay (Farmer, 2016, p. 17). A culture of sub-contracting has also increased the complexity of the supply chain and resulted in layers of process management that add to the overall costs and inefficiencies. This is a good example of where the 'survivalist shape' of the industry can be seen to emerge, and also where the Farmer Review recognizes that there are alternatives to correcting these now endemic practices. Laing O'Rourke is used as an example of the 'New Entrants' who, rather than trying to improve the existing 'accepted model', are taking this alternative course of action, where they can avoid this fragmentation by setting up and controlling their own supply chains, and by establishing their own vertically integrated markets around off site manufacturing. This, it is suggested here, effectively reduces the company's risk by removing the uncontrollable contractual elements of the building process. What this doesn't remove, however, is the risk associated with a cyclical economy, and by investing in an employed labour force, not to mention the considerable off-site manufacturing plant costs, that risk could, if anything increase. The issue of maintaining a regular throughput during a recessionary period therefore remains the unresolved factor in the equation.

[Fragmentation endemic and tied to the cyclical economy]

Leadership Fragmentation

The degree to which the industry is operating in pockets of self interest is symbolized by the plethora of advisory bodies and lobby groups operating within the space between industry, the government and the public, often covering very similar ground (Section 6.1.1). Add to these the umbrella groups that are attempting to gain more relevance by connecting these bodies in differing permutations, and the picture becomes one of an almost complicit fragmentation, with no real leadership to bring these efforts together. The Farmer Review recognizes the need for these bodies to amalgamate under a common goal (Farmer, 2016, p. 20), but seems doubtful of the likelihood of this ever happening, as the industry is effectively in competition with its constituent parts. Again, there is reference to the modernization that is needed coming from 'outside the traditional housebuilder approach' with the 'New Entrants', forging an alternative path being a more promising scenario than attempting to reform the industry from within. The government, on the other hand, whilst it is accepted that it does want to drive reform, is seen as ineffective, both because of the limited influence it has over the wider construction industry, with public sector works put at only 25%, but also because its own procurement system is as fragmented as the industry itself. Clearly the industry is struggling to co-ordinate its thinking due to the incredible complexity of its constitution, and to accuse it of lethargy, as this report does, is possibly missing a fundamental point, in that it is more likely this co-ordination that has become the barrier to change, not the openness to change itself. If this is the case, the reason why the New Entrants are seen as more likely to embrace change might not be because they are less complacent, but because they have developed a simpler model that allows them to embrace change without the risk that comes with having to co-ordinate such a complex body of participants. The proposition being made here is that with complexity comes risk, and with risk comes an inertia to change, which is misconstrued by this and the many preceding reports as disinterest, lethargy and complacency.

[fragmentation of control increases the risk associated with change to unviable levels]

Low Industry Margins, Adversarial Pricing Models & Financial Fragility

The review paints a picture of an adversarial business model with many non value added tiers within a supply chain that supplements its low profit margins by extending payment terms to enhance cash flow. Operating margins are low and cyclical along with the economy which tends to promote opportunism when either material or labour supplies are limited. Competitive tendering has long been the norm within the industry, but this is not the first review to suggest that the industry needs to find a more collaborative way of working that encourages repeat business within the supply chain and promotes a more stable learning process, and as a consequence more profitable outcomes. Again, the survivalist shape can be seen in the many ways the industry has learnt to play the adversarial system rather than replace it, with *"whoever wins a project often being the party that has made the largest mistake in pricing it"* becoming normal procedure. The choice, as suggested in the previous sections, is to either improve the system that exists or bypass the issues that are now systemic and too entrenched to effect. The Farmer Review itself accepts that:

"The reality is that many clients, especially in the real estate development sector, are simply conditioned to operating in an adversarial way with industry and do not see a case to move to more collaborative and integrated approaches for fear that a lack of commercial tension will impact their own financial outcomes."

If this is the case, and to replace the long-standing system of competitive tendering is more a pipe dream than a realistic goal, the only alternative is to create the non-adversarial environment by taking as much of the operation in house as possible and thereby control the production process from within. Again, this is implicitly described in the Farmer Review as the new entrants' business model, without wanting to admit that the current housing industry's model is close to irreparable.

[adversarial model cannot be changed by the industry alone and requires government intervention]

A Dysfunctional Training, Funding & Delivery Model

Training and skills development within the industry is funded by a levy raised by the CITB (Construction Industry Training Board) on all its member employers and redistributed through initiatives and grants. The housing industry profile is one with a long tail, where a large percentage of housing, and that using the most innovative methods of construction, is delivered by small SMEs who the review finds do not benefit proportionally from the grant system. To some extent this is due to small SMEs not having the resources to apply for the funding in the first place, but there is also a feeling amongst these companies that training is not cost effective because of the tendency of employees to move on once qualified, or drop out altogether during recessions. Overall, the level of training offered by construction industry employers is the second lowest of all industry sectors (Farmer, 2016, p. 25), and this feeds into the sense of low confidence and poor industry image amongst the general public. Systemic changes are needed to rectify these problems, and they have been called for on many occasions (Ball, Cowley and Slaughter, 2005) and again in this review. The situation has no doubt been

"exacerbated by a widespread and possibly misplaced fixation in this country with progressing to Higher Education (HE) rather than a fuller consideration of more apprentice based or vocational courses" (Farmer, 2016, p. 28),

but it is suggested here that the issues are even more deep seated than this, and find their way back to our cyclical economy. Whilst a redistribution of the grant funding from the CITB will help promote innovation within the sectors it is most likely to be embraced, this does not go to the root causes that have led to this lack of uptake in skills training. The SMEs still have to feel confident that the training is worth investing in, which they will not if they feel their individual risk will only benefit the collective whole. This is emerging as a key issue – the need for the reward received to be directly related to the risk taken. Too often in a complex structure such as the housing industry, the very real risks taken by small individual companies when attempting to adopt new innovative solutions only show returns if others in the supply chain also agree to participate, and even then, tend to be distributed disproportionately widely for the individual risk taken. It is these concerns that this research contends are behind the reluctance or even inability to participate in the innovation process.

"There is often an unfair burden placed lower in the supply chain to train. It is clear though that despite the financial risk, some parts of the supply chain have actively embraced long-term thinking around skills and training. This seems to be often led by a non-financially motivated sense of collective responsibility to do the right thing and maintain a sustainable level of resources for the industry in the future. Unfortunately, this is not the industry-wide approach and is not inherently scalable." (Farmer, 2016, p. 28)

The reality of the impact of not addressing a fair sharing of risk is investigated further in Section 6.3.2 where even governments are shown to be failing to reap the necessary rewards for their efforts that would enable them to continue to prepare the environment for entrepreneurial development.

[disproportionate individual risk for uncertain and shared reward stifles the adoption of innovations]

Workforce Size & Demographics

This perhaps more than anything else shows the extent to which macro-economic events can and will influence the way in which the housing industry has to evolve. There is nothing unforeseen about this looming crisis, although our departure from the EU will no doubt exacerbate the situation, at least in the short term:

"Perhaps most worrying of all of the symptoms identified in this section, is the fact that the pure physical capacity of the construction industry to deliver for its clients appears to be in serious long-term decline."

The impact that an undersized workforce will have on any decision making process regarding how to deliver housing will effectively dwarf all other considerations in our short to medium term future. The government's planned expansion and its demands on skilled labour are themselves dwarfed by the replacement demands caused by retirement figures that have been apparent for over twenty years.

"A combination of an ageing workforce, low levels of new and an overlay of deep and recurring recessions which induce accelerated shrinkage, now threatens the very sustainability of the industry. It is potentially in danger of becoming unfit for purpose."

Unlike the decline of many other UK industries, construction cannot easily be supplemented by imports, resulting in the dependence on migrant labour, particularly in London. It is this belated realization that is driving the push for off-site manufacturing more than its many other benefits, especially because of the problem of regional hotspots such as London where completed units can be 'shipped in' from elsewhere (although it should be remembered that elsewhere could also be overseas once the concept of modular housing has been proven and accepted). The scale of this problem is reflected in the Farmer Review's lack of answers on this point beyond saying that the government's house building targets "*must now surely be seen as increasingly unrealistic*". In the longer term, it must be assumed that the numbers going into the industry will increase as the demand pushes up wages in the sector, but this leads on to what is already an inconvenient truth about the cost of our

current housing solutions: The reason why the volume house builders are reluctant to increase their output is because they already supply enough - or to be more accurate, just less than enough - housing for the market that can afford to buy their product. The need is for housing that is affordable below this price point, and that is the what has to be delivered with a shrinking workforce that will demand higher wages to encourage it to grow. Basic macro-economics will not only dictate how we build, but what we build, and would suggest that it cannot be more of the same.

[our capacity to service the demand for housing will ultimately dictate what we build and how we build it – but what we can afford to buy will dictate its price point]

Lack of Collaboration & Improvement Culture

"The construction industry's 'collaboration problem' is at the root of its change inertia."

This comes back to the adversarial nature of business transactions and contractual agreements within the supply chain, and how they prevent the cross fertilization of ideas and knowledge. BIM provides both an analogy and a possible solution to this in that it requires all participants to be on board before its real benefits can be appreciated by any one individual or by the project as a whole. Its presence as a data management tool also opens up lines of communication in a collaborative way which should then theoretically lead to further avenues of co-operation, but getting it established at the outset – and maintaining that collective ideal once it has been – is a major undertaking. Past experiences of the off-site manufacturing industry have proven how important it is to gain a critical mass of industry players to provide it with a constant throughput of work. Towards the end of a boom time, however, when the speed of construction becomes less critical and the supply of onsite labour more available, the alliance begins to falter, often leading to the collapse of the off-site provider (W. Mann, 2017). This is potentially a cyclical inevitability of a boom and bust economy, unless the supply of work can be guaranteed during a downturn. For this there would seem to be three possible solutions. Either the government has to provide that need in the form of social housing demand (Lyons, 2014, p. 22), or the off-site industry has to diversify or provide its own market for housing. The solution to this and any form of collaboration, where the aim is to reduce the level of future risk, is to have at least some control over the participating sectors. The New Entrants are not entirely relying on the government to protect their investments, and are effectively controlling elements of the supply chain from concept to purchase, or often long term rental. They are also, as a consequence of this, more able to introduce and demand the use of BIM throughout their supply chain, without fear of that chain breaking. The more achievable solution in their eyes is to create an alternative simpler marketplace than to attempt to correct the existing profoundly complex one.

"The industry's route map to collaboration and high efficiency new delivery models can only be underpinned by BIM and the importance of its adoption cannot be overestimated"

The realities of creating a more collaborative environment are discussed in Sections 6.4.3 and 6.4.4 and show how such chicken and egg challenges cannot be brought about internally. Again, the act of calling for change without recognizing the reasons why this has not been successful on previous occasions runs the risk of yet again postponing those changes taking place.

[the task of reintroducing collaboration into a complex and adversarial marketplace is in itself a major barrier to change]

Lack of R&D & Investment in Innovation

Figures for investment in R&D in construction in the UK are lower than any other sector.

"This is symptomatic of a lack of interest in or incentive to consider modernisation in the industry despite meaningful tax offsets being offered."

Whether or not this is an over simplification of the reasons behind the problem, it is nonetheless, unhelpful when it comes to finding a solution. But would a more complete picture, taking into account the role of disproportionate risk, supply chain complexities, public conservatism - and all the perceptions and past experiences that have fed into that – provide us with anything more useful to work with?

"This review heard evidence from businesses that are investing in innovation but appear to meet problems in getting new products and propositions to market at any scale. This is often due to a deep-seated perception of risk within the wider supply chain".

The review focuses at this point on the trials of off-site manufacturing and the many barriers to its acceptance. It recognizes the 'The cyclicality of construction demand', the negative perceptions from past experiences, the reluctance of investors, lenders and insurers to participate, the inappropriateness of our traditional tendering process, the need to co-ordinate supply and demand throughout the industry, the power of the traditional developer model over the marketplace, the inconsistency of government policies, plus all the factors already covered above that all feed into the wall of resistance that needs to be overcome. But for all this, it sees OSM as the only viable solution to the extent that it will either be addressed here or it will be won by overseas markets, notably from Asia.

The underlying issue here is risk, and it is felt across the whole industry, not just by the small entrepreneurial companies who are often portrayed as the only players gambling with their investments. Governments and large corporations also take risks by investing in creating the fertile environments for those startups to flourish, and the public takes risks in moving away from the accepted housing norms with possibly the biggest investment they will ever make. There is no avoiding the need for the whole industry to share this risk to break the stalemate of inertia that has settled upon it. For that to happen implicitly suggests that the industry needs an external influence to intervene.

"Ultimately, innovation led modernisation continues to be inhibited at all levels by the lack of industry-wide strategic leadership with a more integrated client and industry agenda."

If that is not to come from government, which is the reluctant conclusion that the New Entrants have come to, it is up to these industries operating on the periphery of housing to step in with alternative

solutions that simplify and de-risk the offer, not just for themselves, but for the investors, the insurers and the end users.

[perceptions of risk due to complexity and uncertainty stifles investment in innovation]

Poor Industry Image

These nine symptoms culminate in the industry's poor image, deemed worst within the house building and residential sector, due to high risk, poor health & safety, austere working environments, embedded prejudices and perhaps crucially, poor job security, reinforced by a feeling in general construction circles that it is this sector that is most at risk from 'boom and bust' due to a strong alignment with the housing for sale market. If this industry is going to attract the workforce needed to survive, let alone grow to deliver the government's targets, and do this from within the UK, the most influential factor that will dictate the way the housing industry will evolve, it is suggested here, will be whatever it is that appears most attractive to the labour market. And if high incomes is not an option, as these houses will have to be more affordable than those currently being built traditionally, it will most likely be down to work environment, 'high tech appeal' and job security. It may well be that the ground rules are so fundamentally different now to make the case for off-site manufacturing unstoppable, and the negative past experiences for the first time, surmountable.

[OSM may become the only option for improving the industry's poor image, but would still need to deliver more stability through recessionary periods]

3.2.2 Synopsis of Governmental Impact

The intention of this analysis of the Farmer Review and the government white papers it builds upon was to gain a better understanding of the role played by the legislative sector in influencing the decisions made by the housing industry regarding the adoption of innovation. In the absence of the breadth of interviews needed to create that picture, this was seen as the most direct route to the evidence needed, at least to the message that government sources wanted to be heard.

In recognition of the likely disparity between that message and the real intent or ability of governments to influence decisions, the review had to look beyond this and consider the impact that these white papers have had. This analysis reflects the analysis carried out in the industry interviews, where the questions asked were aimed at discovering where the true barriers to innovation were to be found. Were they due to a lack of knowledge of the issues being addressed, a lack of motivation to consider the alternatives on offer, or a lack of ability to enact any proposal accepted as beneficial?

This analysis focuses mostly on the Farmer Review but only after establishing its role in providing an overview of those papers that have gone before, and also those papers' remits to operate within a similar framework of acceptable discourse, as defined in Figure 3-6.

In its holistic approach, the Farmer Review, unlike previous papers, draws attention to an alternative solution offered by the 'new entrants' that has already emerged from the industry interviews as a

possibility, although this is only implicitly referred to. It is implicit to the point of not being made at all, perhaps because suggesting an alternative model is not felt to be an acceptable solution, but the negativity of the Farmer Review towards the likelihood of their own proposed solutions being successful suggests that the alternative might be where the industry as a whole should be focusing its attention. To summarise these thoughts, the Farmer Review draws attention on many occasions to the 'New Entrants' whose business models are seen as the most likely to bring about the changes that the review says are so desperately needed. The review also draws attention to the fact that much of what is recommended here has been recommended before but has not been enacted by the mainstream industry players. What it does not expressly do, however, is focus on what it is that allows the New Entrants to operate in a way that is different to the norm, which this research posits is their avoidance of both the complexities of the industry and the uncertainties of government policies that exist for the remainder of the industry. Why it chooses to stop short of this level of analysis is possibly a political decision in its own right, but the review clearly defines the symptoms of an ailing industry, not the causes that lie behind them. Those causes, as suggested above are not within the gift of the housing industry to influence, as they are political issues, relating to the wider economy, but are also seen as being outside the remit of acceptable discourse.

Controlling a well-defined vertically integrated market and minimizing their exposure to government policy and market forces avoids the New Entrants having to concern themselves with the bulk of what the Farmer Review itemizes as dysfunctional within the industry, and in reality the greater economy. Their solution, were it to be repeated across the wider industry, would be to maximize what can be controlled internally, and treat whatever is outside that sphere of influence as a factual reality to be dealt with for what it is. The reluctance of the Farmer review to expressly promote this approach perhaps lies in the sense that it portrays an air of isolationism and even defeatism by turning its back on the problems that beset the industry as a whole in favour of a new self contained alternative. But there does come a time, and 'Modernise or Die' would seem to be suggesting that is now, when the dysfunctional status quo might have to be abandoned for a revolutionary alternative course of action (Farmer, 2016, p. 49).

The relevance of this train of thought for this research is in the prescribed need to find the path of least resistance for innovative solutions. Finding where that resistance lies is where that process needs to begin, and the underlying message in these reports is that resistance to innovation stems from the level of risk involved which in turn stems from the complexity of the task of introducing any form of innovation within an uncertain environment. The Farmer Review very successfully defines those complexities, and collectively the reviews discussed show, through their limited success, how intractable the associated issues remain to this day. Whilst it is understandable that the review does not feel able to promote a wholesale abandonment of the existing industry structure as a solution, the argument does exist within its findings and cannot be dismissed if that same review sees the New Entrants as our best hope.

This is not a call for revolution, but merely an investigation into how this new external intervention might not only define a viable alternative, but also show by example how our existing housing industry could be de-risked in a similar way. There are clearly some very definite government policies that would assist in the Farmer Review's recommendations being enacted, such as providing a secure,

stable, low risk environment in which to operate, plus some key planning and regulatory decisions that would help set out a clear trajectory for businesses to build on. But if government cannot be relied upon to deliver these policies, this needs to be recognized, and not assumed to be a fait accompli. It is on this basis that the research proceeds in Chapter 4, looking at the role of risk, to what extent it influences the decision making process and how it might be reduced to an acceptable level by either accepting, avoiding or removing the barriers to change.

3.3 The Public Surveys

The search of the literature and the subsequent interviews undertaken across the industry sectors helped paint a picture of what was known about volume house building in the UK and also how that knowledge differed across the sectors that all have an influence on the housing delivery system. It highlighted some interesting areas of disagreement, sometimes formed from evidence based beliefs, but more often from perceptions of how the industry operates within its different sectors. One area of mutual agreement, however, was on what the public are perceived to think and know about housing, which was what made the need for this survey so important.

'The public' is a collective term for what is clearly not a single market, and yet the interview responses gathered showed little recognition of how many different opinions are potentially hidden within that definition. There was also little knowledge of where the evidence for these beliefs came from, and consequently little proof of their authenticity. In effect, this represented a collective generalised perception, which was that the 'public' are not engaged with the debate about what type of housing should be delivering for them, the end users, and are therefore not a major concern to those controlling the process. The validity of these opinions needed to be tested but not by undertaking a small number of interviews with random members of the public. In order to differentiate between the many opinions held by 'the public', a full survey would need to be developed that considered these variations to a level of detail that was clearing missing in the interview responses from other sectors.

This section therefore covers the aims of that survey, the methods used to carry it out and a discussion based on the findings from what was in hindsight a pilot for the more thorough omnibus survey this study has proven the need for.

3.3.1 Existing Surveys

Existing surveys were first looked at to establish what data was already available, and how surveys in this field are normally carried out. The general trend was that they tended to be either too generalised or too biased to be of much academic value, certainly for the purposes of this research. The generalised sources were those orchestrated by governmental bodies, such as the National Census, carried out every ten years, and the English Housing Surveys, carried out annually. At the other end of the spectrum, there were many purpose driven surveys, such as those carried out by the House Builders Federation on behalf of their clients, predominantly the major volume house builders, that tend to show increasing levels of customer satisfaction with their products, year on year (House Builders Federation 2015). Between these two extremes were some focused surveys carried out by more independent bodies such as the NHBC (National House Building Council), RICS (Royal Institute of Chartered Surveyors), the RIBA (Royal Institute of British Architects), GHA (Good Homes Alliance) and the now disbanded Zero Carbon Hub. Access to these sources varied, and became particularly difficult when asking for the core data and information on sample sizes, denominators, etc. as opposed to just the key findings taken from that data.

By way of example, a survey commissioned by the RIBA, 'Housing standards and satisfaction : what the public wants' (Ipsos Mori, 2013), focuses on dissatisfaction levels and the reasons behind this, and

suggest that how long respondents have lived in a new property before they are asked can influence their answers:

People are usually satisfied with their homes, as is revealed by a number of surveys across the sector. However, our survey compared length of residence and age of property to understand whether satisfaction decreases over time and whether people are more likely to be satisfied with older or newer properties. Traditional surveys about satisfaction with new homes focuses on the period immediately after residents have moved in and satisfaction rates are high at this time. We found people who had lived in their current home for up to 2 years voiced higher levels of dissatisfaction (31%) than those who had lived in their home for 3 years+ (13%), a statistically significant difference.

This statement contains a direct contradiction, and also confuses the evidence relating to age of property and length of residence, making the findings alone an unreliable resource to work from.

Research in other fields into the 'tangibility effect' (Horsky, Nelson and Posavac, 2004) – the consistency between individuals' stated preferences and their actual behaviors, show that surveys even when well written and well conducted cannot be relied upon to give reliable information. In this study the very process of using a survey to reflect actual buying behaviour has been shown to skew the results obtained towards desirables as opposed to essentials. This together with the possible lack of information about the questions asked, the sample size, the denominators used, let alone the level of interpretation added, means that public preferences remain a relative unknown.

The decision reached therefore, was that the public's opinions represented a gap in the evidence either gathered or available, and that in order to make a case for the impact that the disconnects between the sectors was having on the housing industry, this range of opinions had to also be considered. Before embarking on this process, however, it was necessary to clearly define what the purpose of this survey would be, and also to learn from the shortcomings, some of which have been touched on here, by first studying the content and the structure of similar surveys already available.

3.3.2 Learning from existing data

Not all available data comes from verifiable sources, but some statistics are so frequently replicated that there is a certain level of credibility to be gained from that, if the research is interested in trends rather than specifics. Magazine and newspaper surveys carried out as investigative journalism are commonplace and it could be assumed relatively free of bias compared with those that are industry financed. There is also data available from many sources that attempt to categorise the public's priorities when it comes to choosing a home. Many of these do set out to prove a point, and without direct access to the source data, cannot be relied upon for their accurate interpretation of the facts, although most do concur with the views held about location being by far the most important aspect for the purchaser. www.investopedia.com for instance carries the claim that

> *"The age old punch line "Location, Location, Location" still rules and remains the most important factor for profitability in real estate investment. Proximity to amenities, peaceful, conforming areas, neighbourhood status, scenic views, etc. are major factors for residential property valuations."* (Seth, 2017)

An interesting explanation for the importance placed on location, even putting it above the choices we make in our personal lives (who we marry, the choices we make regarding our education, and the choices we make about careers), is that our location structures all those other decisions (Florida, 2014). These observations may well be true, but mask the real concerns regarding housing quality and type, as most purchasers in the UK, ie: those not building their own homes, have little to choose between once their available budget and the required location have dictated what is on offer. However, as was pointed out by Richard Simmons, Chief Executive of CABE (Chartered Association of Building Engineers) in their report on 'What home buyers want: Attitudes and decision making among consumers',

> *"The fact that consumer choice is limited by land supply should not become an excuse for ignoring the fact that people want well designed homes and neighbourhoods with real character and sense of place."* (Samuels, 2005, p. 1)

For this reason, some surveys take location out the equation, and focus on the factors within the house itself that are seen as important, even if they are not always achievable due to what is on offer. An RIBA IPSOS Mori survey carried out in 2013, asked home owners to rank their top reasons for dissatisfaction with their home, these, it is argued, being more tangible than a wish list of what they would want from an ideal home.

> *"High energy bills (49%), lack of space (32%) and lack of natural light (20%) are the most cited causes of dissatisfaction with the home" and "high energy bills and lack of space are most likely to be mentioned by those living in new properties."* (Ipsos Mori, 2013, p. 2)

ie those built within the last 30 years after the Government of the day dropped the minimum space standards.

Whilst this is useful information, the purpose of this particular survey was to establish the variance in opinion due to house type and age of property rather than any variance due to owner demographics, which is what this research is also trying to establish.

> *"Online panel members were invited to identify their current tenure, the age of their property and how long they had lived in their property before being asked to complete the survey".*

Estate agents often produce statistical analyses from their data which can be based on good sample sizes and also provide trend information over a number of years. A survey by Savills Estate Agents in 2014 found that *"properties close to good schools could fetch 25% more than those less well situated."* Similarly, a survey by HomeSearch in the same year *"put a figure of 20% on the value which a tidy garden could add to a property."* Research carried out by Zoopla, which requires little more than a database search on address names has shown *that "the average price of properties with 'hill' in the address was more than double that of properties on bog-standard 'streets'."* (Davidson, 2015). Even having a name rather than a number, or more bizarrely still, having an odd numbered house rather than even has been shown to increase a property's value. But all this shows is that house on hills or with names tend to be more expensive properties, and possibly that the public, taken as a whole are not necessarily driven by logical, practical factors.

Some Estate Agent's surveys, such as Countrywide's survey carried out in 2014 by YouGov of over 2000 people provides a more nuanced picture, with statistics broken down by age groups and gender:

> *"Location is the most important factor when buying a property. 36% of people buying a property within the next 3 years would be least likely to compromise on location. This rises to 47% among 35-44 year olds compared with just 26% of 18-24 year olds."* (Countrywide PLC, 2014)

But what is it that makes location so important for this demographic? In this instance, is it more that they can afford to make it non negotiable, with 35 to 44 year olds being the most likely age group to have the ability to travel to amenities, schools, etc. and therefore most able to demand the location they desire? This does not mean that location is less important for other groups, but only that some demographics are more likely to have to compromise on this factor than others. Being aware of how many of the factors being assessed can impact on each other is critical to how the data from these surveys is interpreted.

Asking respondents to prioritise what it is about a property that is seen as most important when buying or renting, in this case by asking what it is they would be least likely to compromise on can therefore still disguise true motivations, but begins to get closer to the reality of how people act. In comparison, the RIBA survey that asked respondents to state what it was about their house they were most dissatisfied with does not necessarily translate into a priority list when choosing a property. This can be seen from the fact that energy bills, whilst being the clear winner when asked about dissatisfaction in a property already bought, is not what dictates how a house was chosen in the first place.

The results from surveys of this nature are open to interpretation, and can be misleading. Certain factors are now taken as read as being priorities, such as location, but so too are features like central heating and double glazing (Butterworth, 2017). Ticking a box to say that central heating and double glazing are 'must haves' should not necessarily be taken as meaning that "energy efficiency is a key priority for househunters" (gocompare.com, 2016).

In conclusion, whist the existing body of data from numerous surveys all helps to generate an overall picture, if the raw data behind the interpretation cannot be accessed, let alone the questions as they were originally framed, this information cannot be used as the basis for an academic study. Furthermore, the surveys that were found, not surprisingly, did not focus on the use of concrete but on the more general priority lists normally associated with housing choices amongst the general public.

It is important to recognise the role of public surveys at this point, because they are not always the best vehicle for gathering information. They are primarily for establishing perceptions or levels of knowledge, but neither on their own will give a meaningful picture to work from. It is a fact for instance that houses built with modern methods of construction (MMC) are more difficult to mortgage (Broadhead 2016, p.2), but we don't necessarily know to what extent this is known by the buying public, and if so to what extent it might influence their decision to buy a concrete framed house. On the other hand, estate agents will run surveys to establish confidence levels amongst the buying public

regarding future property prices. From their perspective, the public's perception, no matter what it is based on, is more important than any industry projection, no matter how reliable that may or may not be, as it is public confidence that drives sales. And to complete the picture of alternative realities, public perceptions, whilst being no less relevant, are often evidentially wrong. Most housing surveys for instance, show a strong preference for out of town living, with one of the main reasons given being relative safety and low crime, something not born out by the statistics. And when asked about the negatives associated with inner city living, inadequate parking is bottom of the list amongst prospective buyers, but very prominent amongst those already living in those environments who have experienced the reality.

The questions that need to be asked therefore, fall into these two categories. Assessing levels of knowledge is the first objective, and armed with that information, establishing opinions about particular aspects of housing, primarily relating to innovation and the use of concrete. It would, as suggested, be of little benefit asking whether someone would consider buying a concrete house without knowing if they were aware or influenced by the difficulties they might face in obtaining a mortgage, as we would be none the wiser about their like or dislike of concrete as a material, not knowing what information they were basing their decision on. It can be seen that unpicking the associations that are made relating to concrete and housing is far from straightforward. As it is with trying to understand what lies behind any decision, it requires a process that establishes what is known, what is perceived and what is seen to be important, and then for the purposes of this study, being able to break these finding down by categories of people – by age, gender, race, income, etc.

As an example, expressing a desire to live in a bungalow could stem from a number of perceived needs depending on the individual, many of which could be satisfied by other solutions. If it is a decision driven by future planning for old age, there are lifts. If it is because of a dislike of noise from neighbours above or below, there are sound proofing measures. If it is for privacy, that is purely a design issue. It is therefore the reasoning behind the desire that is the valuable information, not the desire itself. Even Housing Associations with their constrained budgets, can still be seen providing bungalows, by far the least cost effective housing solution, because their client base has shown a desire for them. Armed with the knowledge of the reasoning behind that desire, far more affordable solutions could potentially be offered.

3.3.3 Aims: What additional data is required?

Learning from our recent history, it is acknowledged that there was little attention paid to consumer preferences during the last great building programme of the 60s, and to some extent this has been seen as the reason for the high levels of dissatisfaction that followed. A more nuanced study of this era, however, suggests that the housing itself was, despite this lack of consultation, appropriate and well received. It was how that housing was managed, again with no channels of communication open to the residents to make their opinions known, that led to the increasing levels of dissatisfaction.

"Yet simply to have followed preferences expressed by consumers would not have necessarily provided better homes. The new housing was often appreciated by the first residents and problems only arose after some years of occupation." (Samuels 2005, p.4)

Either way, what is needed is a better understanding of what is wanted by the public so that better informed design decisions can be made on their behalf but with their approval.

The key needs for the proposed survey are therefore to establish:

the public's perceptions of concrete,
their levels of knowledge about concrete,
how both of these break down across different demographics,
and how they influence decisions regarding housing choices.

To encompass all this within one survey would be a complex undertaking, with conditional questions to establish perceptions held as well as levels of knowledge, and also to what extent that knowledge would influence any future decisions. The preferred route at this stage was to run some initial focus groups to test this approach before settling on a final questionnaire format for use in a full omnibus survey.

The proposed structure for the focus groups is shown in Figure 3-7 based on a triangulation of information covering their personal status, their level of knowledge and their vision of housing, broken down into the following categories of data:

Personal data: demographics, sociographics, psychographics, current dwelling data

Perceptions held: regarding aesthetics, sustainability, social connotations

Current knowledge: concrete's credentials, its benefits within housing, its use in housing globally

Future desires: house type, location, environment, image, ownership, construction.

A full account of how these categories were decided upon and subdivided into questions can be found in Appendix G Public Survey Structure

After making numerous attempts to secure funding for this process through the BRE, CLC and other interested bodies, it was decided that for the purposes of this research, an online survey could act as a trial for an omnibus survey to be carried out at a later date, once the potential benefits of the information to be gathered had been established.

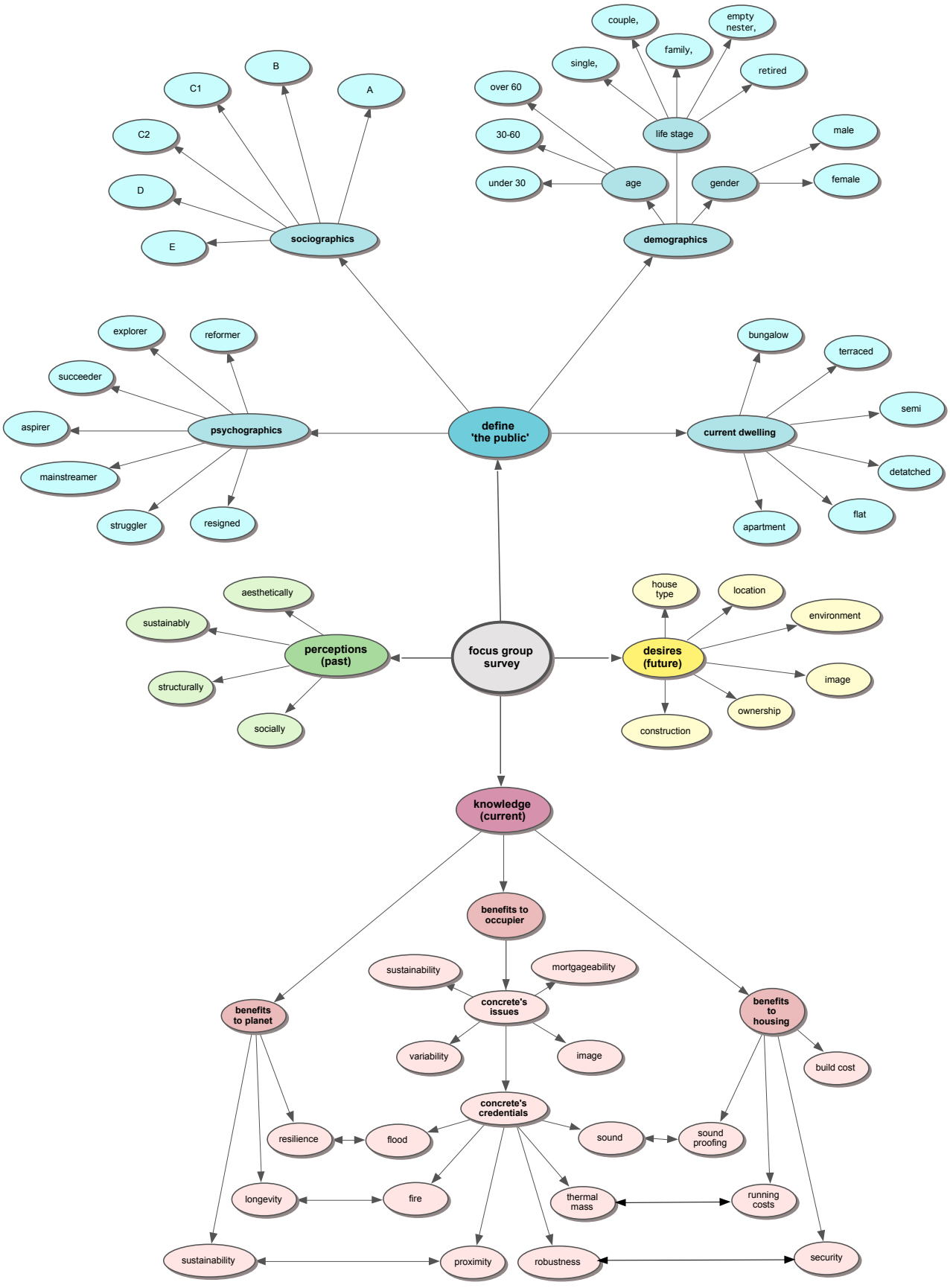


Figure 3-7 Structure to Focus Group questions

3.3.4 The structure of the on-line survey

Poorly defined surveys can be misleading in ways that are not clear to see, even before the process of interpretation creates its own level of ambiguity. It was therefore vital that the information required from the survey was fully understood at the outset, and whether the information gathered was to provide a statistical analysis of the situation, or just qualitative data to establish a range of opinions. The interviews undertaken across the other sectors were primarily intended to provide qualitative data, as the numbers interviewed only represented a cross section of opinions, and for comparison purposes, it was decided that the same approach should be taken at this stage with the general public. Similarly, it was decided that the questions asked should, if it made sense to do so, follow a similar pattern to those asked across the other sectors, allowing for the fact that those interviews had been semi structured, with an opportunity for the interviewees to expand into their own areas of individual knowledge.

When analysing the industry interviews, a set of coding parameters were defined at the outset which were then reassessed and added to during the process. The survey has been approached in a similar manner with the questions asked being driven by what information is known to be missing from the existing data so far accumulated. Some of the questions we know we want to ask arise from the interviews undertaken so far and the realisation that the opinions held about the public are not factually based, but strongly held perceptions. To start with these observations from industry, we have the following:

'The public are not even in the room' – a reference to the fact that public opinion on many of the arguments being discussed is muted and for that reason, rarely considered. This was a belief expressed on a number of occasions and across different sectors.

'The public don't like concrete' – a view expressed almost exclusively by the concrete industry, but not by the house builders.

'The public are very conservative when it comes to housing' – often expressed by the volume house builders when pushed to explain why their offering is so limited and unadventurous.

'The public are only interested in location' – proximity to good schools, quality of the neighbourhood, size of garden, maybe number of bedrooms, but with nothing else being a deal breaker.

If these perceptions are indeed true, there would be little to be gained by the concrete industry lobbying the public to get them to be more accepting of their material solutions. These opinions would suggest that concrete represents an aesthetic they are not interested in, that represents change, is associated with risk and is not in any case high on their agenda, even if it were seen as a positive. They are, in other words, not in the room, and if they were, it wouldn't be made of concrete. These are the commonly held beliefs uncovered by the industry interviews, and there is no doubt an element of truth behind them. But in order to both confirm these findings and deal with them, we need more evidence and more detail.

The preliminary role out of the on-line survey, conducted through Survey Monkey was run for four months. In total, over 150 people completed the survey, with a good mix of participants. Because of

the set of questions defining 'the public' it was possible to intervene during this time and focus the survey at different age groups, etc. as was seen to be necessary to ensure a broad coverage. The hardest age groups to attract were the over 65s (18% of the UK population), and those educated up to GCSE level only (almost 50% of the UK adult population), but the fact this was known to be the case meant that this can either be addressed in the future or allowed for. Being aware of such limitations is critical to the way in which the data from public surveys is used, and in this case the failure to attract over 50% of the country's demographic meant that, without some serious caveats, the results gathered were of limited use outside of a pilot study to be built upon at a later date.

3.3.5 Findings from the survey

This account follows the survey in the order it was written, taking each section in turn, and concluding with an analysis of the data broken down and sliced in the many ways needed to extract the information that was known to be missing at the outset. A full copy of the survey as it was published on line is in Appendix H Public Survey as published on-line

The first question was to obtain consent, answered by 100% of all respondents, after which the drop off began, which is recorded here, and also of some interest.

Question: Which, if any of the following would you say are inadequate in your current home? Select whichever boxes apply.

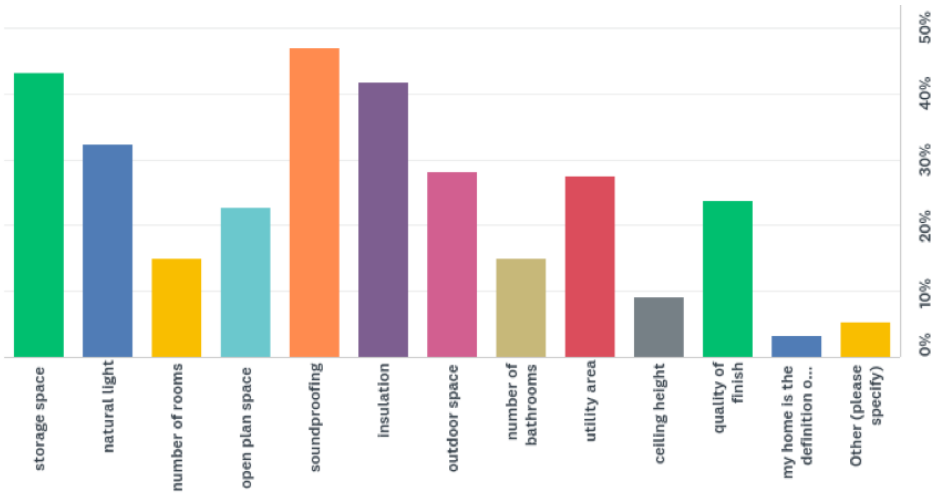


Figure 3-8 Survey responses, example output

This was very much a 'warm up' question, and also one that could be used to validate the responses with other similar preference surveys. Through the analysis of this survey there are numerous opportunities to drill down into the data to see how the general picture compares with different categorizations of the public – by age, gender, nationality, education – and even any combination of these criteria. It was the major trends we were looking for, so the analysis looked for those disparities rather than recording every possible permutation, whilst making sure that the number of participants in any one category did not become insignificantly small.

In this question, the overall figures showed the four most mentioned inadequacies to be, with the most popular choice first, soundproofing, insulation, storage space and natural light. Soundproofing was unexpected, whist the other three reflected similar recent surveys that had been found.

Looking at the figures for the different age groups showed a consistency with these four issues remaining the most important throughout with some differences beyond that, with the under 25's wanting more outdoor space and more open plan space. Whether that reflects a correlation between youth and 'volume entertaining' at home or an emerging trend which they will carry with them into their later years is unknown. Under 25's also put more emphasis on quality of finish and number of bathrooms, neither of which would be expected to become any less important with age, as they are more likely to be expectations born out of their experiences growing up - perhaps exacerbated by the over-generous specification of modern university accommodation, in turn fed by students' loan-induced ability to pay more than is necessary and the tendency to use student halls as hotel accommodation for conferences over the summer months.

Whilst this is all speculation based on an interpretation of the results, we are at least now able to speculate based on some level of evidence, rather than just making assumptions based on very generalized perceptions of 'the public' as a whole. Interestingly, the same data split by gender showed very little variance other than a male desire for more rooms. Garden sheds were not an option in the survey.

Perhaps the most important finding here however was the importance given to soundproofing, or more accurately perhaps, the belated realization of the importance of soundproofing having experienced living in a poorly soundproofed house. Unfortunately, the one question not on the survey was 'age of property' which might have given an insight into the worst performing properties. We can however compare the results by house type:

House type	% of respondents choosing soundproofing as an issue
Terraced house	61%
Semi-detached	67%
Detached	34% (soundproofing beaten by insulation as the no.1 issue)
Apartment block	71%
Flat, converted	37% (soundproofing beaten by outdoor space as the no.1 issue)
Flat, high-rise	0%

The only one of these that will almost definitely be constructed from concrete is the high rise flat, which is a useful example of why the next section, on the performance of materials was seen as an important exercise in establishing whether the public know what the material benefits of concrete are. It is important to point out that for the first half of the survey there is no mention made of the emphasis on concrete in this research, and indeed, the survey was deliberately not sent out to anyone who knew of the researcher or the purpose of the research beforehand.

Questions on Public Knowledge

The seven questions asked in this section covered the main material attributes relevant to housing needs, and each was asked of five different construction materials – steel, brick, concrete, wood and CLT.

Question asked:	***Most popular answer:***
Best sound proofing qualities:	**Concrete**
Most waterproof:	**Concrete**
Most fireproof:	**Concrete**
Least travel distance:	**Concrete**
Least detrimental to the environment:	Timber, brick, CLT, **Concrete,** steel
Absorb the most heat:	**Concrete**
Most durable:	Steel, **Concrete**

From these results, knowledge of concrete's credentials does not seem to be an issue, except for in one very important area, that of environmental impact. More likely, these answers reflect the public's perception of concrete as a material rather than their knowledge, as there is little reason to assume that any of the participants have any in depth knowledge of these materials outside their everyday experiences either within the housing industry or elsewhere. The perception, certainly from the interviews carried out, is that concrete is environmentally damaging, whilst timber, a natural harvested resource, has either a negative impact or at the very least a neutral impact on the environment.

For many reasons, discussed in detail in the following section 6.1.3, this is a negative perception that should be confronted, and its foundations questioned. These results suggest that this is the one barrier to acceptance that is currently blocking the remaining six positive connotations that the public has with concrete. It is not a co-incidence that these answers reflect the accepted science in each of these areas, but whilst six are relatively straight forward and uncontroversial, environmental impact is open to interpretation. Has the right answer prevailed, or is this an example of industry influence creating a belief system that has been left unchallenged for long enough for it to become enshrined in regulation?

Questions on Public Perception

The next section focuses on areas where the public is perceived to have perceptions about concrete. If that sounds vague, it is effectively how the housing industry is currently operating – basing its decisions on what it thinks the public thinks about concrete. Again, what is missing is any evidence of

this, and a more nuanced picture of who thinks what when broken down by the many parameters available in the data.

The three areas investigated were aesthetics, environmental impact and social connotations. A selection of terms were provided to choose from, but only after requesting the participant to answer the question in their own words first. The purpose of this element of the question was to compare gut reactions with more considered answers when shown both the positive and negative aspects of concrete to choose from. But on a more general level the aim of these three questions was to establish whether the industry's perceptions about their customer, 'the public', were correct, and if so, whether these beliefs varied within the subdivisions that were being captured.

Aesthetics:	open	chosen from lists
negative comments	77%	62%
positive comments	20%	38%
neutral comments	3%	~

Aesthetically, the results seem to confirm the widely held belief that the public don't like the look of concrete, with the words chosen to describe concrete being overwhelmingly negative, and very polarized, with few respondents giving balanced answers. There are assumptions made here based on the tone of the answers given, as for instance Brutalism, whilst for many being a negative term, is for some a thing of beauty. Minimalist was another term that was used by both camps, showing that aesthetics can be very subjective – hence the need for a more nuanced perspective.

From the list of words, 'drab', 'ugly' and 'rough' were used more often than 'old fashioned', 'prefab' and '60s', which would suggest that this is an ongoing dislike, and not one based on past connotations, at least when assessing the public as a whole. But what if these comments are sliced by age to compare the responses of those over and under 25? Unfortunately for the concrete industry there is very little movement in opinions to detect. Drab rough and ugly score highest across the board. One possible lesson to draw from this is that whilst the TV programme Grand Designs has undoubtedly done much to raise the aspirational profile of concrete, this is seen as being at the fantasy end of aspiration, and does not appear to translate into every day experience and expectations.

One positive to be drawn however, is the degree to which opinions changed when confronted with a balanced choice of words rather than being left to draw on individually held perceptions. A near doubling of positive associations at this point would suggest that many of the beliefs held about concrete are relatively 'un-thought' and more assumed. A number of participants actually wrote 'I am lead to believe' at the beginning of their open answers which again shows an openness to being persuaded otherwise. When split on gender, female dislike of concrete is stronger than male but not to any meaningful extent.

Environmental Impact:	open	chosen from lists
negative comments	25%	46%
positive comments	40%	54%
neutral comments	34%	~

Open answers given in this section were more positive towards the environmental credentials of concrete than had been expected, and by a substantial margin, but with a third of respondents unsure, and a third of those giving both pros and cons in their answers showing a recognition of the complexity of the argument, which should be seen as encouraging. When asked to select from the key words, durability, perhaps a less obvious environmental benefit, was chosen by almost all respondents as a positive with an equal spread across all other options.

Social connotations:	open	chosen from lists
negative comments	82%	82%
positive comments	10%	18%
neutral comments	9%	

To refer here to positive and negative comments would be inaccurate, as it would assume an association with council housing as a negative. There was however an overwhelming tendency to associate concrete with council housing with only three respondents linking the material with high end aspirational architecture, with one of those suggesting the link as one with "pretentious, rich, people who like to stand out". The words used were surprisingly varied and do not make for a comfortable read, but do need to be seen in their entirety and are listed in Appendix I Public attitudes to concrete

Possibly the most important message to take from this is the need to ensure that this association is not perpetuated by promoting concrete as a low cost, visible solution. Either low cost or visible, but not both.

Question: What percentage of the price of a typical UK house do you think is due to: material costs / labour costs / land value / fees and overheads / profit?

The last question in this section was to find out how aware the public are about where the costs lie in the provision of their housing. The breakdown shown in Figure A: 3 represents a simple approximation of the actual figures that vary substantially across the UK, with land values in particular skewing these figures. A plot for a family house in the Black Country at £15k is less than a tenth of that in many London boroughs, with a consequential impact on all other costs. Despite this, the answers given were surprisingly accurate, in that the percentage of a house's value due to the land value was known to be proportionally more than the other segments, albeit by less than the national average.

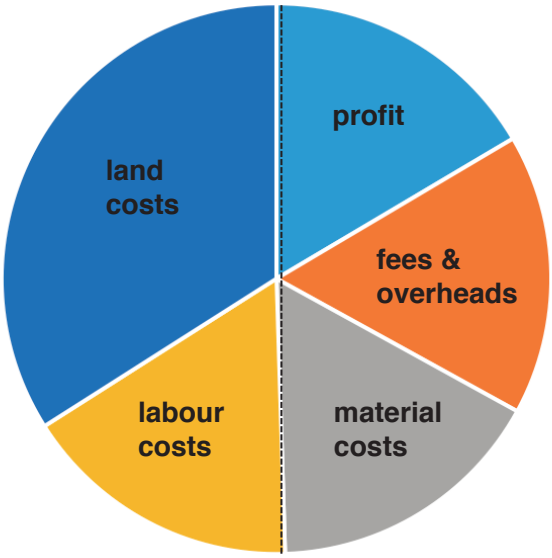


Figure 3-9 approximate breakdown of the costs of housing in the UK.

The need to ask this question stems from the fact that the use of more expensive materials does not in reality impact on the final property price as much as might be expected. An increase of 20% in material costs chosen for their sustainability or resilience benefits might result in less than a 3% total increase, especially after a degree of labour cost savings are taken into consideration.

The principle behind the next section of the survey, was to establish what type of accommodation different sectors of the general public currently lived in and also what they aspired to. Perhaps not surprisingly, the overwhelming response was for a detached house with garden. (Figure A: 4), but with good transport links, internet connection and amenities classed as more important than where that property might be. Most respondents (90%) wanted to own their own home, they wanted it to be sustainable, adaptable so that they could stay there for a long time, but nothing too outlandish, just noticeably different. Within this, however, will be pockets of the general public who will aspire to something radically different, and the final section of questions is where the ability to define who those groups are will be found.

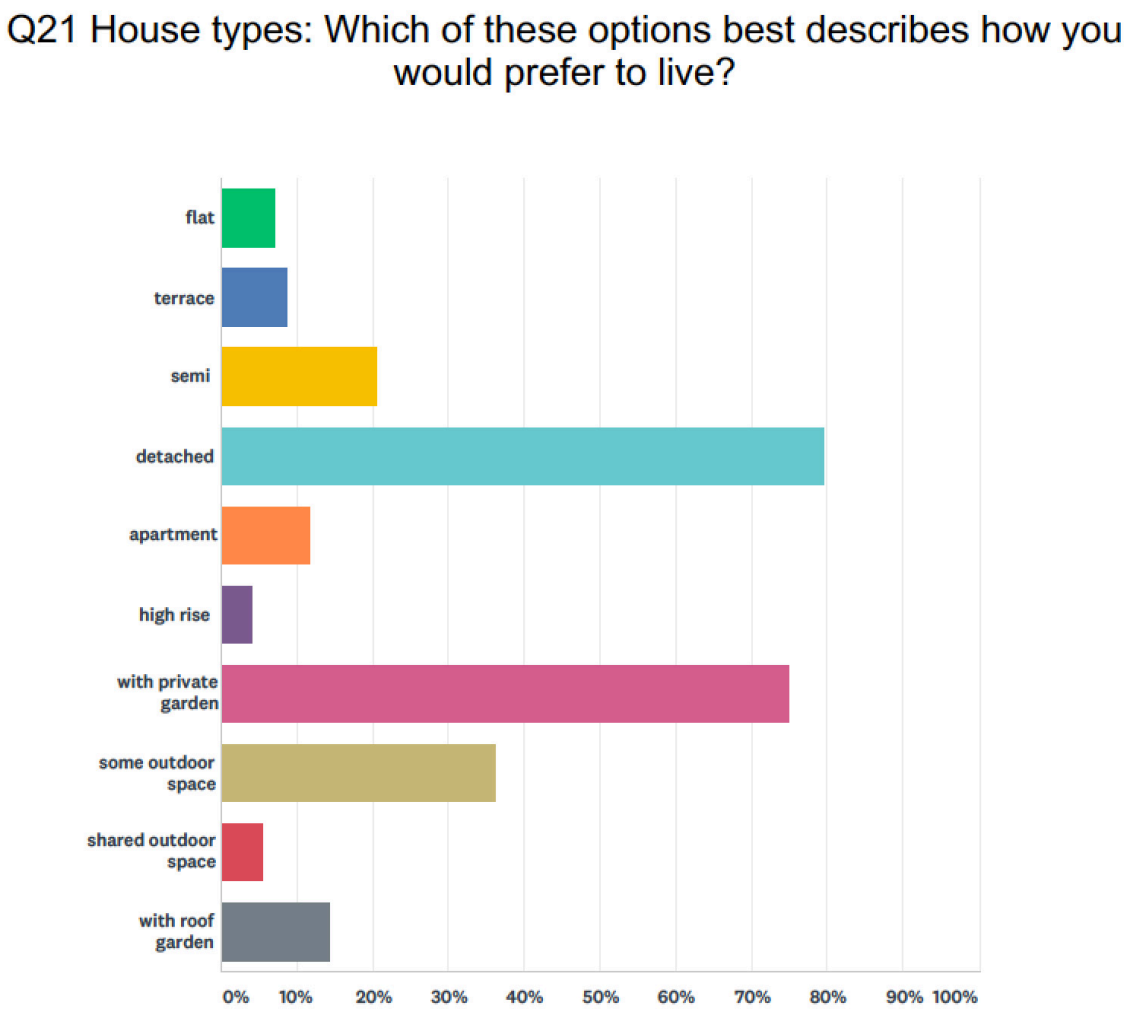


Figure 3-10 Preferred house types

Questions defining the general public by type

These questions are all providing a more nuanced picture of what the public know or believe to be true, but it is how this knowledge varies between different sectors of society that is of importance from a marketing perspective. The next set of questions was therefore asked to help define those groupings in terms of demographics, psychographics and sociographics. To make any meaningful sense of the many subsets within this data would require a broader response than that so far achieved, as stated at the outset. As a next step, focus groups would be a better method for reaching the specific sectors mentioned now that the on-line survey has highlighted the gaps to be focused on.

3.4 Conclusions drawn from the combined methods used.

The collective findings from the interviews and supporting research into the government white papers and data sources used by the industry, together with the public survey has provided a thorough picture of how the housing industry functions, and more importantly where it is failing to function as a collaborative whole. From this a number of conclusions can be drawn about the barriers that these

shortcomings represent for innovation, and some suggestions made for why it is that the industry, whilst recognising the symptoms, still seems unable to deal with the causes.

The question posed at the outset (Section 1.4.1) was 'to what extent is the disconnect between sectors within the housing industry due to a lack of understanding about how each of these sectors operates?'. The purpose of this question stemmed from a need to find how the concrete industry could better influence their market in order to promote the use of more concrete within it, and the realisation that this required the concrete industry to first understand how the housing delivery system as a whole operates. The subsequent research into the sectors that define that system showed a complex relationship between four sectors, each with their own agendas, and each operating with little detailed knowledge of the housing industry as a collective whole. The picture that emerged was, not surprisingly, complicated and very difficult to draw generalised conclusions from, other than the fact that the majority of the answers provided were based on supposition and anecdotal evidence rather than hard facts. There were nevertheless more occasions where these beliefs were corroborated across sectors than those where they conflicted, irrespective of their actual validity.

This filtered down into two specific findings, the first relating to the degree to which collective perceptions can sometimes become more powerful than the facts they replace, and the second relating to the disconnects where sectors were not communicating on the same wavelength. There was also a third finding however, that stemmed from the subsequent question asked of the industry, of why it was that even when there was a consensus of opinion as to what the problems were and even how they needed to be addressed, that it was so difficult for the industry to respond in a positive, unified way. These concepts are outlined here and picked up in detail in Chapter 4 as part of the process of developing a tool for establishing the feasibility of particular strategies.

3.4.1 The power of 'groupthink' – perception .v. reality

"Groups are also susceptible to the tendency to establish entrenched positions (defeating compromise initiatives) or to prematurely adopt a common perspective that excludes contrary information. This tendency has been termed by some as "groupthink" (McDaniels et al. 1999)."

There were many areas where the answers given in the interviews showed an unexpected level of consistency across the sectors, although with no more evidence for that of them being based on any real knowledge of the subject in hand. This phenomenon should be of even greater concern, as it shows how easy it is for misinformation to gain traction when the time available for factually based research is limited, and a reliance upon reported evidence becomes the norm. The entire industry's opinion of the general public and what it is that they want from housing was a good example of this, with little thought given to the vast range of opinions that the public voice will inevitably contain. A similar situation arises when interviewees were asked about the motivations of house builders. In the same way as 'the public' was taken to mean a person representative of the norm, house builders were taken to mean the large volume house builders, who again only represent a percentage of what is a broad collective of opinions. What these two sectors have in common, interestingly, is the lack of first hand data available on either of them, resulting in the other sectors needing to rely upon their perceptions instead. Not only is this unhealthy, but it is remarkably robust, in that perceptions once established would appear to be very difficult to dislodge, even with hard facts, perhaps because those

'facts' invariably come from business sources where there is a recognised vested interest in self promotion. - The increasingly common tendency to be wary of information from official sources and the consequential reliance on gut feelings and perceptions as equally valid substitutes is a topic in itself, but this research has certainly found a blurring of the boundaries between the two. The underlying concern is the lack of rigour, most likely due to the lack of time made available, when it comes to making important decisions. Immediately available resources, such as the many advisory bodies' websites become not only the first but often the only source used, feeding into the cycle of uncorroborated opinion and promotional statistics becoming widely accepted as fact. This lack of investigative initiative leads to statements about 'the public' with no consideration given to demographics, statements about the volume house builders without recognising that this represents less than 50% of the house building industry, and, of most concern to the concrete industry, statements about timber being the most sustainable building material based on little more than a collective acceptance of this being beyond doubt.

How to counter this acceptance of 'facts' without interrogation is a vitally important element of this research, especially when considering the simplistic arguments being used to dismiss concrete as a sustainable building material (Chartered Institute of Building, 2012), an aesthetic building material (Salmon, 2016) or even a structurally sound building material (Spicker 1987, p.4). None of these arguments are based on current factual evidence, and yet all would appear to be deeply held perceptions, and as one interviewee reluctantly pointed out, 'perception is reality', and must be afforded equal importance.

An alternative to fighting to overcome deeply help perceptions is to provide the factual evidence to the next generation at the earliest possible opportunity, a policy that TRADA, (Timber Research and Development Association) are actively pursuing. Their university educational programme shows how effectively some trade bodies are seeding the industry with knowledge and resources to influence the decision making process (Appendix E).

3.4.2 The disconnects between sectors – economy, equity and ecology

The areas of contrast were found to be most apparent between the interviews within the concrete industry and those undertaken in other sectors. Disagreement would suggest some level of communication had taken place between sectors, whereas in reality much of what was said in the interviews was based on perceptions held rather than evidence gained about each other's points of view. Examples of these conflicting opinions have been covered already, but the theme that emerges is one of a lack of understanding of what is of importance to the markets into which the concrete industry is selling its products. The model that best portrays this conflict is the 'three dynamics of sustainable communities' of economy, equity and ecology (Hansmann, Mieg and Frischknecht, 2012), representing the short medium and long term benefits from business planning. The sustainable credentials of concrete, for instance, represent a long term benefit that is of little interest to the volume house builders who have little vested interest in their properties after day one, and respond instead to their buying public's concerns, who purportedly put sustainability low down on their agenda of key decision making factors. (P.01.1)

"Running costs from what I've gleaned over the years, if you say to someone - I mean all of us are governed by the latest standards that the government imposes so there's an equalisation there, so do you offer something better that costs more? People welcome that but they won't pay a penny for it. They are not interested in paying any more for something that will save them money in the future."

There have been many examples of this kind of disconnect between sectors, suggesting that the concrete industry would be more successful if it either tailored its message to fit closer with the motivations of its preferred clients or chose its clients to fit better with its preferred message. If neither of these proves successful, the only alternative left is to change the product on offer. This observation is relevant not only to the industry's dealings with the house builders, but also with the government legislators and the public end users. Further problems arise however where the motivations of any of these parties conflicts with the others, requiring the priority of the sectors in the decision making process to also be understood.

3.4.3 Collective inertia – the risk factor

In the conclusions drawn from the industry interviews in Section 3.1.5, it was asked why it was that the housing industry as a whole seemed unable to respond to even the most uncontested of issues confronting it, not least, the need to increase their production levels. The chronology of the research then led to the review of the government white papers, many of which concern themselves with exactly this underlying need. The intention was then to return to the interviews to see what could be learnt from their responses regarding working practices, agendas and specifically how they perceived and dealt with the process of change. Much of this information was implicitly discussed through the four key questions about attitudes to concrete, but was not at the outset seen as the main purpose behind the interviews. Recoding the data under these new categories was therefore an enlightening exercise that showed just how much further information can be gained when this is approached as an iterative process, building off the knowledge gained through the broader research.

Risk was a recurring theme brought up in many of the interviews, with the interview at the NHBC scoring highest, but what was not discussed, either in the interviews or throughout the many white papers written about the industry's inertia, was the possible connection between the two. Risk is certainly recognised as a reason for avoiding specific choices, such as CLT in high rise apartment blocks or concrete cladding elements on mainstream house building solutions, but seldom mentioned in terms of it being a debilitating factor that could be responsible for the industry's inability to innovate. This is however a conclusion that has been drawn from the review of the white papers and then further evidenced from the responses gathered from the interviews, or more specifically the house building sector. The concrete industry, overly focused as they are on the potential benefits of their solutions, are perhaps failing to recognise the practical barriers and many more less tangible barriers involved in 'changing horses', whereas the house builders approach the whole concept of change from a cost benefit perspective, where risk is seen as a major negative to be overcome.

Unfortunately for the concrete industry, those negative arguments voiced by the house builders far outweighed the material's positives, and to a large extent, this was irrespective of what that material might be. Helping the concrete industry understand and address these negatives is what this research hopes to achieve, and as with the benefits to be accrued, starts by categorising these into definable

risk factors such as a state of mind, a lack of knowledge or more tangible reasons such as the practical realities of implementation - or the financial burdens of retraining and changing supply chains. The further interrogation of the interview data (Section 3.1.7/8) along these lines resulted in the following diagram where the risk factors have been categorised into a hierarchical structure to help define what the root causes might be (Figure 3-11).

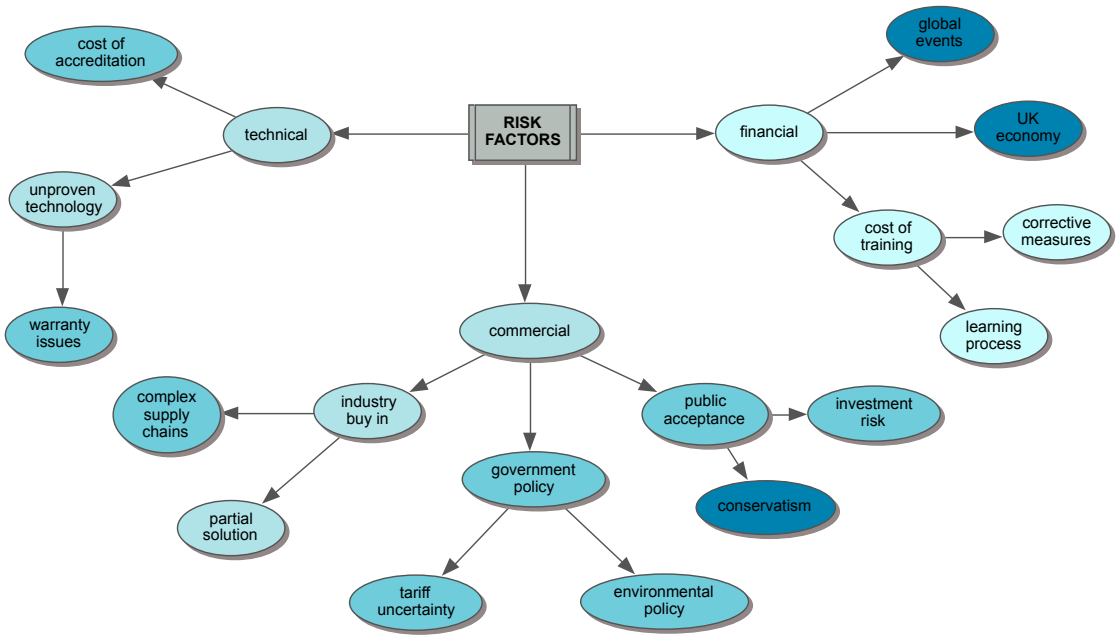


Figure 3-11 Grouped risk factors (darker colours represent those more difficult to influence)

All risks ultimately come down to financial considerations, but what defines how risky that risk is seems to depend on the level of control there is over the outcome. Some, such as the cost of retraining staff is an entirely internal calculable cost decision whereas others, such as global events are clearly background risks over which one has no control. Most risks, however, fall into a middle category where there is either an informed position that can be taken, or some way of mitigating that risk by approaching it in a certain way, but all these middle category risks involve a level of participation between sectors, whether that is government legislators, the product suppliers or the public end users. Sharing knowledge is a relatively straight forward if time consuming exercise, but the real issue, it is suggested, is about the sharing of the risk itself. This is the necessary endgame to the innovation process, and it is here that the current industry model is possibly broken. If there is a disconnect between those taking the risk and those reaping the rewards, even if that is the difference between individual risk and collective benefit within the same organisation, the innovation is unlikely to take hold (Lazonick and Mazzucato, 2013b). Our construction industry, notoriously adversarial in its constitution, is not well structured to deal with the level of co-operation needed for innovative change to take place, and this is possibly one of the root causes of the industry's inertia.

This conclusion corroborates with the findings exposed in the Farmer Review, which, without wanting to condemn the existing industry structure, implicitly suggests that the best opportunity for change

and innovation comes from the New Entrants (Farmer 2016, p.49). They are seen as having taken control of these middle category risks which have traditionally left innovating companies exposed to the whims of adversarial supply chains, government policy u-turns and fluctuating market demand. Reducing exposure to risk by avoiding the barriers rather than removing them would therefore seem to be a viable option when promoting innovative solutions.

3.4.4 Outcomes to take forwards

These three methods of research, the industry interviews, the analysis of the government white papers and the public survey, have together provided a comprehensive picture of how the housing delivery system operates as a whole. They have allowed the author to investigate the propositions put forward as a result of the initial literature review, and show in some detail where the barriers to innovation lie. The system of categorisation that at the outset divided the industry into four sectors has now been further developed to consider the benefits to be accrued and the barriers to be overcome in doing so, and further subdivided each of these in response to the information gathered from all sectors.

The accrual of benefits has been shown to be necessary, not only for the innovator, but for the client and all parties involved in its adoption. Those benefits can be defined as ones that improve quality, affordability, productivity or appropriateness. The barriers have been shown to be many and complex, requiring there to be knowledge, motivation and ability in all camps before an innovation will even be considered.

Knowledge of an innovation has been shown to be the necessary first step, whilst highlighting how deeply held perceptions can be a powerful detractor. The motivation to adopt an innovation has been shown to require engagement on the right terms across all sectors, and an understanding of what it is each sector wants to gain from that adoption. And the ability to adopt an innovation, once its benefits have been realised, has been shown to require the risks involved to be manageable and to achieve this, shared appropriately.

As well as evolving the framework for the decision making tool being developed, this process has provided a wealth of information about the different sectors' perspectives which has begun to show how the most appropriate markets can be better defined. By using these measures to assess the strength of any proposed innovation in terms of its potential benefits for all those involved, the idea being posited is that a path of least resistance should emerge, in terms of the least barriers preventing its adoption needing to be either removed or avoided, or in some cases accepted for what they are and worked around.

Where this leads to next is the development of the processes that are needed to translate the reasoning behind the industry's actions into something that can be replicated in a systematic way by any person or business confronted with a similar set of conditions to interpret. The following chapter is dedicated to the first stage in this task, of 'deconstructing' the information that has been gathered in a systematic manner, looking in turn at the viability, the feasibility and the process to be followed in both the promotion and the adoption of innovative solutions.

Chapter 4
THE DECISION MAKING PROCESS - DECONSTRUCTING THE DATA

Now that a clearer understanding of the issues being confronted has been gained from the methods of research applied to the sectors defined in Chapter 1, that knowledge needs to be dissected in order to make sense of how it differs between the sectors and how those differences might be acting as barriers to considering new technologies and innovations. Exactly how do these different viewpoints manifest themselves as barriers, and what questions need to be asked to unearth these differences? This is the beginning of the development of a Decision Making Tool, and represents the third objective of establishing which factors are influencing the decisions to either adopt or resist innovation (2.2.2). The process developed here focuses on recognizing the conflicting realities that have been found to exist and attempts to show how understanding the barriers helps define the most productive path to follow.

4 THE DECISION MAKING PROCESS - DECONSTRUCTING THE DATA

During the literature review the concept evolved of barriers to innovation beings an important and possibly overlooked element in the process of promoting and adopting new ideas. What also emerged was the recognition that overcoming those barriers was a staged process. That process began with the need to be aware of the innovation, followed by the need to be motivated to consider it and finally having the ability to follow through in adopting it. In Chapter 3 the industry interviews shed light on how much those motivations differed between the sectors being studied, and the model of the 'three dynamics of sustainable communities' – economy, equity and ecology – was used as a way of categorising those motivations. The point being made here is that whilst each are needed to deliver sustainability, in itself a key driver of innovation, any variance between the perceived importance of these drivers across the sectors of the housing industry represents a considerable barrier.

This lack of consensus over the relative importance of these key motivators can be seen in terms of the timescales being considered, as they reflect short, medium and long term benefits to be gained. It is for that reason that economy, at the short end of the spectrum, is invariably given greater emphasis than equity or ecology. This is not to say that short term financial gain should be prioritised over social welfare or the environment, but viability, however it is measured, needs to be recognised as a prerequisite of either of these other two benefits being achievable. Defining and measuring viability therefore becomes a very necessary first stage in this process.

In this chapter, the deconstruction of the data gathered, effectively 'part 1' in the development of the decision making tool, is set out as a process that mirrors the inductive approach taken throughout this research. In that respect it begins with the known benefits and the accepted need for financial viability when considering an innovation (Section 4.1), before growing this to encompass the barriers to be overcome both from the innovator's perspective and then from those of the other sectors that have an influence over the decision to adopt (Section 4.2). And finally, in Section 4.3, it looks beyond defining the pros and cons of adopting an innovation to deconstructing the actual process of enactment.

The path taken by the research and now also in the development of the decision making tool itself is defined by the mindmap in Figure 4-1 that will serve to visualise the lines of questioning followed, and again in Figure 4-2 showing the initial stages in this evolving process. The three stages shown in blue, red and green are those of the benefits, the barriers and the process respectively, and form the structural basis for the research going forwards. The correlation between the benefits and viability and between the barriers and feasibility is less well defined, but has proven to be a necessary vehicle for clarifying the arguments being made: viability, which can be defined in terms of ecology and equity as well as the more immediate economic argument, represents the benefits to be accrued for all those involved, whereas feasibility represents the practical realities that must be overcome in order to achieve this. The process, on the other hand, represents the culmination of this balancing of pros and cons, and it is hoped will define the path of least resistance that emerges as the most appropriate strategy to adopt.

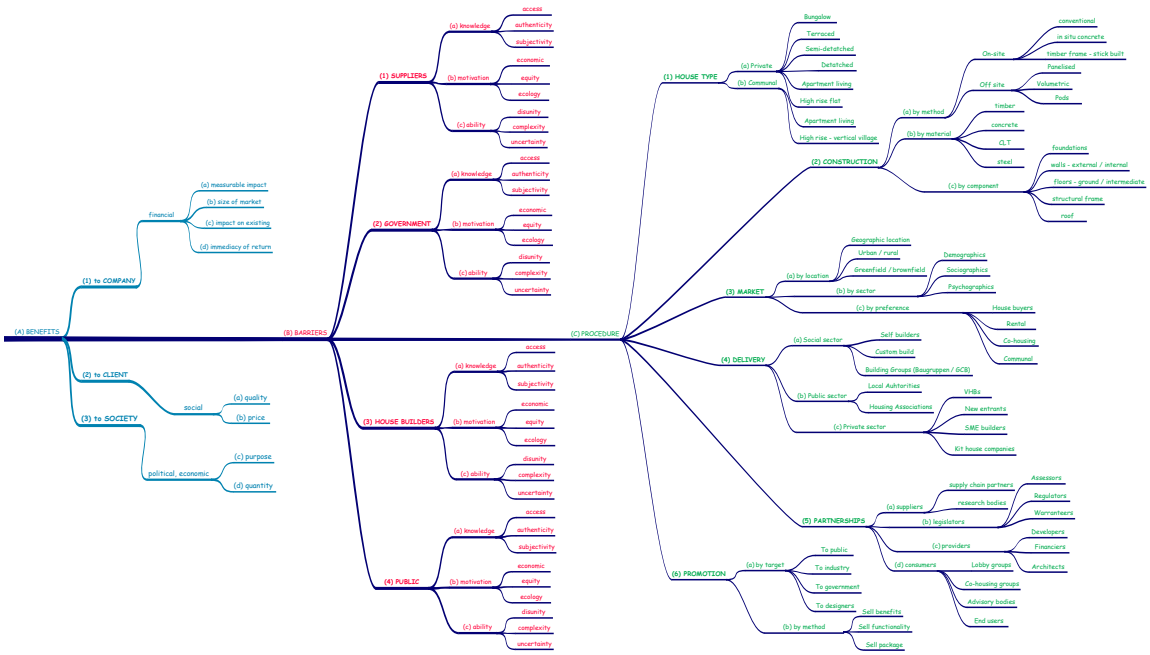
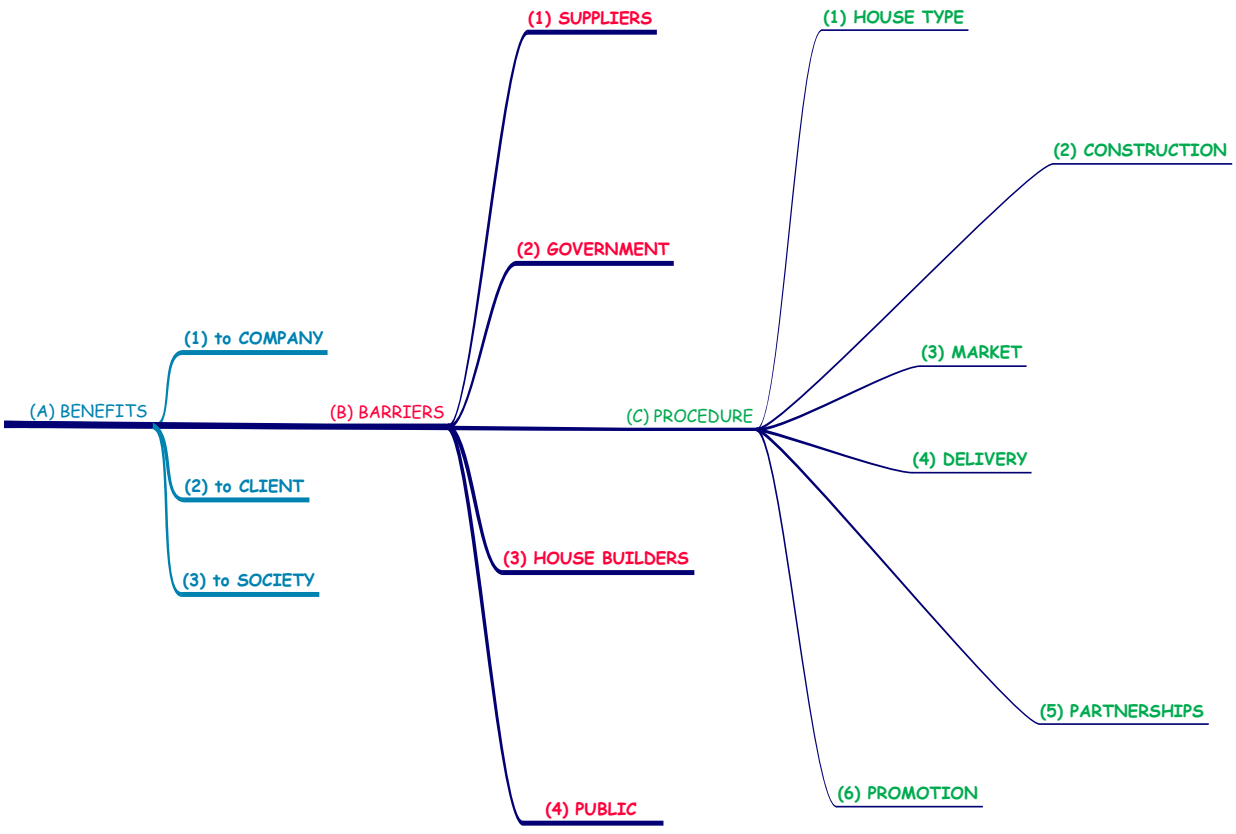


Figure 4-1 mindmap of research

benefits *barriers* *process*



viability *feasibility* *emerging strategy*

Figure 4-2 First level

The hierarchy of questions to be asked during this deconstruction can also be translated into this model (Figure 4-3) which shows the nested conditions that need to be met in terms of knowledge, motivation and ability before a successful outcome can be expected. Each of these models are referred to throughout this chapter to help visualize the argument as it develops.

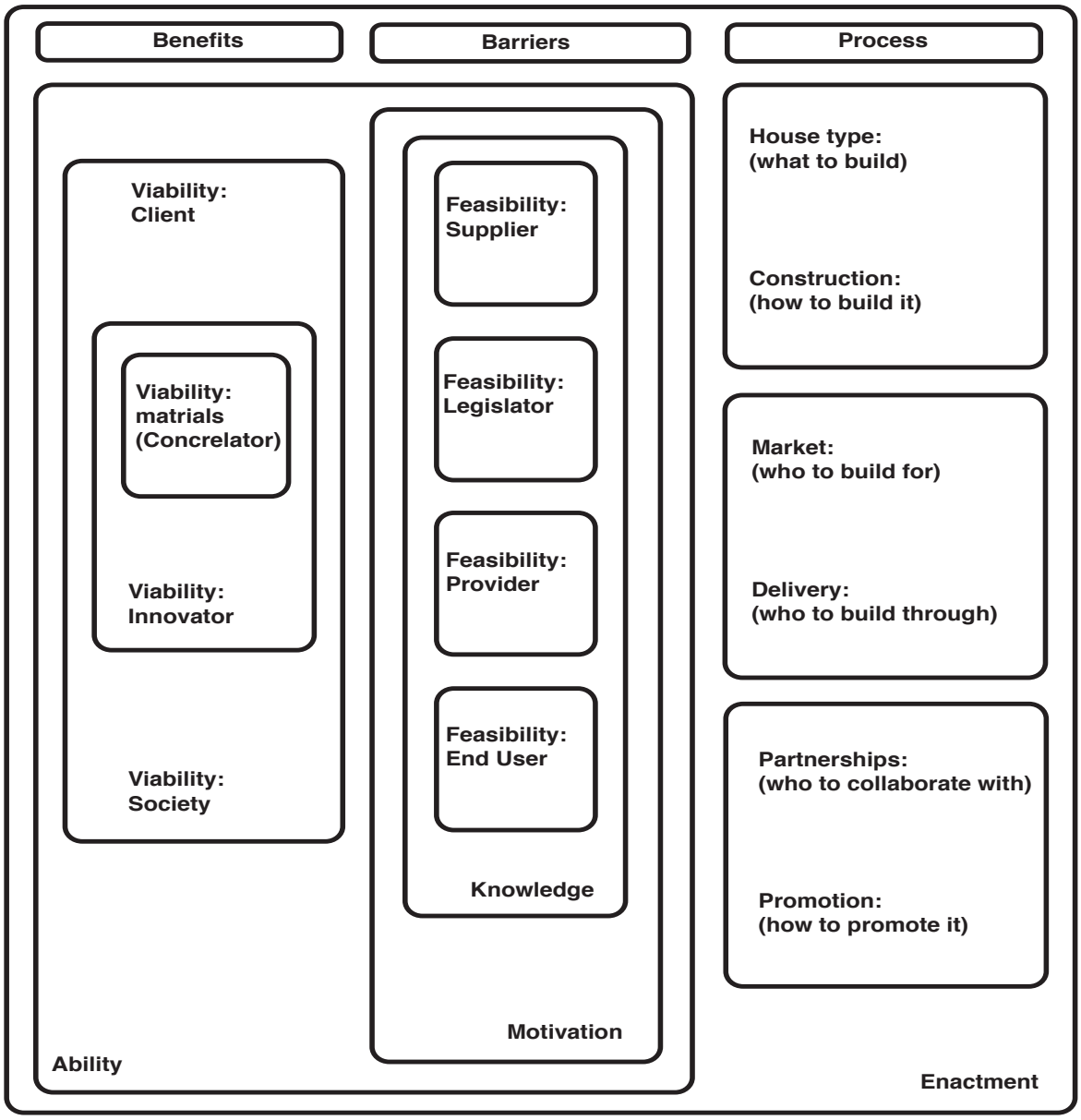


Figure 4-3 Model of the Deconstruction phase

4.1 The benefits of innovation - Measuring Viability

This section initially deals with the viability of the concrete industry's proposed product solutions by defining a baseline against which the quantities of concrete each would require can be measured. At this stage, this process has been carried out across Tarmac's entire range of concrete products used in housing. The baseline chosen was therefore a modern traditionally built house, broken down into its component parts. At a very simple level this tool was designed to calculate the quantity of materials used so that direct comparisons could be made between the financial benefit of pursuing any one marketing strategy over another. An example of this, quantified later, would be the choice of pursuing concrete beam and block first floors – currently timber – over a policy of promoting blockwork inner leaf construction over timber frame. The impact that both of these option have on the quantities of concrete used in a house was unexpected but how that information is now used to assess true viability requires viability to be defined beyond that immediate bottom line figure.

4.1.1 Viability from the innovator's perspective

An initial measure of the quantities of concrete used by volume is a necessary starting point but of little use in isolation. The value of products can vary enormously, with the volumes of concrete in strip footings and concrete piles being a clear example of how volume alone cannot be used to measure financial benefit to the supplier. But there are also many other factors beyond profit margins that also need to be considered, such as the impact of an innovation on existing markets or any unintended benefit to competing markets – again exemplified by concrete piles and the potential competition that opens up from steel piles. There may on the other hand be consequential benefits, such as a concrete beam and block floor also resulting in a screeded finish, or softer corporate image benefits by being associated with, for instance, a more durable, long lasting solution.

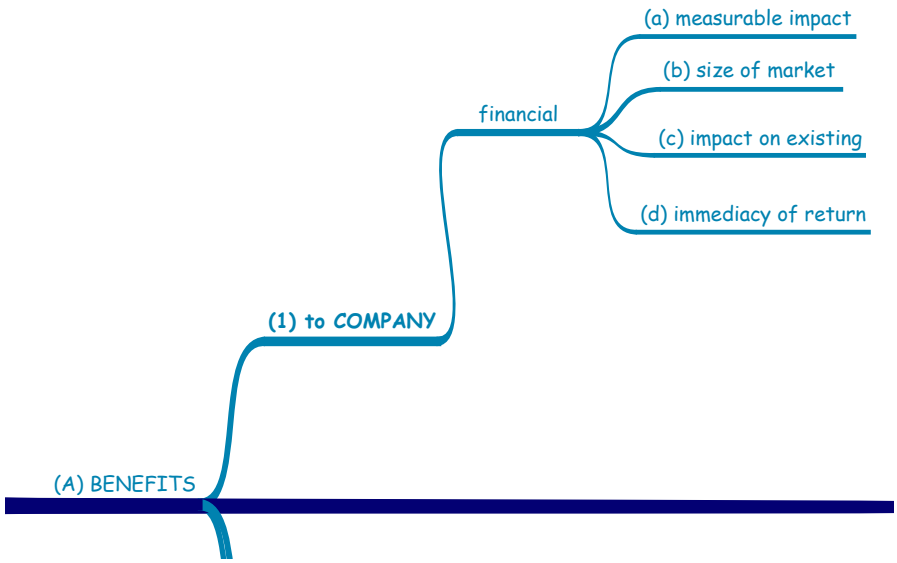


Figure 4-4 Benefits to the Innovator

All these factors can be seen to sit within a hierarchy, with the material costs forming one small branch [(A) Benefits: (1) to the innovator: (a) through measurable impact] within an expanding tree of factors to be considered. These wider issues around viability are returned to later in this chapter, but none of this negates the need to know the volumes of material involved, which is what this particular tool, now part of the greater Decision Making Tool, and christened 'The Concrelator' was designed to do.

4.1.2 Defining the baseline measure – The Concrelator.

The initial attempt to answer the question of how much concrete is currently used in the housing industry was through trying to populate a comparative dataset of how concrete is used within different sectors of the construction industry, the building industry, the residential market, and then across different methods of construction and within each element of a typical domestic construction. (Figure 4-5)

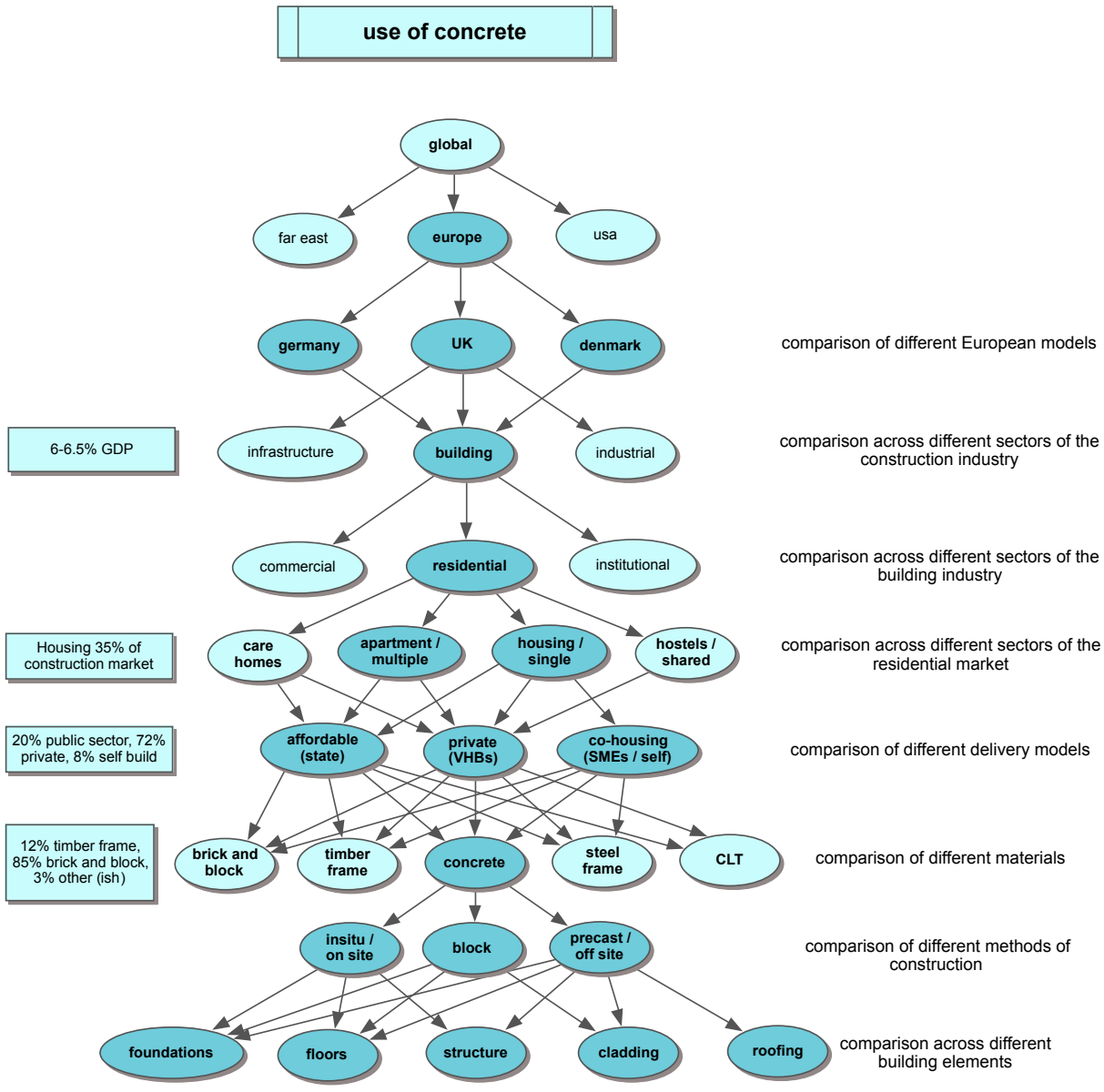


Figure 4-5 Categorisations for the use of concrete

Beyond establishing the necessary categorizations to work with however, this proved to be a near impossible task as none of the data needed could be sourced from comparable datasets, with each one tending to be from different years, based on different geographical areas, incomplete in their breadth or just focusing on the requirements of specific companies. This is in fact a knowledge gap in itself, but one that although this research has now drawn attention to it, may well be beyond the gift of any organization to collate in a meaningful way due to the fact that much of the data is not in the public domain and in no one business's interest to publish.

The second attempt, the Concrelator, focused in on the breakdown of where concrete is used within a typical house type by element, and how each of these adds to the overall percentage used. At one point this was considered to be the main output from the research being undertaken, filling a fundamental gap in the industry's knowledge base and providing new information in a database format that could be expanded to link in with other datasets if it were seen as necessary to do so.

Information is generated through a series of relational databases that draw on existing data from different sectors of the concrete industry, and combines that with HQI (Housing Quality Index) data for different house sizes based on occupancy, plus a simple set of algorithms to calculate the volume of concrete used within each element for all typical house types.

As a tool, this allows the user to compare the impact of, for instance, changing the first floor of housing from timber joists to beam and block as a percentage of the overall use of concrete within the building. This is one of many comparisons that can be easily made, and will help inform how important various markets actually are to invest time it, or equally how important various threats are from other competing industries, such as timber frame.

4.1.3 Functionality

Behind the scenes is a series of relational databases (Appendix J Structure of relational database) working together to calculate the amount of concrete that goes into typical house types. The 'front end' or user interface (Figure 4-6), is a page where the user can enter all the variables that define the range of house types, sizes and methods of construction that are typical to the UK. The information used by the Concrelator is stored in three further databases that it relates to (Figure 4-7)

House type parameters		Enter values to define typical house type and size based on occupany
Housetype	Flat	
No. of external sides	4	
No. of storeys	2	
Housetype Reference	I	unique reference for house type
No. of bedrooms	3	
No. of persons	5	
No. of storeys	2	
Internal floor area	93	calculated from HQI index figures
Ground floor area	47	Internal floor area / no. of storeys
Intermediate floor area	47	Internal floor area - ground floor area
Roof area	51	ground floor area * 1.1 (25° pitch)
External wall area	113	assumes 2.6m storey, 20% glazing
Internal wall area	113	assume equal to external wall area
Perimeter length	27	assume square footprint

Construction type		Enter values to define construction methods	
Foundations	trenchfill	hardcore?	150mm
Ground floor	beam and block, block d	screed?	65mm
Intermediate floors	beam and block, block d	screed?	65mm
External walls	BWa, BWd	rendered?	non
BW=blockwork, BR=brick, a=aerated, l=lightweight, d=dense		mortar	10mm_blockwork x2
Internal walls	thinjoint	plastered?	non
		mortar	10mm_blockwork
Roof	non	basement	basement - in-situ

Material quantities	aggregate %	aggregate quantity m³	sand %	sand quantity m³	cement %	cement quantity m³	all m³
Basement	53	8	32	5	15	2	15
Foundations	53	14	32	5	15	2	21
Ground floor	85	3	0	3	4	1	7
Intermediate floors	85	3	0	3	4	1	7
External walls	29	7	20	6	9	2	15
Internal walls	12	1	0	1	7	1	3
Roof	0	0	0	0	0	0	0
total volume of materials	total agg	37	total sand	21	total cement	9	67m3

Figure 4-6 The Concrelator Mk I user interface

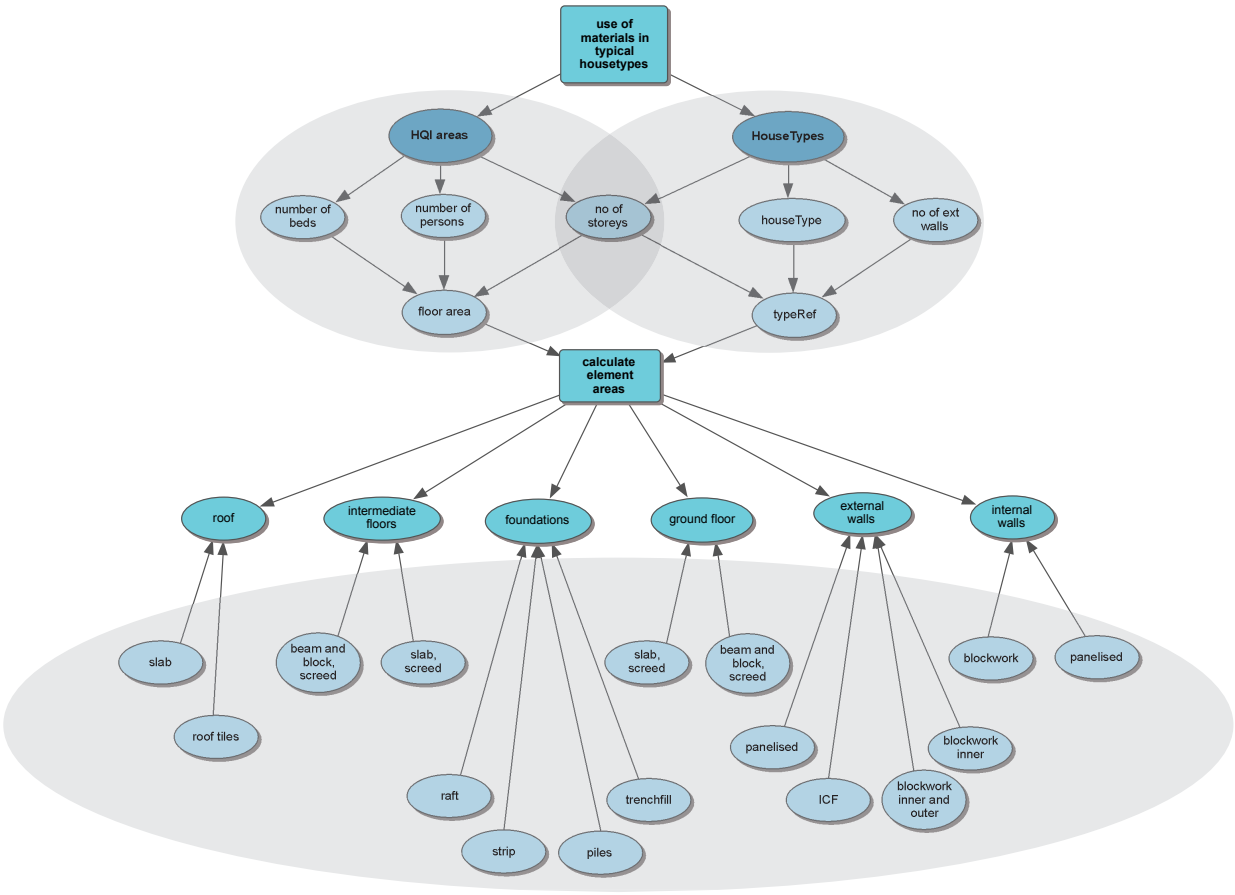


Figure 4-7 Concrelator database structure

This did not need to be a precise tool but did need to consider all the influencing factors as a way of assessing what impact certain decisions would have on the amount of concrete used in different methods of house building. Discussions were had about how the tool could be modified and honed as required, but initially, version 1 makes a number of assumptions which are explained below.

HQI areas: These are the minimum internal floor areas required by the Housing Quality Index tables for housing based on number of floors, number of bedrooms and number of inhabitants. The final figure produced in m2 is therefore an absolute minimum and can be overwritten if required, remembering that our minimum requirements are the lowest in Europe and 80% lower than the highest (RIBA, 2013).

House types: This database generates a code for each house type, based on number of floors and number of external walls - i.e.: bungalow, terraced, semi, detached, up to 3 stories. This information is then used to calculate the approximate floor, wall and roof areas. The main assumption here is that the house is square with a 25˚ pitched roof. Deciding what level of accuracy is required will be dictated by how this is used, but for now, the Concrelator has been designed for comparative purposes rather than as a precise measurement tool.

House by Elements: The final database is the one that holds all the information about the elements of construction - if they potentially include some proportion of sand cement and aggregates. The level

of detail in this database is as accurate as can be using the information available, and again involves a number of assumptions. Concrete mixes vary, additives and admixtures abound and the building materials themselves come in many different dimensions. All these can be fine tuned, but currently, for instance, concrete blocks are all 100mm in width, and are either dense, lightweight or aerated. A factor for density has been added, as the volume of materials used alone would skew the output with aerated blocks for instance having 25% the density of mass concrete and therefore using less materials.

The end result therefore, is a list of volumes weighted for density, and broken down by element (foundation, ground floor, external wall, etc.) and also by composition (sand, cement, aggregates and additives). This allows for a number of comparative studies to be carried out, between house types, or house sizes, construction methods, material use above / below ground, etc.

Appendix K Sample outputs from the Concrelator shows some example outputs with a brief description of each one. It shows how the amount of concrete in a brick and block .v. a timber frame house varies by less than 5% whereas the amount of concrete in a 4 bed bungalow is twice that in a similarly built 4 bed semi - if you have a ground floor concrete slab.

4.1.4 The Concrelator in use

The Concrelator has been designed to allow for further development. The addition of a building price index would allow for the cost implications of any proposal to be assessed, whilst the addition of thermal values to elements would allow for running costs and pay back periods to be considered. The principle of this tool being a series of relational databases is to allow for existing data sources to be used rather than recreating new data sources where they already exist. Not all data sources are in the public domain, however, so it may not be possible to develop the tool without the co-operation of other parties. The addition of thermal values for instance, would require the U-values of each component to be added into the database structure, but the danger here is that the results would be crude and potentially misleading without going to great lengths to effectively recreate the SAP calculation algorithms, which are themselves seen as an over simplification of the as-built realities.

It was agreed therefore, that whilst this would be a useful addition to the tool, especially for the concrete industry, because of their need to convince the housing industry about the benefits of thermal mass and decrement delay (Section 6.1.4), this would realistically require them to have access to the existing SAP calculations, something that the author has established to be an unlikely outcome. Applying the principles behind this research, however, it was instead decided to pursue an alternative route of enquiry where there were mutual benefits that would help drive this line of enquiry:

The primary role of the Concrelator is to establish the quantities of concrete used within each element of the building. One potential benefit of this would be to compare the energy consumption in two properties, one lightweight and the other heavyweight, and in permutations of these based on the thermal mass's location within the construction. The BRE (Building Research Establishment), current custodians of the SAP procedure, are willing to consider that their static software might not be delivering an entirely accurate picture of the benefits of thermal mass, but are unable to extend its

functionality without there being a requirement within the Building Regulations for this to be addressed.

"A simple dynamic version of SAP is one possibility being looked at for the next but one version. I understand that they [DCLG] feel they are very limited because the legislation in place does not cover overheating explicitly and they are therefore powerless to go much further than they have until that is changed, perhaps by amendment of the building regs to add a new 'part' specifically targeting overheating. There is currently a review of the building regulations going on, so it is possible this will happen – but I have no insider knowledge on that. If they want to implement this as part of the SAP calculation we would be very happy to redesign the methodology accordingly and do a much more thorough job." (Henderson, 2017)

For the Building Regulations to be amended to show the true impact of overheating, the government not only requires evidence (the knowledge), but they need there to be a body of opinion demanding change (the motivation) and they also need to know that there is a viable solution to deliver this change (the ability). It is therefore the concrete industry's task to remove these barriers, and it must do this to enable the SAP assessment to be improved to show how thermal mass could provide the solution that is needed to deliver low tech, low energy housing.

This digression from the main purpose of the Concrelator is to show how important financial viability is in driving change, and also how the need to drive change drives the need for collaboration. In order to gather the evidence the government needs to prove the need for change, the concrete industry needs to collaborate with others with similar agendas. In this instance, EDSL, a company already using their dynamic modelling software in the commercial marketplace are keen to break into the residential market, and are therefore also keen to show the limitations of static modelling. The proposal put forward was therefore to use their software to calculate the heat loss parameter for a development of prototype concrete housing being proposed by Tarmac PLC and then convert that output for SAP, thereby giving a direct comparison between the two methods. By then changing the digital design to a lightweight construction and re-running the calculations, the potential for thermal mass to reduce the instances of overheating could be measured, something that SAP cannot register. This would then give the government both the evidence of the benefits of thermal mass and the solution to the problem of overheating, leaving only the issue of motivation to contend with. A brief explanation here of how the process that is being developed works in practice helps explain both the scope of the Concrelator as a tool for providing quantitative data and the validity of the overall approach being proposed.

4.1.5 Validating the Concrelator

Validating in this sense was more a case of assessing the accuracy of the assumptions used in the calculations, and then fine tuning those calculations where necessary. The tool was initially designed for comparative purposes only, so any inaccuracies in calculating volumes or surface areas were seen as less critical to the information being gathered. Before deciding on the need for more detailed definitions of components, therefore, such as adding a choice of roof pitches, the impact of the existing inaccuracy had to be measured. This process exposed a number of areas where more detail

was needed, such as the introduction of party walls as an additional element, the ratio of width to length of the footprint as this was used to calculate external wall areas, and percentage of external wall as fenestration. Rather than continuously growing the list of parameters available it was decided to create a separate process for defining specific house designs that could then be programmed in as preset solutions.

This addition would allow the proposed validation of Tarmac's prototype housing to be carried out and compared against a lightweight version of the same design. The results of this are awaiting the final design solutions to be agreed and will be taken forwards when possible.

It is worth noting however the impact that such baseline measures can have on the decision making process. As shown in the example above, the ability of the concrete industry to influence the government's decision whether or not to change its assessment procedures is primarily dependent on the empirical evidence the concrete industry can provide: What is the reduction in energy use that could be expected from adopting a thermal mass approach? What house types would this be most appropriate for? What percentage of the total housing stock does this represent? Would the returns justify the effort involved? The Concrelator is central to answering all of these questions, but more important are the other changes that can be brought about as a result of this one change in the assessment procedure being adopted, many of which are discussed in the case studies in Chapter 6.

It was this realisation that whilst the information gained from the Concrelator could be beneficial in dealing with far wider issues, it was not in itself information that would have any meaningful impact on the use of concrete within an industry context. Those decisions were far more complex and would involve far more information being fed into the equation, and drove the research forwards to investigate how those wider issues could be captured, starting first with those relating to viability.

4.1.6 Viability in the broader context.

As stated at the beginning of this chapter, the measure of viability of an innovation goes far beyond the bottom line cost of materials or products sold, and can be heavily influenced by opinions held in the other sectors. Beyond the consequential benefits suggested earlier, the strength of the market being pursued in promoting a new product can also impact on the viability of a strategy. It's size, growth potential, how fragmented it is, and its exposure to economic cycles are all considerations to weigh up against the costs involved in taking a product to market. Immediacy of return on an investment, in terms of development and accreditation times, the likely rate of uptake, reskilling and retooling costs, not just for the supplier but also the customer, can all impact on what might initially appear to be a viable proposition.

The additional factors put forward here for consideration stem from the industry interviews and the knowledge gained from talking to all sectors about their measures for viability. Through coding their responses and letting the categorisations emerge, the four main reasons given to innovate were:

to address our chronic housing shortage	*Quantity*	↗
to commit to our sustainability agenda	*Quality*	↗

to provide more affordable housing	*Price*	↘
to build more appropriately for our changing demographic	*Purpose*	↗

Quantity, quality, price and purpose. As with all priority lists these represent a set of often conflicting requirements, and also ones that were prioritised differently across the sectors. A further subdivision of benefit to the client and benefit to society as a whole defines Quality and Price as benefits for the client whilst Quantity and Purpose could be construed as more socially orientated.

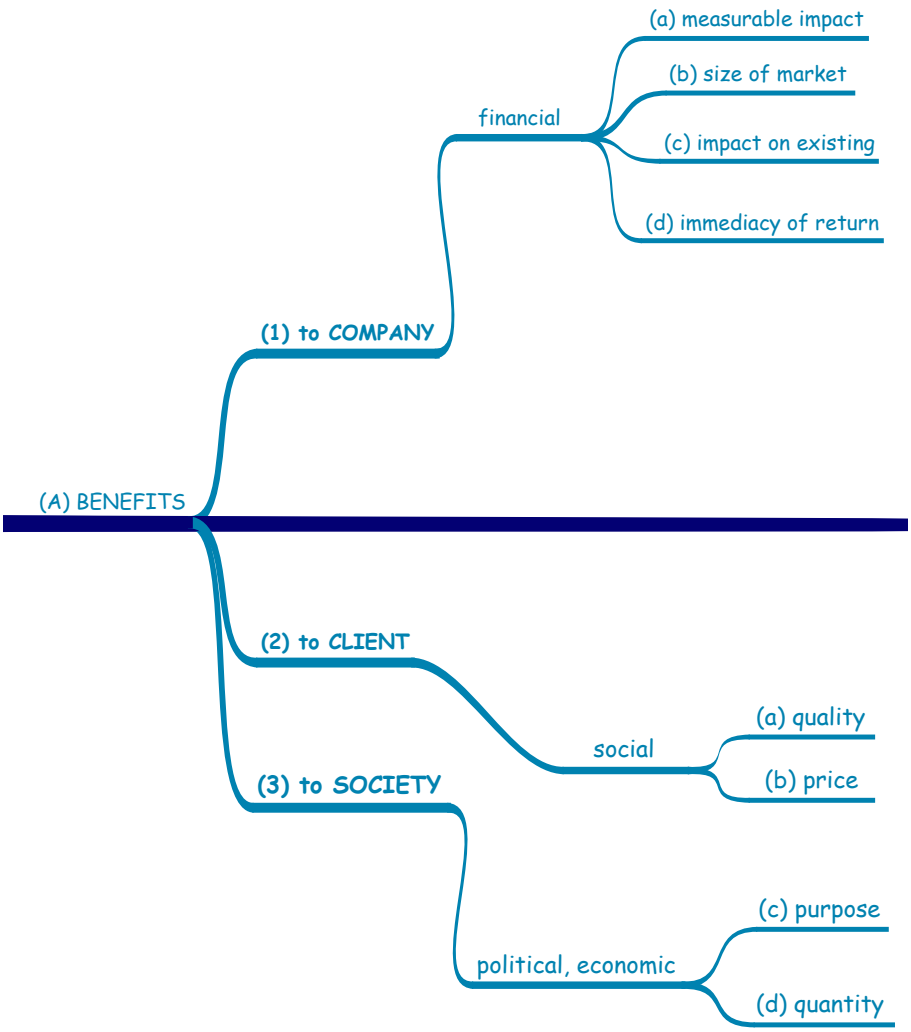


Figure 4-8 Benefits to all parties

In an ideal world, all four of these factors would represent the government's agenda, although in reality we might also have to add:

the need to get re-elected.
the need to maintain a majority of voting property owners.
the need to keep public spending to a minimum.
the need to keep their financiers compliant – whoever they might be.

The purpose of this exercise is to highlight the conflicts of interests that exist when defining a benefit and why it is necessary to approach each factor independently and also from the perspectives of each sector before reaching a conclusion about the overall viability of an innovation. A similar exercise can be carried out from the perspectives of the general public and the volume house building sector, which produces further alternative realities:

The General Public:

the need for more choice of housing where it is needed	*Quantity*	↗
the need to reduce running costs	*Quality*	↗
the need to get value for money	*Price*	↘
the need for housing appropriate for different lifestyles and stages	*Purpose*	↗

The Volume house builders:

the need to control supply and demand to maintain profit margins	*Quantity*	↘
the need to resist government policies for increased standards	*Quality*	↘
the need to find new ways to maximize profits	*Price*	↗
the need to focus attention on those who can afford to buy	*Purpose*	↘

Even at this basic level, it can be seen that the volume house builders' agenda is at odds with the public's and society's needs. As for the government's agenda, that is far more conflicted and requires deeper analysis. None of this, however, is revelatory:

"The high volume homebuilders dominate the market and are therefore able to shape how it operates. Having purchased land at a given price and devised a scheme that will allow them to recoup their investment and deliver a profit, they will not risk over-saturating a local market to the extent that house prices will fall and their profits decrease. This is rational commercial behaviour and a sound business model. But it is not one that is in the country's best interests." (Communities and Local Government Committee, 2016)

"If we are to plan, we have to plan with plannable instruments. The speculative builder, by his very nature, is not a plannable instrument." Aneurin Bevan, secretary of state for health and housing 1945–51. (Archer and Cole, 2014)

The government agenda is nevertheless, failing to influence the decisions being made regarding the drive for innovation within the house building industry. The first purpose of this tool is therefore to categorise these alternative definitions of 'benefit' so that they can be assessed and ultimately measured in relation to each other. That process of categorization however can only come from a deeper understanding of the divisions that exist, which for this research is an inductive process starting with the literature search and continuing through the research into the wider industry perspectives. As a deeper understanding is gained, further subdivisions become necessary to define the options that need to be considered.

The ‘General Public’, for instance, comprises many conflicting viewpoints of its own, many of which, especially regarding the need for more housing, will change over time:

Home owner – favours a limit supply to protect investment

Aspirational home owner – favours an increase in supply to reduce house price to allow entry

Resigned renter – favours an increase in supply to bring down rental values

In this scenario, the aspirational homeowner will at some point become either a home owner or a resigned renter, and from a personal perspective their opinion on the need for more housing will change accordingly. This is central to the how this tool needs to perform, and also helps to explain the often conflicted governmental position on such issues. All the positions held within each sector as outlined above are fluid because they are all inter-related, and those relationships need to be part of the model being developed.

For now, Table 4:1 shows the categorisations being proposed. The decision to make these the divisions as opposed to the four industry sectors previously adopted came about through the knowledge gained from the industry interviews. The innovator is invariably the supplier, the client is primarily the provider of the housing, although ultimately for the benefit of the end user, and the societal need is or should be the remit of the government, albeit again for the benefit of the general public. All three of these sectors can be further subdivided, and there are housing providers who have very different remits to that of the speculative builders, not least when the housing is commissioned directly by the end user. For this reason ‘client’ and ‘society’ were seen as a clearer divisions to use in this instance.

Sector	Benefit	measures	Questions
Company			**How will it benefit the company?**
	financial	measurable impact	what are the baseline measurements for benefits irrespective of all external considerations
		potential	what is the size of the market, how fragmented is it, how stable is it, how accessible is it
		impact on existing	how will this effect exiting markets and complementary markets, and will it open up competition from others
		immediacy of return	are returns immediate, certain, direct or long term, dependent on others and for the benefit of the industry as a whole
Client			**How will it benefit the customer?**
	social, economic	quality	is there an improvement in quality to be gained, is there a demand for it, and where is that from
		price	is there a financial benefit to the cost of housing, either directly or in terms of whole life costing
Society			**How will it benefit society?**
	social, political, economic	purpose	does it address a need in our housing provision, in terms of changing demographics, social cohesion, resilience, etc.
		quantity	will it result in an increase in the quantity of housing delivered through increased productivity, new resources of material, labour, methods of construction

Table 4:1 Benefits of Innovation

The purpose behind deconstructing the information gathered from this research is so that these complex problems can be broken down into a series of binary questions that can then be considered in turn. For now that is the exercise being undertaken, with the divisions used to do this being led by the evidence gained from across the housing delivery system. The tool, as it develops will need to allow for these subdivisions to be altered and added to, and will also need to introduce some form of comparative analysis, all of which forms the second phase of the development covered in Chapter 5. But before that process of analyzing the deconstructed data can begin, the same process of deconstruction needs to be applied to the barriers to innovation as has now been done for the benefits to be gained.

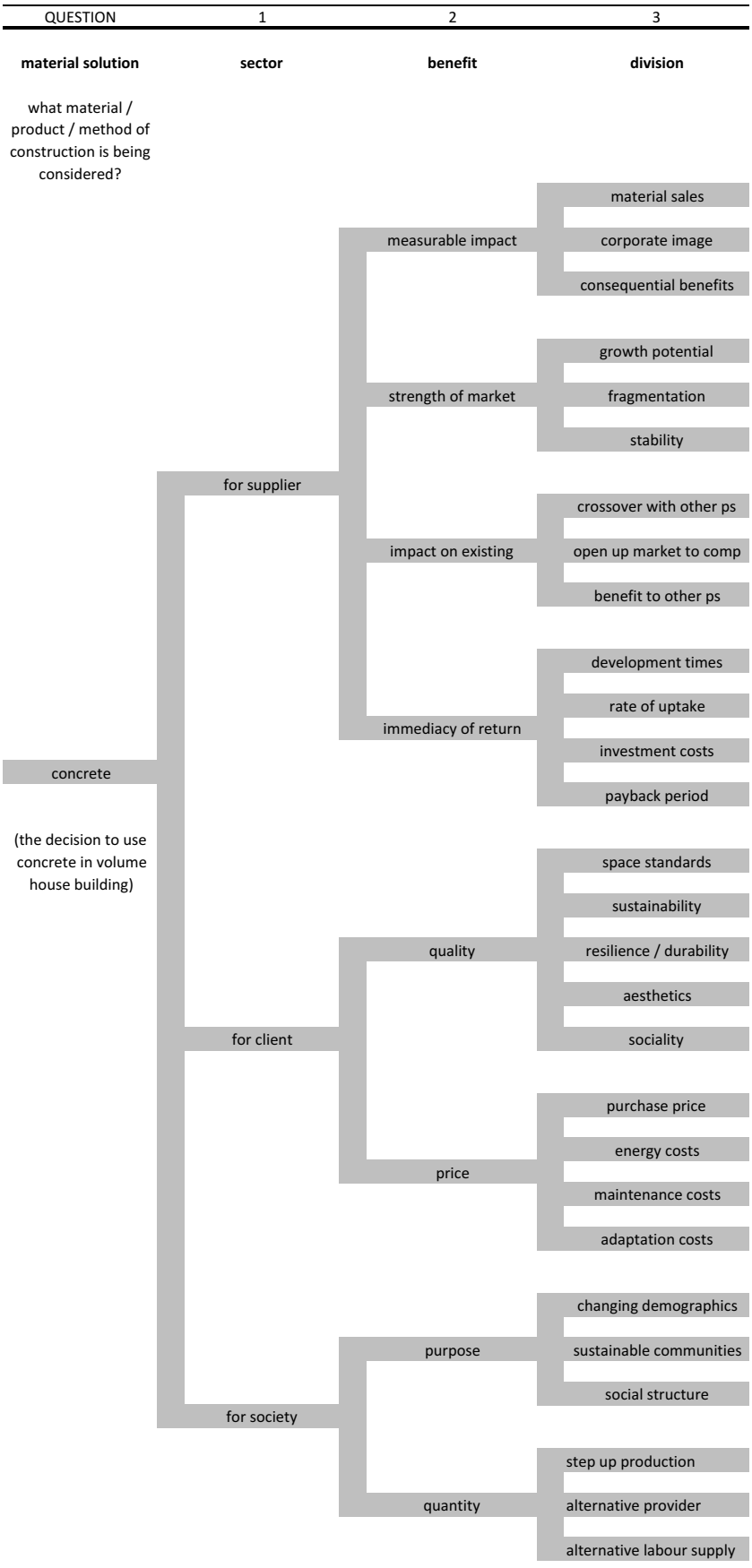


Figure 4-9 Viability measures defined for development of the Decision Making Tool.

4.2 The barriers to innovation - Measuring Feasibility

The feasibility of either promoting or adopting an innovative solution could be defined as a measure of the practical realities that must be overcome in order for all those involved to benefit. The model, repeated below, shows how this ultimately will also encompass viability as a measure, as the ability to follow through with an innovation will, when all else has been resolved, become a financial decision. Before that decision making stage has been reached, however, there are other barriers that were identified as a result of the literature review: There has to be knowledge of the innovation, and there has to be some motivation to consider it, not just in terms of the client, but all sectors influencing that decision. This therefore forms the structure for the next stage of the tool's development – how to categorise these barriers, so they too can be assessed and ultimately measured in relation to each other.

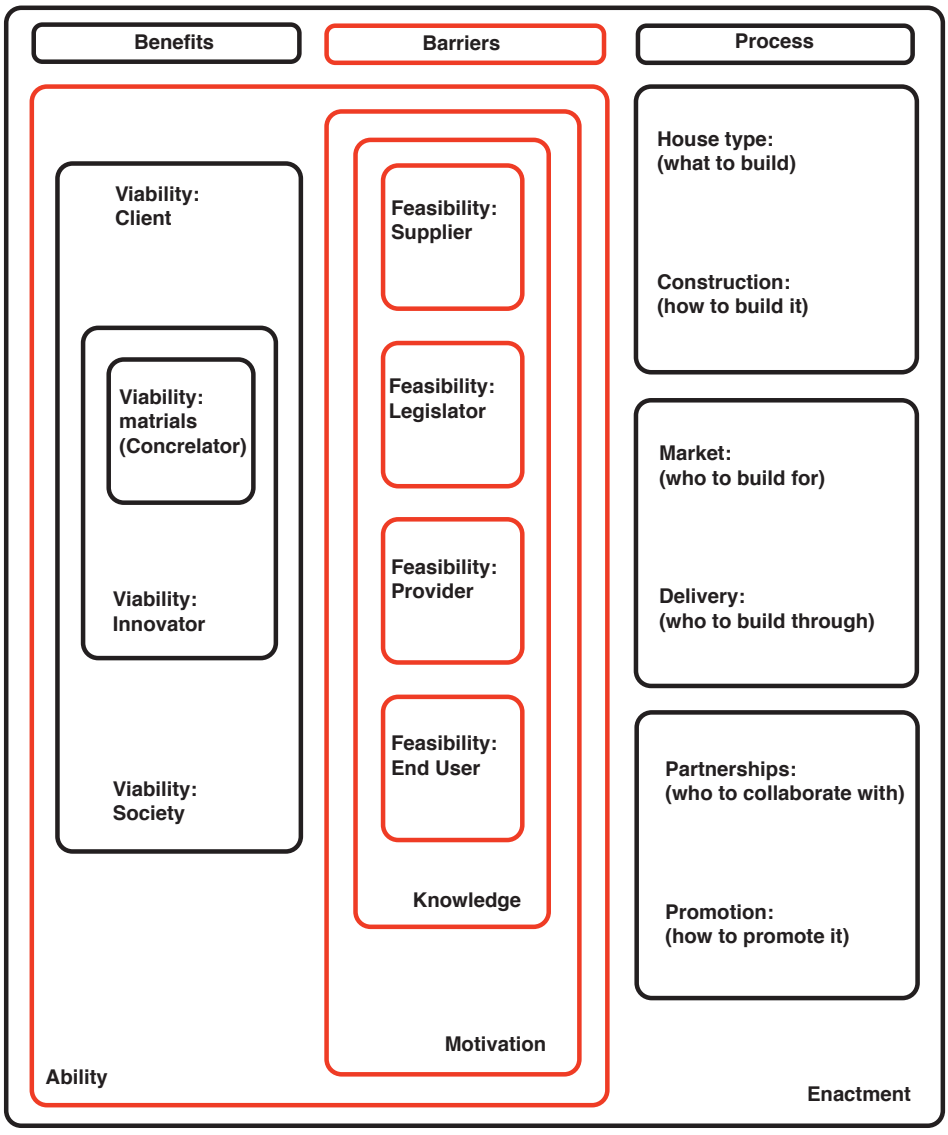


Figure 4-10 Model of the Decision Making tool - the barriers to innovation

Again there is a structure to how the barriers to innovation can be broken down further into a more manageable set of conditions to be considered, and the divisions suggested here stem from the knowledge gained from the industry interviews and additional research covered in the case studies in Chapter 6.

K**nowledge** held has been investigated for its veracity, its source, the depth of understanding, and is later shown to often fall short of what would be deemed adequate as a basis for sound decision making. The term 'perception or reality' was first used here but later re-categorised to include access to knowledge as a potential barrier alongside its accuracy and subjectivity or bias.

Motivation to consider an alternative solution has been looked at from the perspective of short, medium and long term benefits, often referred to as 'the three Es' of economy, equity and ecology, or the financial, social and environmental drivers that are either subliminally or actively considered when confronted with an alternative option to the status quo.

Ability to follow through with a decision, once the understanding and the motivation have been established, is the final barrier to be addressed, and this in turn has been investigated in terms of the individual risks being taken when measured against the potential rewards to be gained if successful. These risks were later redefined as those that are internal to the organization, industry wide or associated with the broader economy.

Table 4:2 shows these steps together with the first level of questions that are proposed as ones that stem from this process. Again, as with the benefits defined in the previous section, the barriers can be depicted graphically in a way that begins to suggest how this deconstruction process can be structured as a decision tree where each component part of the problem has a defined location (Figure 4-11).

Sector	Barrier	measures	Questions
Supplier			**Question both own and competitors' position**
	Knowledge	access	which suppliers are competing in this market?
		authenticity	How much is known about products, development programme,
		subjectivity	lobbying power, promotional methods?
			Which markets are being focused on?
	Motivation	economy	what is the business model?
		equity	Is it driven more by profit, compliance or ethics?
		ecology	
	Ability	disunity	Capability to deliver a solution.
		complexity	What are the internal and external risks and how are they managed?
		uncertainty	Dependency on government policy decisions.
Legislator			**Question how well you understand the system and how it operates**
	Knowledge	access	Knowledge of legislative requirements.
		authenticity	Understanding of an innovation's benefit to society.
		subjectivity	Knowledge of the government processes involved in lobbying for change.
	Motivation	economy	What are the government agendas to focus on?
		equity	What aspects of the innovation relate to those agendas?
		ecology	Which departments are responsible for those agendas?
	Ability	disunity	How able is any dept. to back an innovation?
		complexity	Which departments are most influential in that decision?
		uncertainty	How vulnerable is that support to political / economic change?
Provider			**Question your knowledge of their perspective**
	Knowledge	access	How much does the market know about the product?
		authenticity	Where does their knowledge come from - is it reliable?
		subjectivity	Are competing products being promoted accurately?
	Motivation	economy	What are the key motivating factors that will dictate whether or not
		equity	that sector of the market would consider the innovation?
		ecology	
	Ability	disunity	What are the financial barriers to adoption that might prevent uptake?
		complexity	How many parties are involved in the decision to adopt?
		uncertainty	How much risk is associated with future uncertainty?
Consumer			**Question how much you know about what constitues the public**
	Knowledge	access	What sector of the public is being targeted and how big is it?
		authenticity	How much to they know and how can they be reached?
		subjectivity	How influential are they in the decision making process?
	Motivation	economy	What are the drivers that will attract public interest and in which
		equity	sectors?
		ecology	Which sectors are most alligned with the innovation's benefits?
	Ability	disunity	What are the perceived risks that will prevent the public from
		complexity	considering alternative solutions?
		uncertainty	How much protection can be given against future events?

Table 4:2 The Barriers to innovation defined

QUESTION	1	2	3	4	
material solution	**sector**	**barrier**	**option**		***definition***
what material / product / method of construction is being considered?	what sectors in the housing delivery system are influencing the decision to adopt?	where are the barriers to that adoption?	to what extent are these creating barriers to adoption?		*interpretation for each sector*
concrete (the decision to use concrete in volume house building)	1 supplier	1 knowledge	2 access to facts	**2**	*level of knowledge of own product, competing products and market*
			misinformation (authenticity)	**0**	
			perception (subjectivity)	**0**	
		motivation	need for: financial benefit	**0**	*company's business strategy, marketing campaign information*
			social benefit	**0**	
			environmental benefit	**0**	
		ability	internal agreement	**0**	*company's risk management within the business, the housing industry and the wider economy*
			collaboration levels	**0**	
			future predictability	**0**	
	government	knowledge	access to facts	**0**	*government's awareness of credentials of product in context of alternative solutions*
			misinformation (authenticity)	**0**	
			perception (subjectivity)	**0**	
		motivation	need for: financial benefit	**0**	*government's awareness of benefits that could be gained from the use of the product*
			social benefit	**0**	
			environmental benefit	**0**	
		ability	internal agreement	**0**	*government's ability to manage it's party's agenda, the political agenda and the wider economy*
			collaboration levels	**0**	
			future predictability	**0**	
	house builder	knowledge	access to facts	**0**	*the housing industry's level and reliability of knowledge about the product*
			misinformation (authenticity)	**0**	
			perception (subjectivity)	**0**	
		motivation	need for: financial benefit	**0**	*the housing industry's motivations to consider using the product*
			social benefit	**0**	
			environmental benefit	**0**	
		ability	internal agreement	**0**	*the housing industry's ability to deliver the product in the context of internal, industry and external influences*
			collaboration levels	**0**	
			future predictability	**0**	
	end user	knowledge	access to facts	**0**	*the public's level and reliability of knowledge about the product*
			misinformation (authenticity)	**0**	
			perception (subjectivity)	**0**	
		motivation	need for: financial benefit	**0**	*the public's motivations to consider using the product*
			social benefit	**0**	
			environmental benefit	**0**	
		ability	internal agreement	**0**	*the public's exposure to risk at an individual level, the industry's reluctance to insure, and a cyclical economy*
			collaboration levels	**0**	
			future predictability	**0**	

Figure 4-11 The barriers to innovation: Feasibility measures defined

4.2.1 Understanding risk's impact on feasibility

In Chapter 1 the three causes behind risk were categorised as internal risks, (disunity), industry risks (complexity), and external risks (uncertainty), and through the findings from the industry interviews it was recognized that not all risks can be removed – sometimes they have to be accepted and avoided, and sometimes they just have to be accepted and factored in. It was also recognized that these risks become more difficult to address the further removed they become from the source and the more that collaboration within the industry and the wider economy were needed to overcome them. This progression from simple to complex, or internal through to wider economic issues has been used here to look at these causes, and has also been used in Chapter 6 where case studies have been used to validate the theories being posited. The first section here therefore starts with the awareness or knowledge held of an innovation within the organisations involved, and how a lack of that knowledge can constitute a barrier.

***Internal risks**, caused by a lack of **knowledge**, leading to **disunity** of purpose. Representing barriers to be **removed**.*

Risks at an individual business level are relatively straightforward to calculate, if difficult to counter. Whether or not to adopt a new technology will tend to involve a measurable cost, due to retraining, the purchase of new equipment, or a promotional campaign to sell the new product being produced, not only to the client but to the workforce involved in its production. (Keizer and Halman, 2007) discuss the dangers of not achieving collective buy in, by failing to explain the reasons behind the decisions being made. This lack of knowledge can show itself in unexpected ways and potentially scupper an otherwise sound business decision. By way of example, one of the major volume house builders carried out a series of studies into modern methods of construction and tested, amongst other solutions, large format blocks. The bricklayers found the blocks easy to lay during the trial, but when rolled out they were found to be unsatisfactory. Only later did it become clear that some bricklayers had purposefully created problems on the misapprehension that laying larger blocks would mean less blocks per house and consequently less income for them as individuals.

Internal risks can therefore be defined as risks than can be resolved without the co-operation of others outside the organisation, and tend to involve the dissemination of information to ensure all are on the same page. This also includes ensuring that there is evidence of proposed clients demanding the product being developed. Business failure statistics abound, but failing to establish that a need exists before going into production is often cited as a major factor – something that the off-site manufacturing sector is even now in danger of repeating (Chevin, 2017). So the first measure of risk is one of knowledge awareness.

Industry risks**, caused by conflicting **motivations**, due to industry **complexity**, resulting in lack of progress. Representing barriers to be **avoided.

Risks being confronted by the housing industry as a whole are harder to deal with than internal issues because of the high levels of fragmentation and direct competition within the industry. In this highly complex environment risk can become debilitating (Lutzenhiser, 1994), as companies are increasingly expected to take substantial individual risks for a possible collective gain, as for instance, in the drive towards the wholesale market adoption of BIM. It is at this industry level that risks are easier to avoid than they are to remove, meaning the avoidance of markets that are not compatible, or do not contain enough mutual benefits to balance the risk / reward equation. Conflicting motivations ultimately lead to unstable market conditions as one or other party seek out a more beneficial solution, as would appear to be the case with the volume house builders abandoning off-site manufacturing at the peak of a boom period in the economic cycle, discussed in Chapter 5. Put simply, collaboration with similarly motivated parties within the housing delivery system is key to de-risking the industry, as it reduces the number of adversarial transactions required to complete the house building process (Callcutt, 2007, p. 29). The second measure of risk is therefore levels of collaboration and mutual benefit.

***External risks**, resulting in an **inability** to act, due to **uncertainty** about the direction of travel. Represents barriers to be **accepted**.*

This third tier of risk exists at a level that transcends the housing industry itself and is therefore the hardest to manage. Political and economic conditions are nevertheless key to the success of an innovation and cannot be ignored. Neither can they be completely avoided, without operating at a national or even a global level. Changing these macro conditions under which the industry operates is not an impossibility, but it does require a whole new level of collaboration that requires time and a level of dedication that needs to be fully understood at the outset. The alternative solution, which is very different to ignoring these issues is to accept them as 'immovable' and factor them into the equation as such. In this way, even if these factors are negatives - they are no longer uncertainties as they have now been allowed for, thereby reducing the level of risk they contain. It is also worth noting that there is a difference between uncertainty and volatility at an economic level. The cyclical nature of our economy is not in itself a detriment to innovation if that cycle can be predicted and allowed for (Roper & Tapinos 2016). Taking a calculated risk is very different to taking a chance, making the third measure of risk, future predictability.

4.3 The Process of Enactment

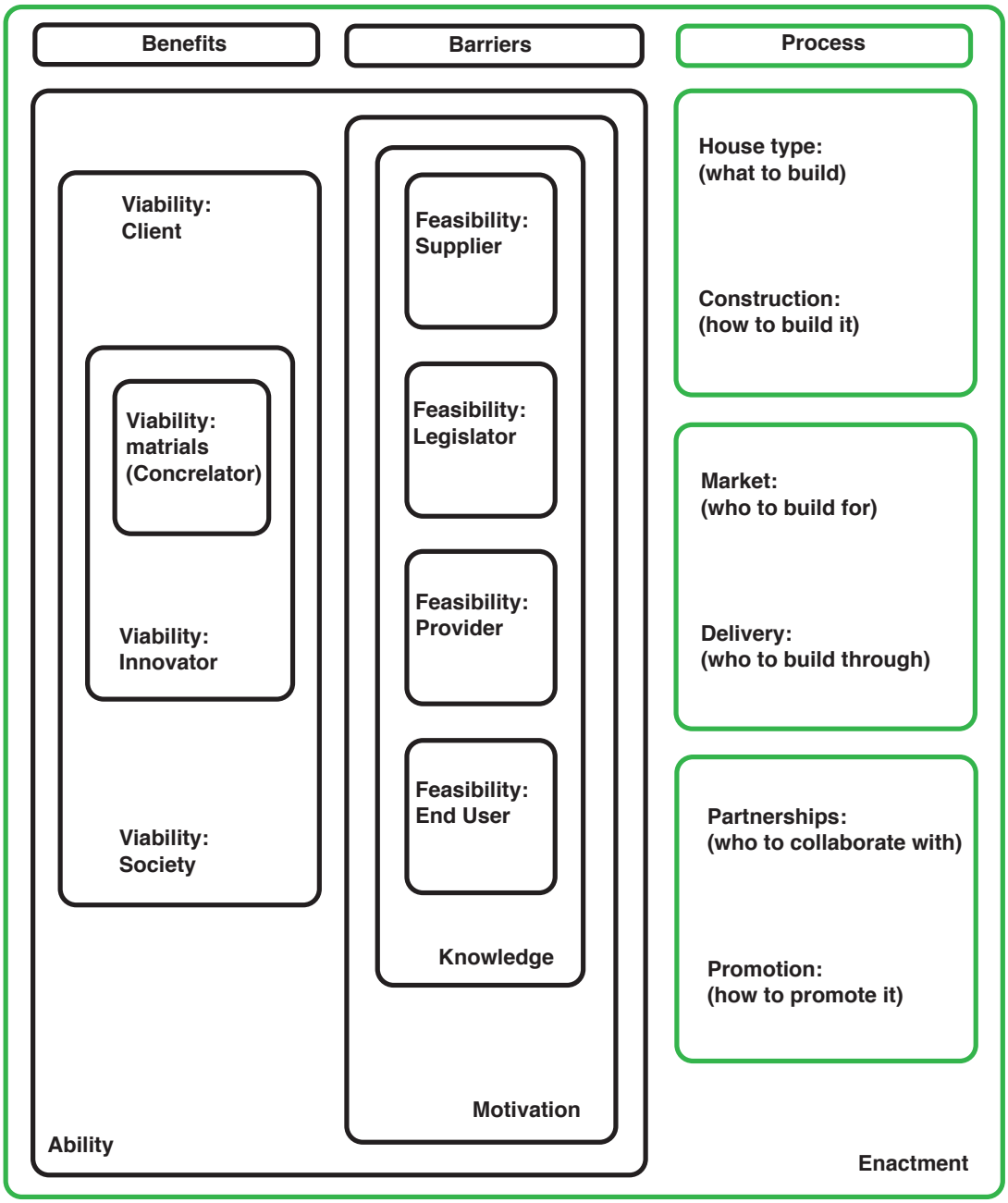


Figure 4-12 Model of the Decision Making tool - the process

The creation of a third model linked more to the building process than to the balancing of pros and cons was investigated as a way of defining the practical decisions that have to be made as part of the housing delivery process (Figure 4-13). The aim here was to provide a semi linear process that would operate in a similar fashion to the previous stages in that it would provide an exhaustive list of factors to consider but from a more practical perspective. It was also envisaged that this would follow on from defining first the benefits to be realised, then the barriers to overcome, before applying this new knowledge to a specific scenario - development, housetype, client, planning condition – with the emphasis on whichever influenced most the choices to be made.

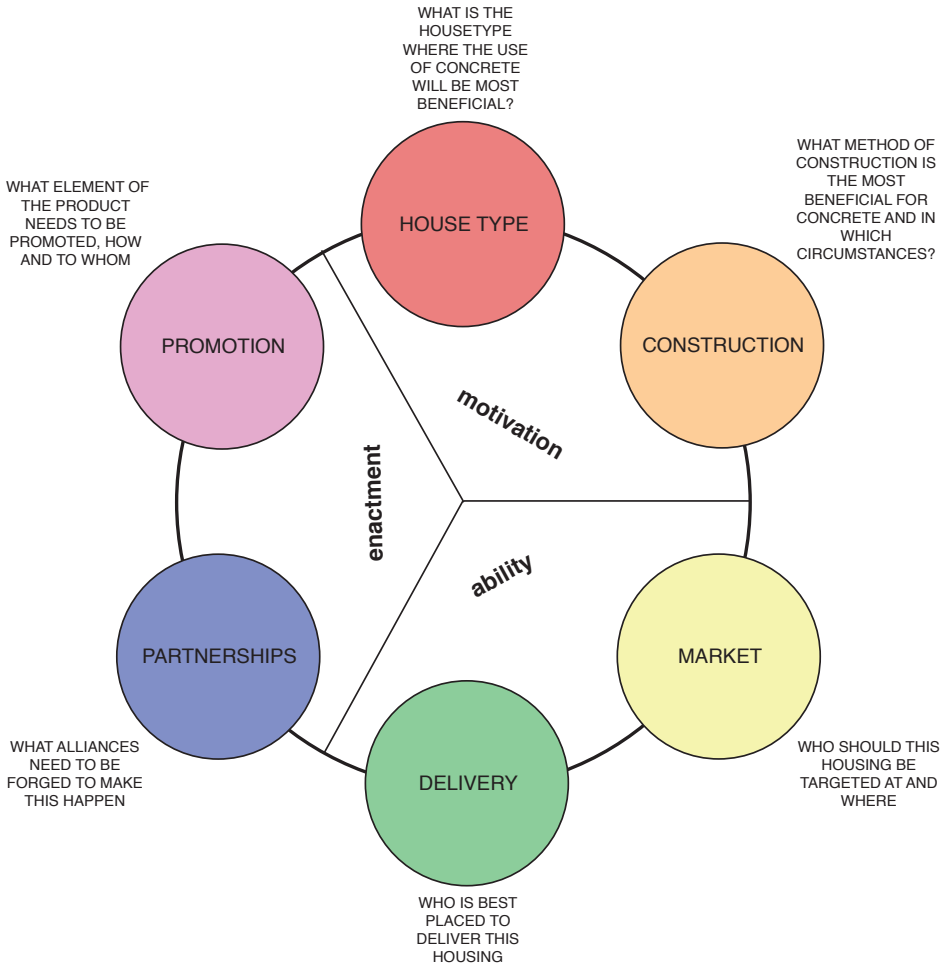


Figure 4-13 model of building process stages

The proposed structure for how to interrogate the decisions to be made with this knowledge in place is based around 'what, who and how' – what to build (building types), who should be building it (business models), and how to enable this (partnerships and promotion). Again this is not in reality a linear process as the key drivers can vary from project to project, but they are all factors for consideration and have been displayed here in a closed loop to portray their equal significance. A correlation has been drawn however between the procedure being proposed here and the main barriers from the last section that they relate to:

BARRIERS	PROCEDURES	DEFINITION
Motivation:	Housetypes and Methods of Construction	**what** are the key motivating factors behind what to build and how
Ability:	Markets and Methods of Delivery	**who** is best placed to deliver this and to what market
Enactment:	Partnerships and Promotion	**how** can this be enacted - with who's help?

Table 4:3 The Procedure

This correlation is also reflected in the case studies that are later used to explore the issues around knowledge, motivation, ability and enactment to validate the proposal that innovative solutions could be far more effectively promoted if the barriers preventing their take up were approached in a more structured and exhaustive fashion.

The next three tables (7–9) show how this process has evolved into a series of questions to be considered based on a better understanding of the benefits and barriers for all those complicit in the decision as to whether or not to adopt the new alternative solution being proposed.

House type – **Construction** – Market – Delivery – Partnerships – Promotion

Process	Division	Measures	Questions
Housetype			
	private	Bungalow Terraced Semi-detatched Detatched Apartment living High rise flat	~ What house type is most appropriate for the benefits concrete can offer? ~ Should the UK be revisiting high rise living? ~ What dictates the optimum height of an apartment block? ~ Can traditional housing be sustainable?
	communal	Apartment living High rise flat	~ Does communal living present a more affordable housing solution?
Construction			
	by method	conventional in situ concrete component cross wall Panelised Volumetric Pods	~ OSM .v. conventional on site - what markets work best for OSM? ~ Where is volumetric financially viable? ~ Where is panelised financially viable? ~ What can concrete offer OSM above other solutions? ~ cross wall solution for group custom build?
	by material	brick and block timber concrete CLT steel	~ Comparative benefits of concrete - ~ Comparative sustainability of concrete ~ How and where does concrete beat CLT? ~ Benefits of large format concrete blocks .v. traditional blockwork.
	by component	foundations walls - external walls - internal floors - ground floors - intermediate structural frame roof	~ Beam and block as a solution for 1st floors? ~ What market would be most appropriate for panelised wall construction? ~ What dictates the comparative efficiencies of concrete and steel frame? ~ Piling .v. strip foundations ~ Where should thermal mass be used?

Table 4:4 The Procedure: Housetypes and Methods of Construction

House type – Construction – **Market** – **Delivery** – Partnerships – Promotion

Process	Division	Measures	Questions
Market			
	by sector	Demographics Sociographics Psychographics	~ Which sectors of the public are most accepting of concrete and how do they live? ~ Knowledge .v. perceptions of concrete
	by location	Geographic location Urban / rural Greenfield / brownfield	~ What locations are most appropriate for concrete solutions?
	by preference	House buyers Rental Co-housing Communal	~ What living preference provides the best market for concrete? ~ What house type is most appropriate for each preference?
Delivery			
	Private sector	VHBs New entrants SME builders Kit house companies	~ Is there a market for concrete kit housing? ~ Which sector is most likely to appreciate the benefits of using concrete
	Public sector	Local Auhtorities Housing Associations	~ How well do concrete solutions suit the public sector's needs?
	Social sector	Self builders (Group) Custom build Building Groups (Baugruppen)	~ What are the priorities of the social sector that make concrete the right solution?

Table 4:5 The Procedure: Markets and Methods of Delivery

House type – Construction – Market – Delivery – **Partnerships** – **Promotion**

Process	Division	Measures	Questions
Partnerships			
	suppliers	supply chain partners research bodies	~ Who should the concrete industry be talking to about whole life costing?
	legislators	Accreditors Assessors Regulators Warranteers	~ Should the concrete industry be loobying government over assessment procedures? ~ Get warranties for standard concrete details.
	providers	Developers Financiers Architects	~ Use of Architectural profession to promote concrete construction. ~ Promote the use of BIM to improve links
	consumers	Lobby groups Lifestyle groups Advisory bodies	~ Which groups are the most effective vehicles for improving communication of facts.
Promotion			
	by target	To public To industry To government To designers	~ Sell concrete's benefits to architectural students. ~ How much time should be dedicated to informing government bodies?
	by method	Sell benefits Sell functionality Sell package Sell new vernacular	~ Sell complete aspirational package built up around concrete. ~ Match message to target audience. ~ Is thermal mass an effective sales message?

Table 4:6 The Procedure: Partnerships and Promotion

Figure 4-14 shows how this model has been developed along similar lines to that for the benefits and the barriers with a hierarchical breakdown of the issues to consider at each stage of the process.

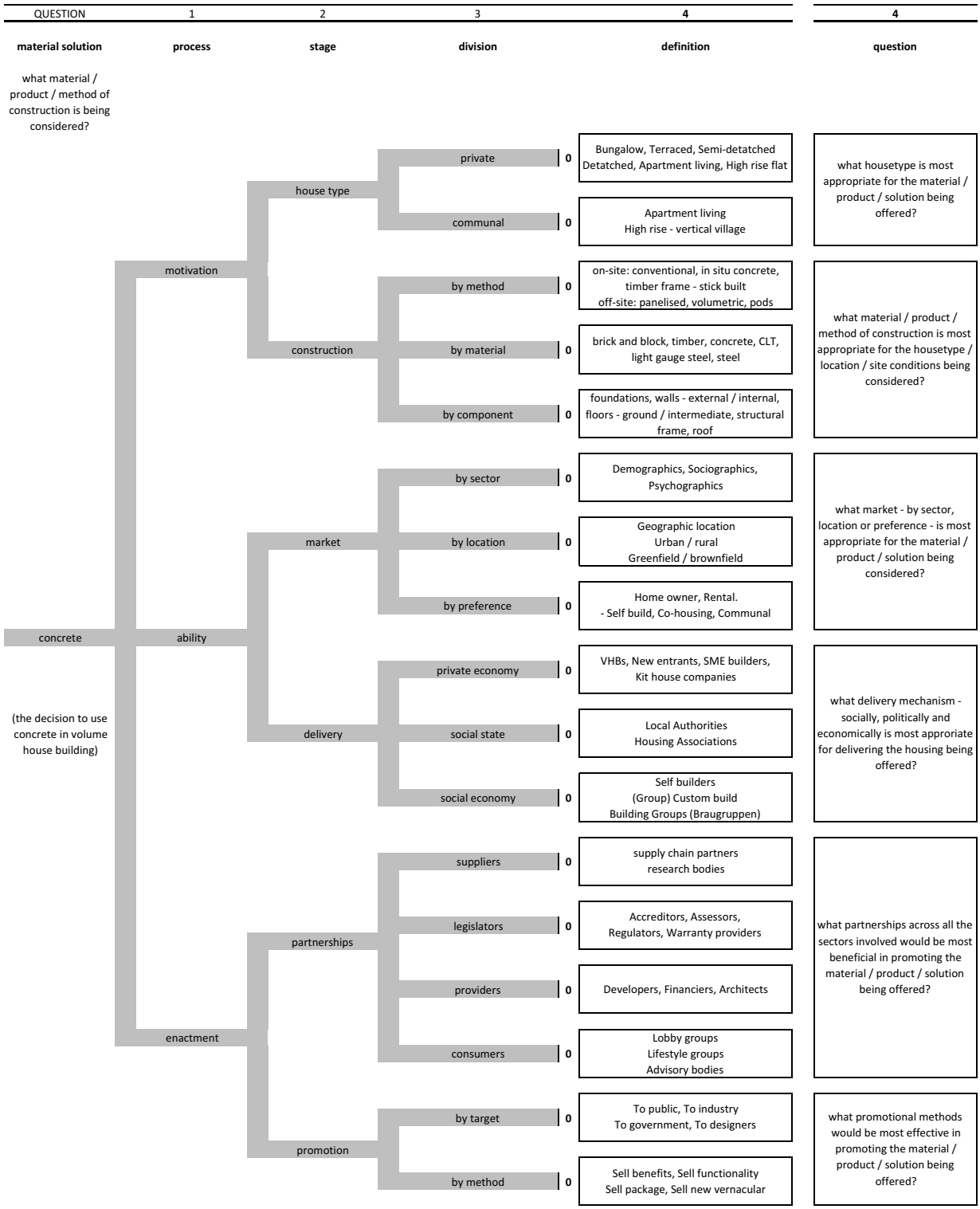


Figure 4-14 Model depicting the practical process to be followed.

4.4 The Decision Making Tool – the development of phase 1

We now have three models that attempt to analyse three defined stages – an assessment of the benefits to be accrued, the barriers to be overcome and the choices available when enacting the outcome of that assessment. What we do not have is a functioning tool for capturing the information being gathered and allowing for this process to be put into practice.

The fundamental requirements of this tool were set out in the introduction, namely, the need to:

• ensure that the user considers all the factors that might influence the decision-making process and do this from the perspectives of all those sectors involved.

• organise those factors in a way that clarifies their position within a hierarchy of causes and consequences so that the root causes can be identified and dealt with.

• provide the user with a way to measure the relative importance of all these factors so as to prioritise those factors that are most influential in the decision making process.

• and use a simple easy to understand process that minimises the time needed to make thorough, well informed decisions without allowing for that process to be short circuited.

The first two of these requirements have now been achieved, and the first phase of the tool's development is to make sure that data is held in a useable format so that the next two requirements can be progressed.

Whilst all of these requirements are important in their own right, the need for this to be a practical tool is perhaps the most fundamental barrier, to use the parlance of this research, that must be dealt with if this is to be adopted by industry. All research should be thorough and employ academic rigour, but it must also recognise the need for the findings from that research to be translated into a practical form. In the case of this research and the tool being developed, that tool should also recognise that the findings recorded will in reality be condensed time after time before they are finally read by those in a position to act upon them. Maintaining control over that process is as important as the underlying research itself, but all too often the nuance, if not the basic premise of the message itself can get lost by the time the information gathered has been translated into an action list.

The hierarchical structure of the three diagrams depicting the questions relating to the benefits (Figure 4-9), the barriers (Figure 4-11) and the practical choices to be made (Figure 4-14) is therefore of key importance in how this process could be used to condense the findings whilst maintaining a link back to their origins. The structure of the three models could almost be used to reflect the roles within the process from researcher up to CEO, defining the path that information takes as it is reduced down from a thesis to a report to an executive summary to the paragraph that will be acted upon.

There are again, parallels here with the principles behind BIM, in that the passage of information within any organisation, sector or entire industry needs a recognised structure for it to become a free flowing process that promotes understanding between all those involved and reduce the tendency for

silo mentalities to develop. A vital requirement of any BIM structure is that it should allow for that information to pass in both directions, as all processes are to some extent iterative and involve revisiting decisions made at an earlier stage when new evidence comes to light. Any decision making process in the broader context should comply with these same requirements.

We now therefore, have a definition of the tool's requirements: A structured repository for information and decisions made based on that information that can be used to both justify and examine the thinking behind the final strategies that emerge from the process. This had always been envisaged as a digital tool because of the relational database structures needed to create a hierarchical system, but with an ability to export reports at various levels of detail based on the information entered. As stated at the outset of this research, this is very much a tool for suggesting what questions need to be asked, not for providing the answers, and aims to encourage more in-house research by providing a focus for where that research would be most consequential.

Figure 4-15 shows a screenshot from the tool, and how it correlates to the model in Figure 4-11 with an input field for notes relating to that specific area of questioning.

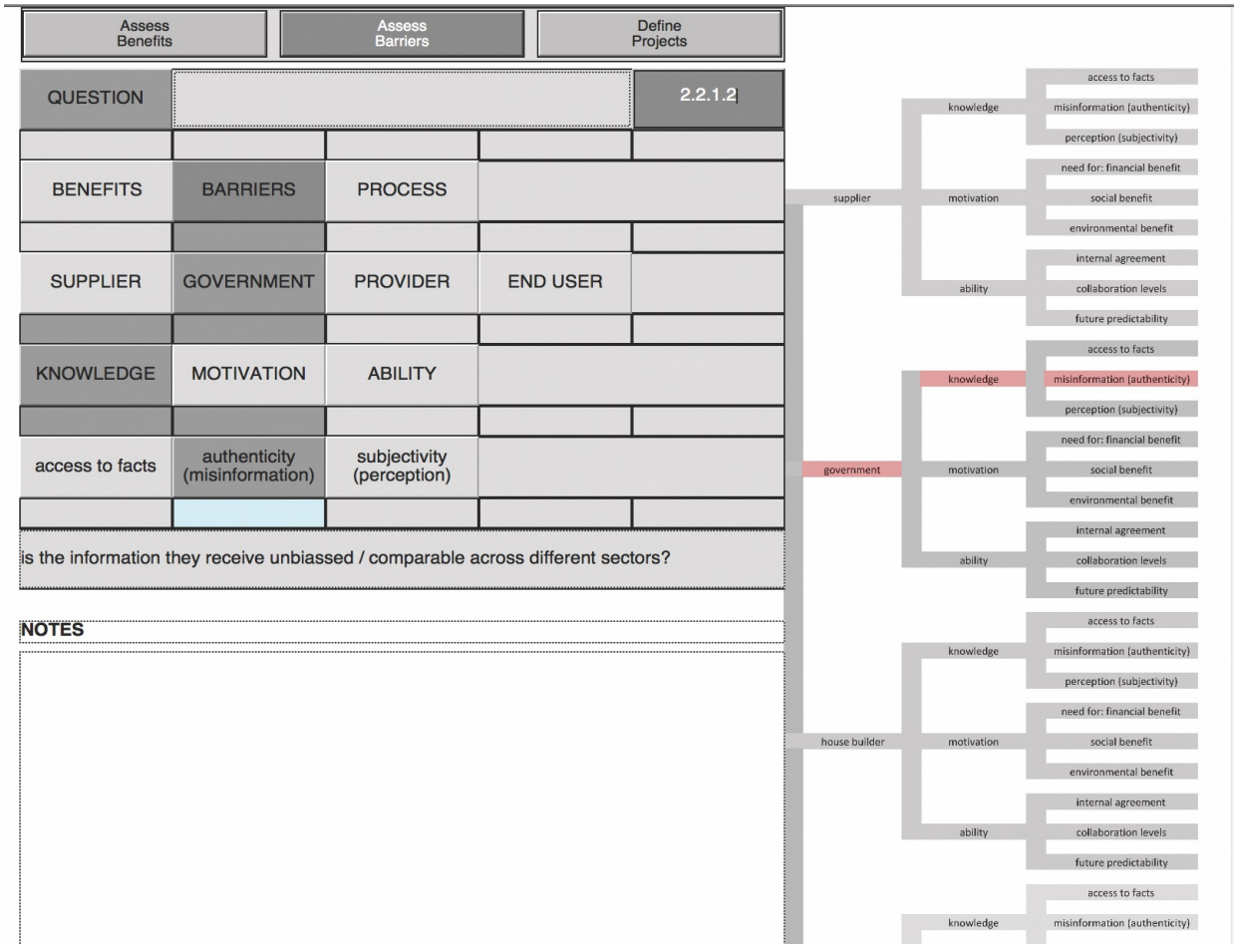


Figure 4-15 first phase of the Decision Making Tool in database form

The following chapter now looks at how to process the data captured and make sense of the many often conflicting opinions and requirements that this approach has brought to light. 'Minimising the time needed to make thorough, well informed decisions without allowing for the process to be short

circuited' is key to the success of this research, but merely highlighting the reasons why poor decisions are often made by shedding light on the previously unexplored reasons for this is not in itself a solution. Those reasons now have to be analysed and their comparative importance measured before more considered decisions can be taken.

Chapter 5
THE DECISION MAKING PROCESS - RECONSTRUCTING THE DATA

Now that the scope of the issues to be considered has been established, and a model developed for recording the information gathered, the next phase involves looking in more detail at how to compare the relative importance of these factors in order to arrive at the most appropriate solutions. The way in which the lines of questioning have been broken down in the previous chapter into increasingly binary decisions lends itself to the multi-criteria methodologies discussed in Chapter 2, such as Conjoint Analysis or Discrete Choice Modelling, used in market research to break down complex choices into a series of discrete choices between two alternatives. Whilst this serves as a useful starting point, the issues being considered here are not on a par with comparing disparate reasons for choosing which house to buy, ranging from location to number of bathrooms – this is a situation of far greater complexity involving multiple participants as well as multiple choices. It therefore requires more thought if it is to produce a generic process for assessing proposed strategies that can be said to consider all eventualities regardless of the specific case being considered and the many varied factors involved.

5 THE DECISION MAKING PROCESS - RECONSTRUCTING THE DATA

The aim in this chapter, as defined by the forth objective (2.2.2), is to develop the Decision Making Process based on existing methodologies used in other disciplines where appropriate, but in a way that responds to the specific needs that have been uncovered by this research into how the housing industry is structured, and how it currently operates.

The approach taken has been guided by the need to simplify the process without short circuiting it, and in practical terms, to also lessen the temptation for users to short circuit it either. A fixed and exhaustive procedure can often result in an excessive workload for simpler tasks, so this has been dealt with by recognizing the difference between 'short cuts' and 'short circuits'. Calculating the comparative importance of factors that have no common denominator by which to compare them is a complex undertaking, and should not therefore be seen as the starting point of the process, as would be the case with discrete choice modelling, for instance. What is needed is a more intuitive approach that allows for different entry and exit points along a path of increasing complex issues to consider.

The first operation therefore was to define a linear process to follow that incorporated all of the factors so far considered as being potentially relevant, but in an order that ensured that the easier to resolve questions were asked at the outset, thereby reducing the volume of factors needing to be comparatively analysed.

Secondly, once the factors to be analysed had been reduced in this way to a more manageable set, the process of weighting those remaining was revisited.

And thirdly, the wider issue of assessing the comparative worth of strategies proposed through this process was addressed, as opposed to the specific factors being considered as part of the process. Whilst that might be seen as yet another extension to an already complex undertaking, it can be shown to be central in reducing the overall workload.

These three stages of development are discussed next, before gathering the outputs from this and the previous chapter together into the final Decision Making Tool.

5.1 Creating a linear process

The literature review uncovered a wealth of work, often from other disciplines, concerned with the less obvious pitfalls or confounders to be encountered when data gathering within complex social and business environments. All these papers have influenced the way in which this research has been carried out, and the caution with which the results obtained have been used to suggest correlations or solutions, but perhaps the most relevant paper has been Dilemmas in a General Theory of Planning (Rittel and Webber, 1973), about the concept of 'wicked problems'.

Rittel and Webber suggest that *"we are all beginning to realize that one of the most intractable problems is that of defining the problem itself".* They go on to suggest *that "the social professions were*

misled somewhere along the line into assuming they could be applied scientists - that they could solve problems in the ways scientists can solve their sorts of problems." Whereas, in reality, *"societal problems are inherently different from the problems that scientists deal with. Governmental planning problems are inherently 'wicked'" "Social (wicked) problems are never solved. At best they are only re-solved-over and over again."*

These statements, although made nearly 50 years ago, seem to encapsulate the problems that have ensnared the UK's housing industry for almost as long. They also lend weight to the approach taken at the outset of this research, in focusing on the questions to be asked rather than on providing definitive answers. If the housing industry represents a wicked problem, the solution lies in defining that problem in a way that it can be re-solved at any time now and in the future with greater clarity than is currently the case. This does not, however, negate the need to find a way of giving comparative weight to the disparate set of factors being considered.

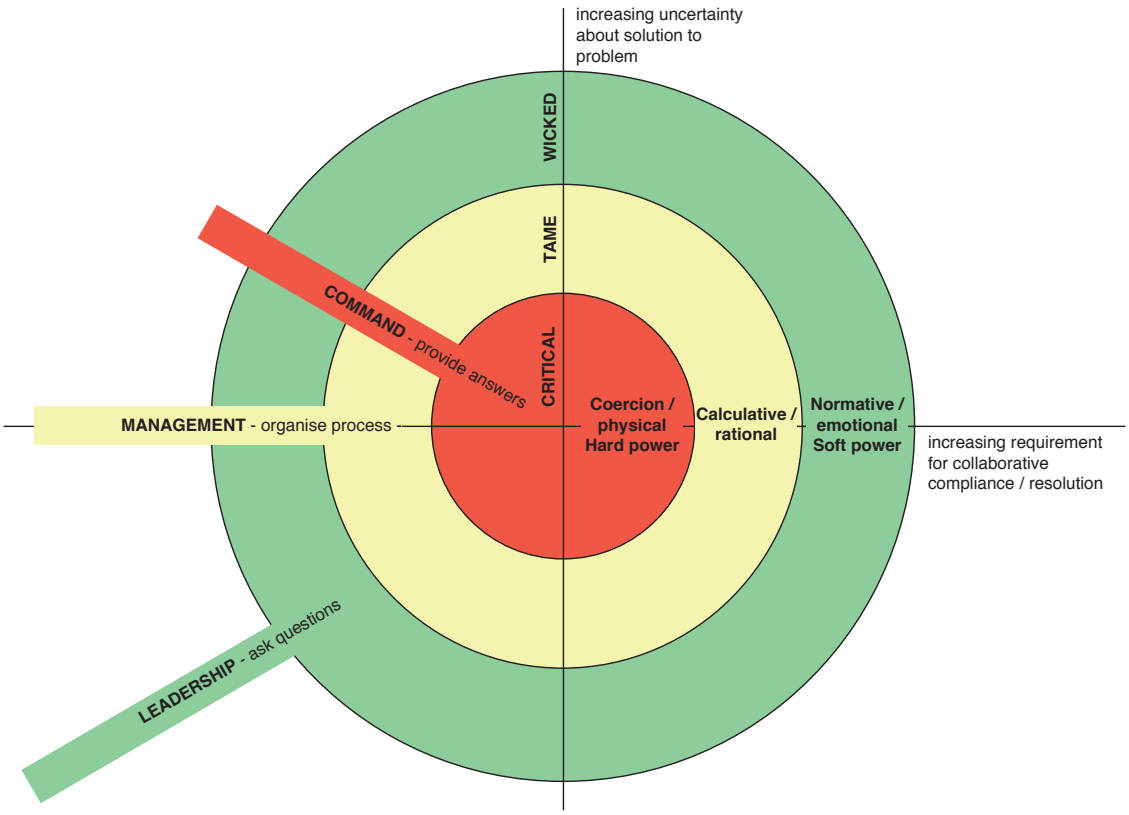


Figure 5-1 Wicked Problems – requiring collaborative leadership

As a starting point, Saaty's paper, 'How to make a decision: The Analytic Hierarchy Process', begins by stating that *"Perhaps the most creative task in making a decision is to choose the factors that are important for that decision."* It is an introductory paper to the process and sets out the fundamental principles to follow so as not to fall into the trap of 'number crunching' or 'normalising' factors that are not comparable before having created clusters of similar factors that can be genuinely related. But it also recognizes the potential for 'thinning out' the factors being considered when some are clearly of a far lesser importance than others. This approach was also reflected in the qualitative process that

was carried out during the coding of the industry interviews, where categories were created to define the comments and opinions relating to the subject areas being discussed.

Relating these principles back to the factors being considered in the housing industry, and bearing in mind the need to resolve these disparate questions as efficiently as possible, the task becomes one of looking for the key issues first before attempting to apply a weighting to the many smaller, less easy to compare issues which will inevitably take considerably more effort to resolve. One of the interesting discoveries to come out of this process during the deconstruction of the questions being asked was that there were often key factors to be found in the decision making process that came to light towards the end of the research, where one might expect to be uncovering increasingly insignificant elements of detail:

An example of this would be a Housing Association's decision to rule out any use of concrete panel solutions on the grounds that the panels would be delivered on vehicles too wide for some of their sites being developed. Despite many attempts to promote their products within this market, that conversation was never had, the reason for the housing association's disinterest never discovered, and the contract lost despite the many positives that such a solution was known to offer. (Whitaker 2016, p.5)

The point being made here is that once a factor has been recognized as non-negotiable, there is no need to assign it any further weighting, and if it cannot be resolved, neither is there any purpose assigning weight to any other factor, positive or negative. This may seem obvious but it is less so when those non-negotiables are buried amongst multiple other factors that, because of the relatively ease with which they can be dealt with, can detract from first ensuring that all relevant factors have been uncovered and recognized for what they are.

The approach taken in reconstructing the evidence into a process to be followed was therefore dictated by the need to avoid unnecessary effort whilst ensuring that no relevant factors were left unconsidered. In other words, recognizing the difference between short cuts and short circuiting, beginning with the search for key motivating factors.

5.1.1 Key motivating factors

In order to minimize the time taken on any one investigation, the proposal is to not start assigning weight to factors, let alone attempt to resolve them, until all factors have been uncovered, and if during this process any factor is uncovered that is an 'unresolvable non-negotiable', the process ends there.

Many non-negotiables however, as in the case of the Housing Association, are easily resolved once understood, and therefore just become factors to be considered alongside all the others - delivering the panels on smaller vehicles, those no bigger than a fire engine, since these had to be catered for in the design layout, would have resolved the issue at minimal cost to the supplier.

In this situation, the need to weight this need for smaller trucks along with all other resolvable factors still remains. How that weighting is to be carried out has yet to be discussed, but what soon becomes clear is that what is deemed to be a key motivating factor, or even just a relevant factor, is very

different depending on whose perspective is being considered. To stay with the use of concrete panel construction for Housing Association projects, the appropriateness of this solution from the perspective of the material supplier will be influenced by the size and growth potential of the Housing Association sector as a market, whereas from the HA's perspective this is clearly of no relevance to their decision to use concrete. For them the reluctance of the concrete industry to consider their market, or be cost effective on relatively small project sites might be a concern, and for the public, the perception of panelized concrete being stigmatized as social housing might make both them and funding bodies reluctant to consider this as an option. Moving on to the legislative sector, the warranty industry singles out concrete construction, even amongst all other 'modern methods of construction' as being of a higher risk than traditional build, and cautions against its use (Council of Mortgage Lenders 2018).

These are all factors to consider, and are no less important for the lack of knowledge in other sectors of their existence. Even the future acceptance by the public of unconventional aesthetic solutions is seen as a warranty issue for the Council of Mortgage Lenders (L.07.1, p.9), as this can impact on future property values. If these concerns represent a key motivating factor for this one sector to reject concrete panel construction as a solution, that alone could constitute an unresolvable barrier for Housing Associations.

Examples of key motivating factors dictating the choice of construction are discussed as case studies in Chapter 6, but more typical is the situation where a perceived absolute barrier to adoption is surmountable once it has been fully understood, as in the case of the large delivery trucks (Whitaker 2016, p.5). For that reason, this becomes the most productive starting point for any discussion, bearing in mind that there may be more than one such barrier, and as a line of questioning, is most likely to 'self prioritise' the show stopper issues that need to be addressed from the client's perspective.

Primary question:
What are the key motivating factors that dictate the decisions made about methods of construction, choice of materials, etc.

Secondary questions:
Are these internal decisions or dictated / influenced by other parties?
Are these decisions site specific or set policies?

5.1.2 The dominant sector

Following on from that secondary question of who's dictating the decision, the next question is therefore one of how to weight the sectors based on which ones are most likely to influence the final decision. In a similar way to how the unresolvable non-negotiable factor can short cut the process, so too can one sector dictating the decision about what is built and how. Whilst the decision making within the Housing Association sector might be less dictatorial, the speculative housing market represents a market where, due to the undersupply that is strategically maintained (Barker, 2004, p. 25), the public, and increasingly the government (Archer and Cole, 2014), have little say over the decisions being taken. As a consequence, there is a clear hierarchy of control in this instance that can

be used to guide the process in a way that minimizes the time spent considering alternative solutions that may in reality be peripheral to the debate.

This therefore provides a second rule to minimize the time taken investigating a proposal: Before trying to prioritise the importance of any one factor being considered, prioritise the importance of the sectors involved in the decision making process. If one sector is controlling that process, less emphasis should be given to the weight of factors from the other sectors' perspectives.

There is a caveat to this rule, however, as the dominance of any one sector over the decision making process is in no way desirable, and could be argued lies behind many of the symptoms of our ailing housing industry. Neither can be it be assumed to be permanent state of affairs, as recent incidents have proven, particularly in the case of one volume house builder whose share value plummeted in response to a social media campaign where many of its unsatisfied residents found their collective voice through the internet and publicized their concerns (Evans, 2017). The point being that rebalancing the roles played by each of the sectors might present an alternative and more productive course of action, albeit a longer term one. These are, nevertheless, the kind of options that this process attempts to highlight and assess as part of the decision making process.

During the course of the industry interviews, respondents were indirectly asked which sectors they felt were controlling the decision making process, and a hierarchy emerged from that process validated by each sector's response. In the case of the volume house builders, that is clearly themselves followed eventually by government legislation and public opinion, a situation undisputed by any sector or the facts on the ground:

"*The high-volume homebuilders dominate the market and are therefore able to shape how it operates.*" "*The sector is over-reliant on an alarmingly small number of high-volume developers, driven by commercial self-interest and with little incentive to build any quicker*"(Wilmore, 2017).

It therefore follows that the most important line of enquiry here would be that of the volume house builders' own motivations, which again, is primarily economic as opposed to social or environmental. It is only at subsidiary levels of questioning, asking how their profits are achieved, that there is any differentiation between the answers given by different companies within this group. Not all cases, if any, are so clear cut, but the process remains the same – one of establishing the degree to which each sector plays a role in the decision making process before deciding where to focus attention.

Primary question:
Which sector has most influence over the decisions about what to build and how?

Secondary questions:
How much, if any influence do you have over that sector?
How much, if any influence do those other sectors have over you?
How much are your decisions influenced by financial, social or environmental concerns?

5.1.3 Mutual benefits

The realization that should stem from the previous question is that the innovator in the equation, in this case the materials sector, is unlikely to ever be the sector that is controlling the process. All that innovation is, or certainly should be, is a response to a demand, whether that be from the house builders, the government or the public. Once financial viability has been established for the innovator therefore, it is those other sectors' perspectives that are important in this process. But whilst this may be about servicing a need, equally important is the impact that satisfying those sectors' needs has on the innovations' initial viability. Deciding, for instance, that concrete panels must be delivered on smaller wagons is certainly feasible, but what impact does it have on the viability of the transaction? All decisions will translate into similar equations, revisiting the benefits to be accrued and balancing them against the barriers to be overcome, and it is these equations, discussed in depth in Section 5.2, that need to be developed as the foundation of the process being developed. The next question, therefore, is 'do the mutual benefits outweigh the conflicting interests?'

The process goes beyond one of making a comparative analysis of different clients' priorities, and involves the further operation of balancing the cost of demands being made by a client against the cost of delivering from the perspective of the supplier. Only by combining the pros and cons from both sides of the equation can a realistic measure of the combined viability and feasibility – the appropriateness of a proposition – be reached. As a process this also begins with a simple subdivision before breaking that down with more nuanced questioning, and that first level question has to be 'do the mutual benefits outweigh the conflicting interests?' Not all demands made by a client result in a sacrifice to be made by the supplier, and the aim of this process should be to seek out those partnerships where the innovation being proposed is of mutual benefit to both parties. The more synergies that can be found, the more appropriate the solution is for that market.

If the barriers to adoption outweigh the benefits, that is a clear sign of an inappropriate market, but it is not just a case of numbers, as not all benefits or barriers carry similar weight. The most fertile ground for an innovation however will always be that where there are the least barriers or no barriers at all to its adoption, so any case where the balance becomes questionable is possibly already inappropriate and should be de-prioritised. An appropriate market on the other hand is one where there are many beneficial criteria and also multiple benefits to be gained from the same criteria.

If, for instance the durability of concrete also offers resilience to flooding and excellent sound proofing, and all three are benefits for a specific market, that multiple benefit should result in a higher weighting. But that weighting also needs to factor in the economic, social or environmental benefit gained, as each of these also has a weighting in the eyes of the sector being assessed. In the case of the volume house builders, for instance, if the government saw a strong environmental – and social - benefit to using concrete beam and block construction at first floor level, but social and environmental concerns were low on the volume house builders' agenda, this would result in a lower weighting than it would for a housing association with different priorities and chasing high accreditation scores. Similarly, if the sector being assessed was lower down in the hierarchy of sector influence, that too would impact on the weighting given. At some point these quantifiable differences will need to be assigned numerical values, but that is dealt with in Section 5.2.

Primary question:
What are the mutual benefits that arise from the use of this solution?

Secondary questions:
In which markets are these most pronounced?
What are the barriers from the client's perspective?
What are the barriers from the supplier's perspective?
Can any of these barriers be overcome?
Are the remaining barriers outweighed by the mutual benefits?

5.1.4 Exclusivity

Defining the most appropriate market for a product from the supplier's perspective, however, does not necessarily make that product the most appropriate from the customer's perspective. There are further considerations that involve the current and future competition from existing solutions and alternative innovations – ie: are the mutual benefits recognized stronger than those that could be claimed between the client and other options available to that market? Could the CLT industry for instance compete in the panelized concrete market on the criteria mentioned? Current knowledge in the UK would suggest not, except in specific circumstances where other criteria – weight in particular – override these factors in the decision making process (Davies, 2018, p. 12). Asking this question potentially reduces the size of the market being defined even further, but also begins to define a market that is exclusive to that product.

In reality, an exclusive market is rare, but it does nevertheless help define where a new product would have the best chance of being adopted and gaining a foothold from which it could expand. This could be defined geographically, as in the case of Kerkstoel's twinwall solution (Section 6.3.4) - regularly imported and used in London, or by constructional viability, environmental necessity, mandatory legislation in specific sectors – any one of a number of conditions. What is being sought in each case is the path of least resistance.

It is rare for no other solution to be competing in the same market, but as an exercise, refining the selection criteria until this is the case eventually results in the most appropriate, if not the most viable market for a product. As with the last question, weighting of the factors considered is key, and effectively follows the same principles, but focusing on an alternative product, the two of which must then be directly compared. This exercise is carried out in Section 6.2.5 looking at the competition between concrete and CLT within the same marketplace. The secondary questions below are key to showing how in this particular case any claim for exclusivity will depend on wider economic and political concerns.

Primary question:
Are there any other solutions that are equally or more suited to the market being pursued?

Secondary questions:
Can the market be redefined so that this is not the case?

Is enough known about the alternative to ensure this is a true competitor?
Do other sectors' influence impact on this comparison?

5.1.5 Viability check

By this stage, the market being defined may be the most appropriate, but due to the many criteria being applied to achieve this, it may also have become very small. There are many ways in which viability can be measured, and the Concrelator discussed in Section 4.1 covers only one of these, albeit a very fundamental one, of volumes of material used. Now that the market being considered has been fully defined, all other factors relating to viability - from all perspectives - have to be incorporated into the equation; not just the size of the market, but its growth potential, its accessibility, future stability in the face of economic downturns or competing providers, its impact on existing markets and the immediacy of returns to be expected. Some of these considerations are future related and therefore more difficult to ascertain. Here, the weighting given has to reflect the certainty with which any one factor can be measured, and the consequences of that measurement being inaccurate.

Questions about viability cannot be asked about an innovation in isolation, as they are dependent on the market being addressed and also when that question is being asked. It is for this reason that this has been defined as an example of a wicked problem, and why there needs to be a process to follow that enables a similar set of questions to be asked on each and every occasion.

Primary question:
Is the defined market viable from the supplier's perspective?

Secondary questions:
Does it represent an increase in product sold when offset against the replaced solution?
Is the market accessible and secure in its own right?
Is that new market under threat from competition elsewhere?
Is it a growth market with support from other sectors?

5.1.6 Feasibility

Feasibility has been defined in terms of the level of co-operation needed from others for an innovation to be successful and the levels of risk that entails for all those involved. At this juncture the aim is not to measure that risk, but to understand where it emanates from so that it can be either removed or avoided to prevent it becoming the immovable barrier that prevents progress being made. Risk, whether it emanates from disunity, complexity or uncertainty, represents an unknown variable that needs to be removed from the equation before that equation can be fully resolved. Whilst that may be a clear statement of intent, it is far from clear how that can be achieved, but it is the next stage in the process that must be addressed.

Establishing viability from the adopter's perspective is more akin to a risk assessment exercise. There being a financial gain to be realized is a given, but how likely that is to be achieved and over what timescales is what dictates the decision to adopt an alternative solution or not. As discussed earlier, those risks are a collective concern, with some residing within the adopter's control, but most being

risks that the industry in general is exposed to and must resolve collectively before any progress can be made regarding innovation. Feasibility therefore represents a more complex form of risk, as it becomes both greater and less easily measured the more dependent any proposal becomes on the involvement of others.

Primary question:
Is the defined market feasible in terms of the risks to both the innovator and the adopter?

Secondary questions:
Do all at a company level understand the implications of the proposal and agree to its adoption?
Can the industry level risks be reduced by more collaboration between the parties involved?
Has the social and political environment been factored into the client's financial equation?

5.1.7 The reconstruction process – the detail

To recap on the reconstruction process so far, we have now proposed a six stage first level check from which all further checks about how to prioritise the information gathered can emanate.

1 Check for unresolvable non-negotiables

2 Prioritise the importance of the sectors involved

3 Focus on mutual benefits to assess appropriateness

4 Check for exclusivity to define market dominance

5 Assess viability of the market defined

6 Assess feasibility in terms of internal, industry and external risk

The order of this process was predicated on the need to avoid unnecessary comparative work by short cutting the process wherever possible, checking first for key motivating factors that might overrule all other considerations, rendering them superfluous to the assessment procedure. If this order proves to be a robust approach to the questions that need to be asked, this would suggest a form of flow diagram that might be appropriate as a foundation for the tool being developed (Figure 5-2).

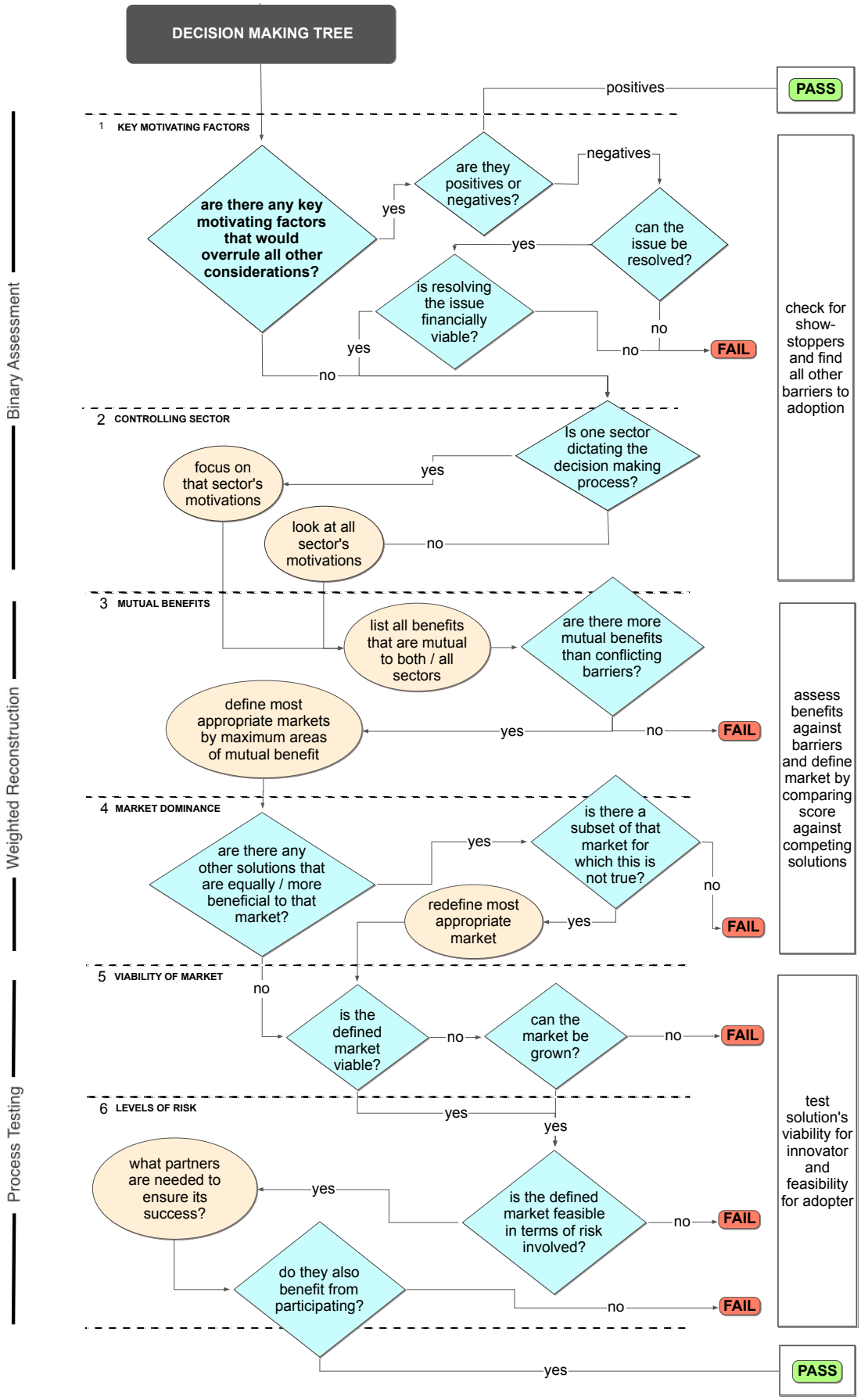


Figure 5-2 flow diagram of evolving decision making process

This provides a useful framework for asking the right questions in the right order, but does not help establish what those questions are beyond some top level categorisations. Within each of these stages of analysis there are still many decisions to be made regarding the balance of benefits to be realized against the barriers to be overcome in achieving them. How, for instance, can the familiarity with an existing method of construction, or a supply chain or a workforce, be measured against the benefits to be gained from adopting an entirely new but patently superior solution? In other words, how can risk, by definition an unknown quantity, be measured? The aim is to further categorise those questions until they become binary decisions that can be answered in turn without the need for provisos or caveats. Much of the groundwork for this next stage has already been established through the research into existing methodologies (Section 2.3) and how they relate to the housing industry as it has been understood through the industry interviews, but that now has to be brought together into a structured process so that some form of comparative analysis of these disparate factors can take place.

5.2 Weighting the factors

So far, the approach taken in reconstructing the data has been to ensure that no complex problem solving is undertaken unnecessarily, by first applying some simple checks that effectively narrow down the field of study to a more manageable set of criteria. This approach of 'task minimisation' is a key aspect of this tool's design, since if it is to be used without being short circuited, it must provide short cuts wherever possible or risk being only partially adopted.

As with the development of the model, the problem of assessing these factors has been approached by working into levels of complexity starting from the simplest of divisions.

Each factor being considered can be said to result in one of five responses:

Positive outcome	strengthens overall case for a strategy	Y
Negative outcome	weakens overall case for a strategy	N
Dependant outcome	further subdivision of parameter required	/
Unknown outcome	further research required	?
No relevance	no action required	X

This first level assessment is effectively a test for whether or not all the knowledge required to base a decision upon has been truly established. By continuing the process of subdivision, further research and the elimination of irrelevant factors, the eventual outcome will inevitably be a set of positive (Y) and negative (N) criteria. Only at this stage does the relative importance of these parameters need to be considered.

5.2.1 Comparative importance

How to approach the measurement of relative importance is essentially the crux of this whole process, and, as suggested earlier, constitutes a wicked problem. It involves incomparable denominators and interrelated factors, viewed from multiple viewpoints, within an uncertain environment.

Given that set of conditions, it is not surprising that many decisions are made by resorting to gut instinct, or by solving the easier to understand symptoms rather than the often impenetrable causes that lie behind them. Returning again to the concepts introduced in Chapter 2 as possible approaches to consider, any quantitative approach whereby numerical scores are given to the available options begins to look unworkable, with more qualitative valuations based on a principle of outranking providing a more plausible approach. This can be equally applied to binary choices within a matrix of options to consider as it can be to the relative influence of the sectors in the decision making process.

Returning to the middle section in the flow diagram (Figure 5-3) where the comparisons are drawn first between the benefits and the barriers of the proposed solution and then between that solution and the alternatives, this could potentially form the basis of a comparative process.

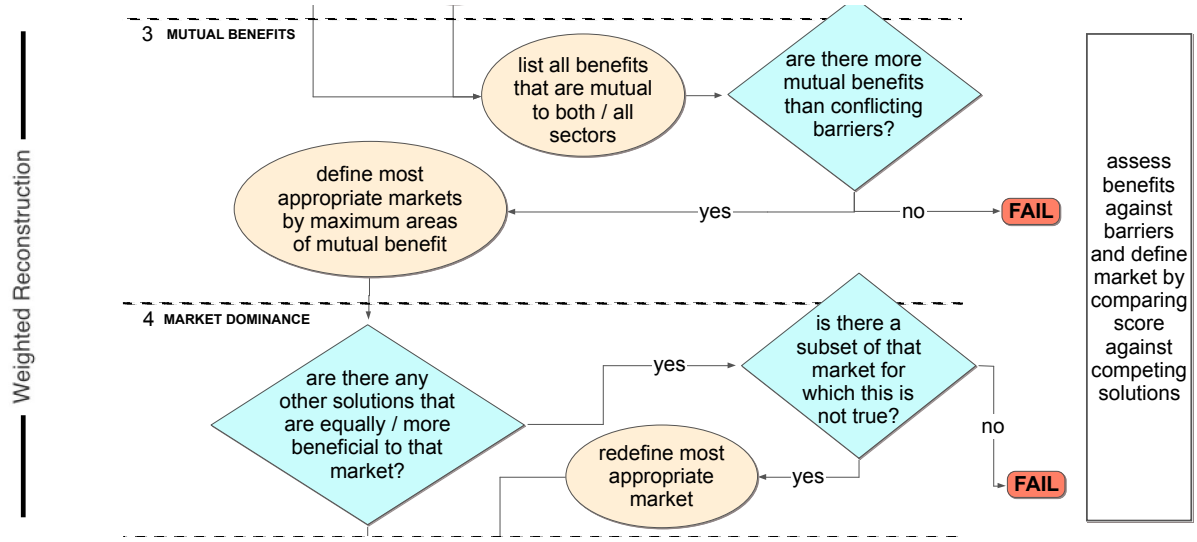


Figure 5-3 weighted reconstruction section

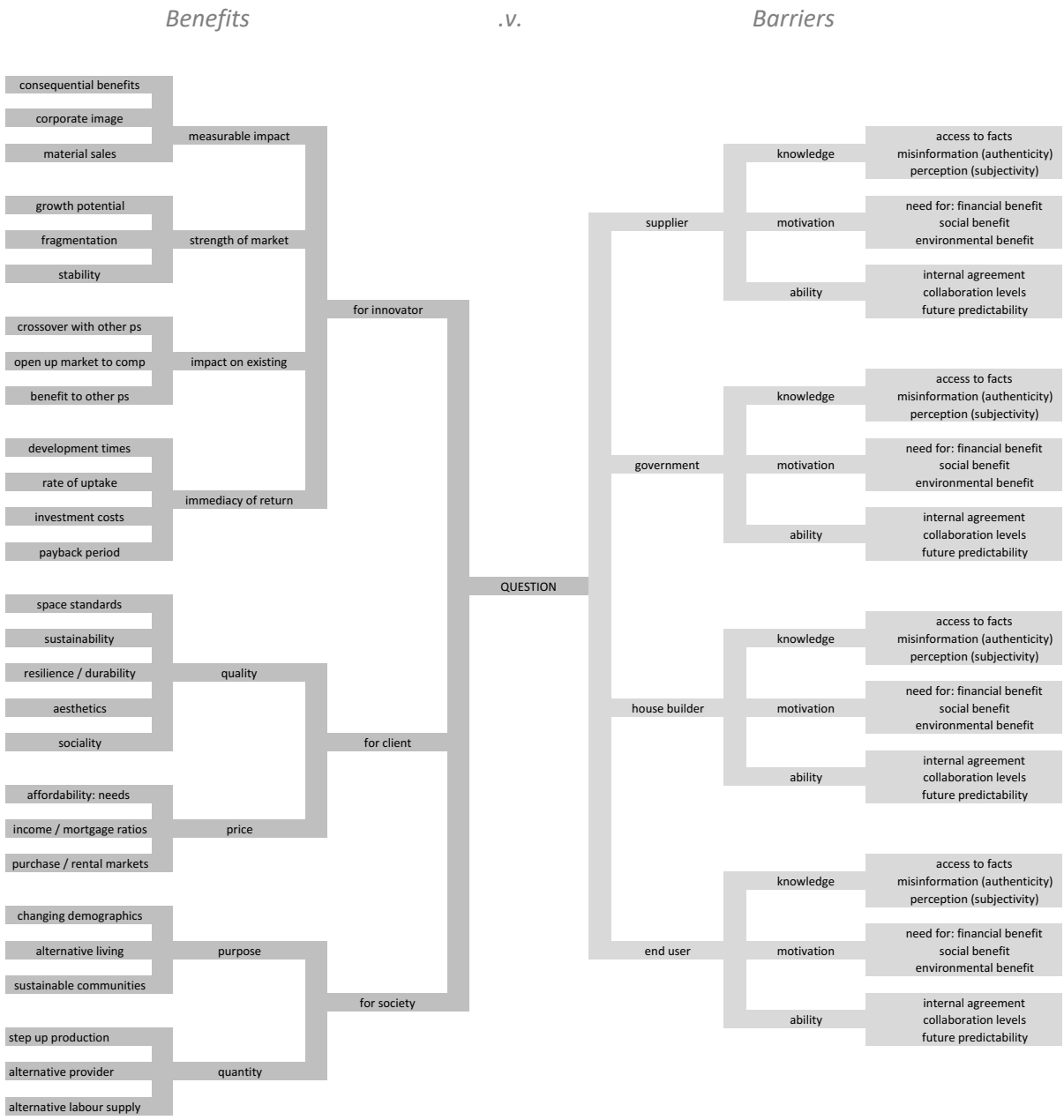


Figure 5-4 Assessment of Mutual Benefits

The first of these comparisons (Figure 5-4), between benefits and barriers asks the questions that show where the mutual benefits are greatest, by assessing the motivations of each sector and aligning these with the benefits that adoption is expected to deliver. (section 5.1.3)

The second (Figure 5-5), comparing the barriers that would be encountered by the adoption of two alternative solutions asks the questions that show where the market dominance lies (section 5.1.4).

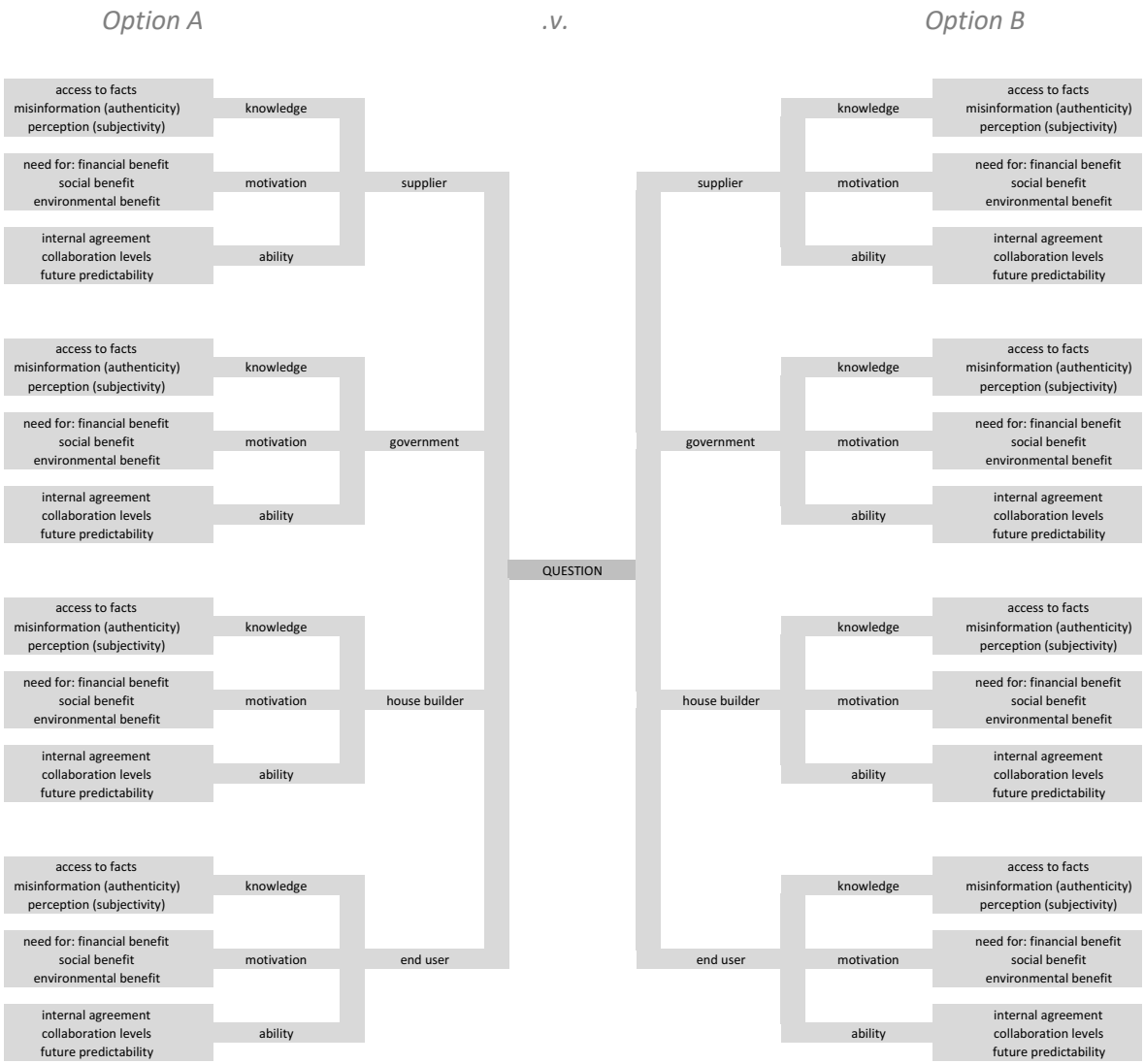


Figure 5-5 Assessing Market Dominance

Together these two operations help to define the path of least resistance, where the innovation has the best chance of being adopted. It has done this by highlighting where the barriers are to be removed or alternatively to be avoided by choosing an alternative market. To some extent this quantifies the comparative importance of these barriers, but what this does not consider is the causal relationships that exist between any two options. So far, this is still a process that, although it now considers all the contributory factors to a problem from all perspectives, cannot pick up on the impact that any one decision will have on the wider environment in which that decision was taken.

5.2.2 The need for a Systems Thinking approach

Causal relationships are the domain of 'Systems Thinking', another area of risk based research touched upon in Chapter 2 and now introduced to deal with this aspect of the wicked problem scenario (Kim, 2000). The three subcategories of risk which were used to define a client's 'ability' to adopt an innovation were Disunity, Complexity and Uncertainty. In this instance, disunity relates to the conflicting motivations across the sectors, and complexity, the interrelatedness of the many factors

to be considered. Uncertainty relates to the factors at play, both in terms of these causal relationships within the industry itself, and the even harder to predict impacts of the wider economy and all the factors that that in turn is responding to. Uncertainty clearly represents the greatest unknown as it is a temporal factor, but it must, nevertheless be confronted. As stated at the outset, barriers can be either removed, avoided or accepted, but they should never be ignored.

As before, when dealing with complexity, the first option to be explored should always be the simplest to assess. In this case, acceptance of a barrier serves as the benchmark against which all alternative options should be measured. If, for instance, the risks associated with the uncertainty of government tariff policies are so great as to be unacceptable, the options are to abandon the business model being proposed, or to lobby the government for change. Alternatively, that risk can be factored in and accepted as something that is outside the company's gift to influence. That is a decision to be taken based on a full understanding of the process of changing government policy versus the detrimental impact that a future change in the tariff agreement might represent. Acceptance may well represent the lowest risk option, but arriving at that decision still requires an understanding of the causal relationships at work.

There are many scenarios to choose from that can be used to demonstrate the benefits of this approach to solving complex problems that evolve over time, but perhaps the most appropriate would be the cyclical return of off-site manufacturing as the panacea to our housing crisis. It is therefore used here to show how the conclusions reached can differ depending on the analytical approach adopted and why this approach needs to be part of the decision making tool being developed.

5.2.3 Systems Thinking applied to OSM

In its simplest form, the housing industry would be described by a 'Balanced Loop Causal Diagram' (Figure 5-6)

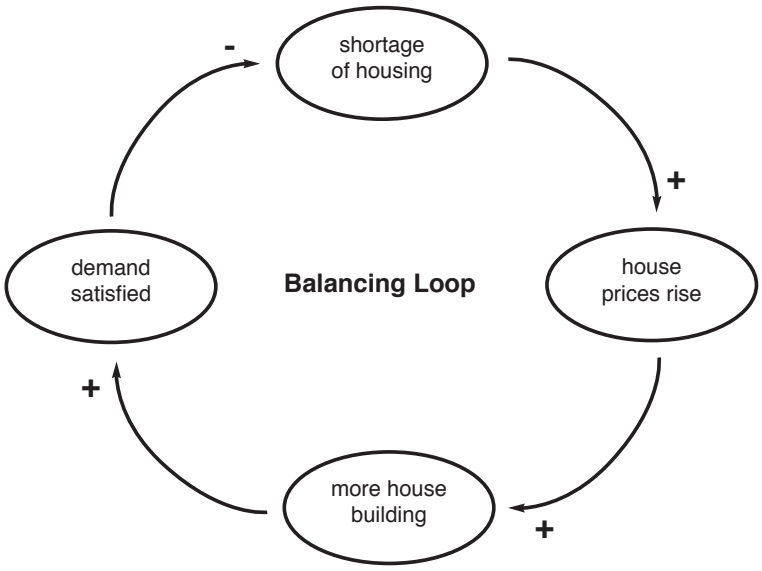


Figure 5-6 the housing industry idealized

A balanced loop will always tend towards the desired solution, in this case stability in the form of an adequate supply of housing, as opposed to a reinforcing loop where the conflict in influencing factors will compound change in any one direction with more of the same. In reality, our current industry model is unbalanced as shown in Figure 5-7, due to the first of many influencing factors that need to be introduced.

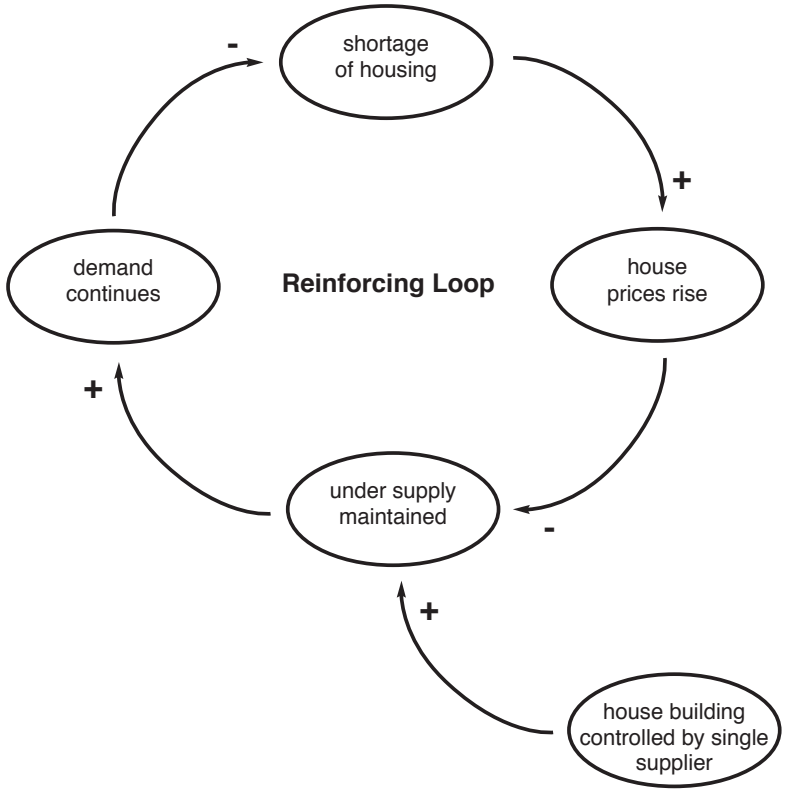


Figure 5-7 the housing industry in reality

The introduction of off-site manufacturing into this model is effectively an attempt to rebalance the model by breaking the control currently held by a small number of volume house builders whose business model is predicated on them maintaining an undersupply of housing, or at best only supplying that percentage of the market that can afford their product (Figure 5-8). It is an attempt to turn a 'vicious cycle' into a 'virtuous cycle'.

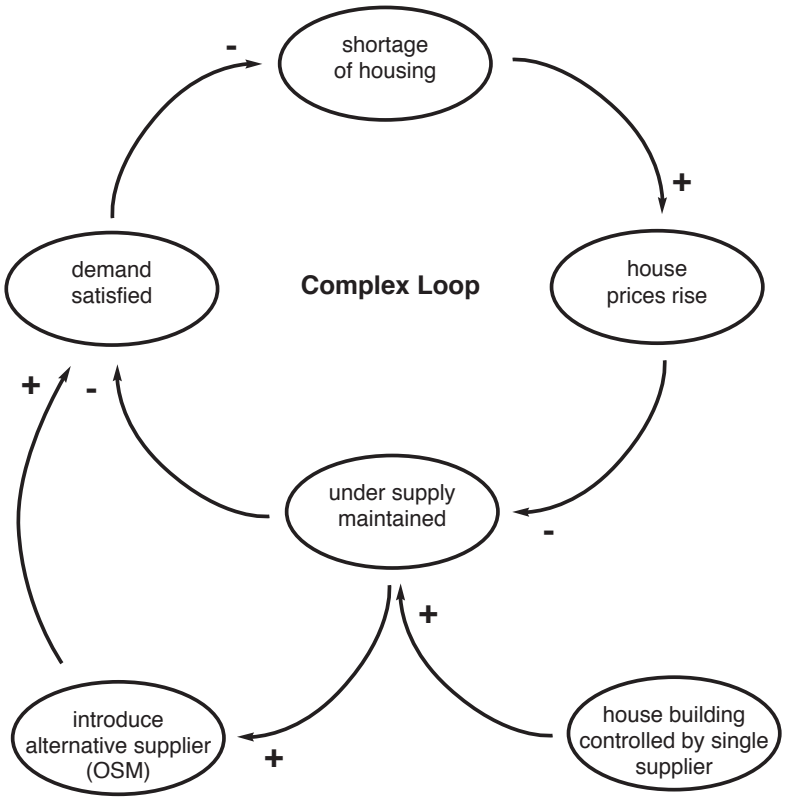


Figure 5-8 the introduction of an alternative supplier

From here on in the model evolves to incorporate the many factors that impact on this intervention in ways that serve to confound the attempts to achieve a balanced solution. As a methodology, this helps to visualize the relevance of the issues being addressed by showing the causal links between them. Growing the model automatically places the most important issues in the centre of the network created, with the more links to and from any one issue defining it as more significant than those with less, and with all links flowing from cause to consequence (Figure 5-9).

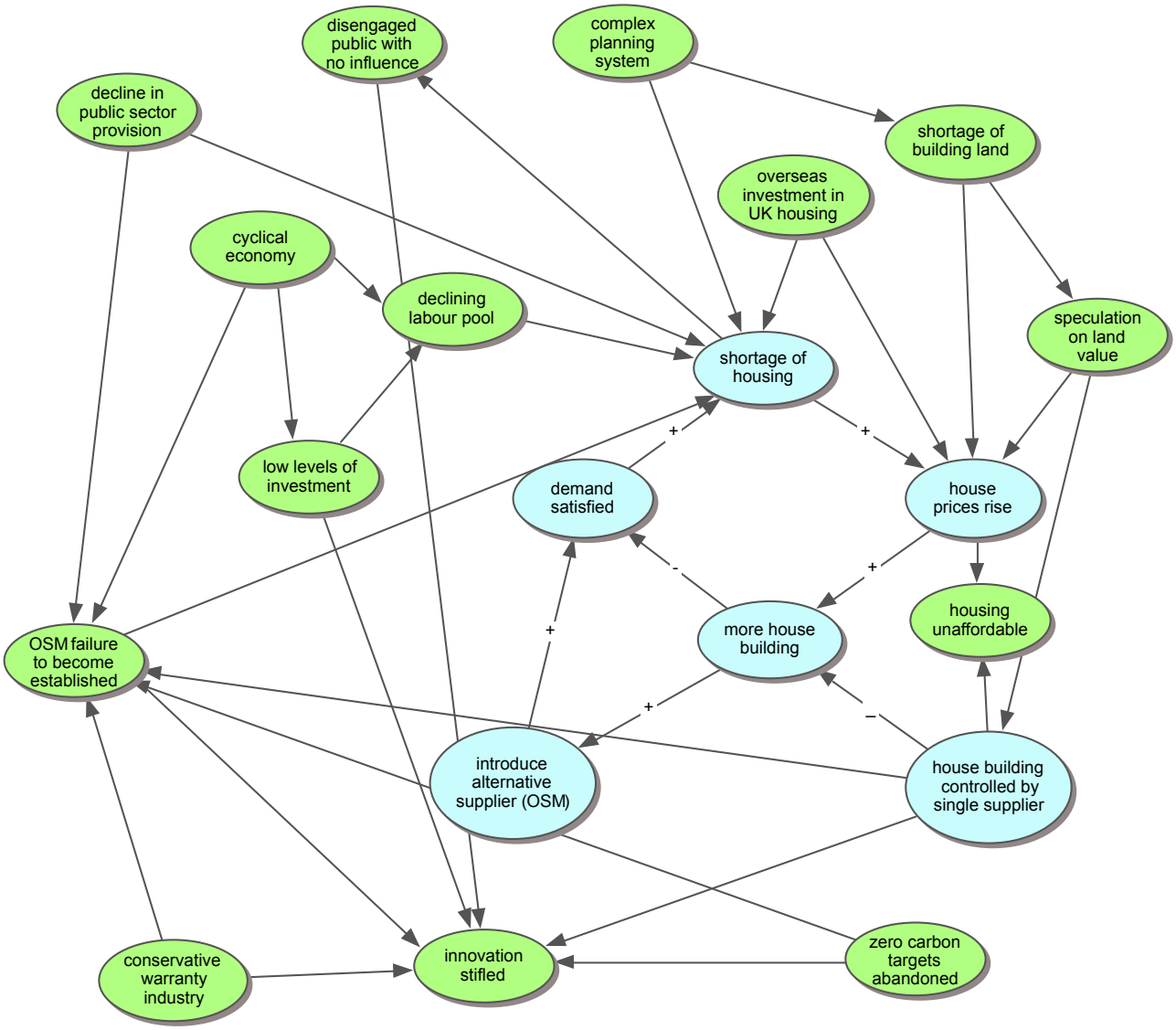


Figure 5-9 extended model of causes and consequences

To accentuate these causal relationships, this model can now be redrawn so that all links flow from top to bottom, setting the main causes at the top of the model and the main consequences at the bottom (Figure 5-10).

Figure 5-10 causes and consequences repositioned

Visualised in this form a number of findings regarding the reasons behind our shortage of housing stand out:

• The main causes are – with the possible exception of the warranty industry – all the consequences of political decisions. (top row)

• OSM's failure to become established is therefore a predominently political issue

• The most 'consequential cause' – ie the factor that is the cause of the most negative factors – is the monopoly position held by the volume house builders (most exiting arrows)

• The most influential factor behind our shortage of housing is the failure of OSM to become established (most entering arrows)

• And the ultimate consequence of our 'broken housing market' is the stifling of innovation. (bottom row)

If OSM is the prescription for fixing our broken housing market, this would suggest there needs to be a prescription for fixing the OSM market, all the more so because of its potential role in delivering innovative solutions. What this model can now show is the impact that changing any one of these factors would have on the causal relationships and to what extent that would reduce the problem central to this case, the shortage of housing. It also allows for certain factors to be 'locked in' as barriers to be accepted, such as the cyclical economy. This particular example represents an archetype within Systems Thinking known as 'Fixes that Fail' (Figure 5-11), where a solution is implemented that alleviates the symptoms, but the unintended consequences of the "fix" exacerbate the problem and over time, the problem's symptoms return to their previous level.

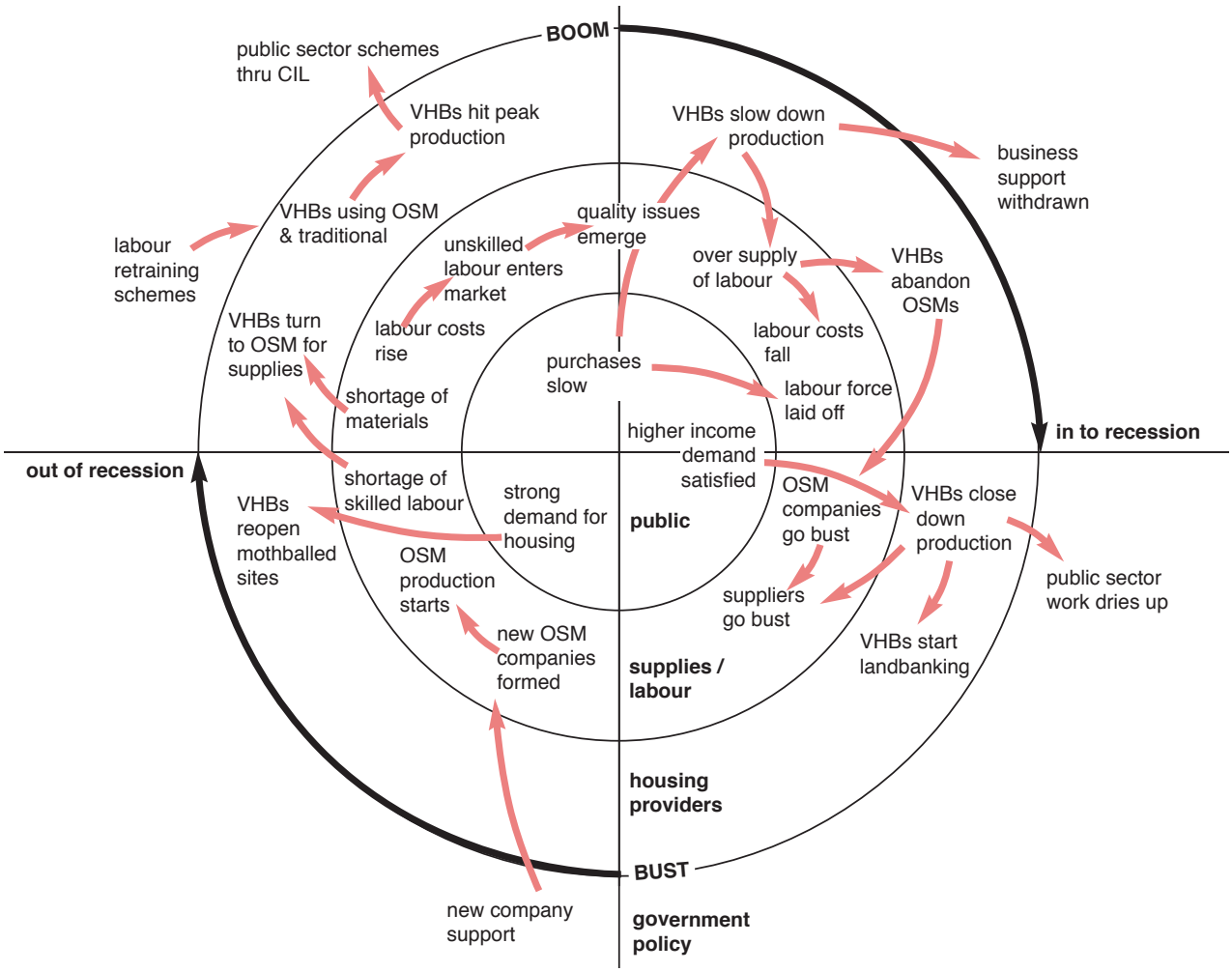


Figure 5-11 the current OSM cycle

In this instance, the returning problem is the monopoly that the volume house builders have over the housing market and the mismatch between their business model and the country's need for more, better quality, affordable housing.

The question that needs to be asked therefore, is where in this cycle of events would an intervention be most productive, and by whom? There are four suggestions shown here (Figure 5-12) to show how the root causes can be quickly identified when the causal relationships are so clearly defined.

Interestingly, these are all political solutions, as was suggested by top tier of issues in the mind map in Figure 5-10.

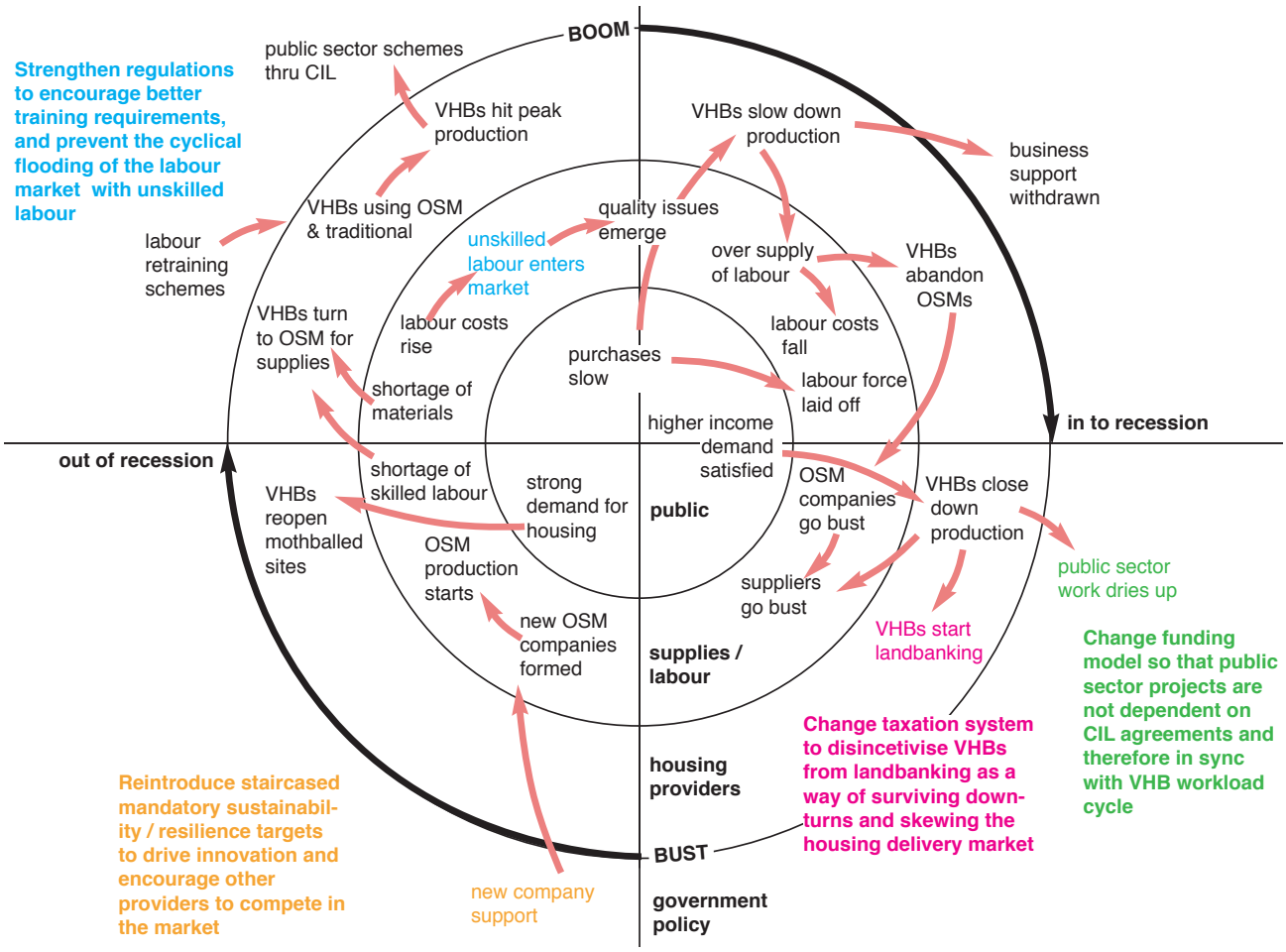


Figure 5-12 possible interventions

As a way of understanding the influence that different factors can have over each other, and how the entire picture can change over time when any one of these is adjusted, this is clearly a necessary concept to adopt. But it also blurs the line between measuring the impact that individual factors can have on a strategy decision and the impact that any one strategy decision can have on an entire company policy. This is not an attempt to grow the scope of this research even further than has already been achieved, but to take the argument to its logical conclusion. All the barriers to adopting an innovation discussed so far have been shown to exist within a hierarchy with causes above and consequences below, and this principle can also be extended to the level of strategic decision making, with all strategies sitting within a hierarchy of strategies to be addressed. The following section therefore completes this process of reconstructing the data by looking at how extending these principles to that higher level can actually help reduce the overall set of tasks by ruling out whole strategies at the outset alongside all the tasks that flow down from them.

5.3 Assessing Multiple Strategies

The previous two sections have developed a systematic approach that helps to evaluate any one task and make direct comparisons between binary choices, both in terms of their viability and their feasibility. But what it has failed to resolve is how the many tasks that have come to light during this process should be dealt with in relation to each other, a process it is suggested here that needs to preempt the undertaking of any one specific task being considered. The more the inter-connectivity between these tasks has been shown to exist, the more important it becomes to consider these issues holistically rather than in isolation. Categorising these tasks therefore, and how they fit within a hierarchy of decision-making has become part of the process to be resolved. The tasks that have arisen so far could, for instance, be categorized under any of the following criteria: the sectors they relate to – the house builders, government legislation, etc; the range of actions they require to be taken – further research, product development, lobbying for change, etc; or the levels of collaboration they would entail and the degree of complexity this adds to the task being put forward.

As this kind of holistic overview is a likely entry point for any organization considering a new approach to existing strategies, it was seen as important to consider the practicalities of this in some detail. The case studies in the following chapter to some extent confirmed the need for this further step to be taken, as they highlight the need to prioritise certain tasks and even entire strategies for them to be successful. In an attempt to define that hierarchy of tasks, the questions posed by the studies were extensively researched, broken down into component parts, reconstructed into groups, arranged into hierarchical structures - all in an attempt to find patterns of behavior that might suggest how their complex inter relationships could be dealt with systematically, and in some way formalised.

The following section shows how this process has been developed to bring some clarity to what at the outset appeared to be an impenetrable set of conditions to unravel, and how in achieving that, the total workload can be significantly reduced.

The concepts discussed in earlier chapters are now brought together to construct a Decision Making Tool that deals with all the issues from the smallest component parts of a problem to choosing which overall strategy to enact. To start with the underlying linear structure, the proposal is to break this down into four distinct stages, any of which could define the entry point for a company considering the available alternatives: Define, Understand, Resolve, Enact.

Define the Questions: How a question is worded can change the scope of the research task it will lead to considerably, but even the question is not the starting point of the exercise. Before this comes a list of concerns, known threats, existing strategies, wish lists, opportunities – anything related to options worthy of consideration or discussion. From each of these options might come many questions. By way of example, the concrete industry's concerns over the threat posed by the CLT industry could result in any of the following questions being asked: How much is known about the barriers facing CLT? Are there any regulations that are skewing the construction industry's decision to adopt CLT? In what sectors is a panelized concrete solution more appropriate than CLT? - These are all relevant but very different questions that all need to be asked. Similarly, questions relating to the comparative sustainability of timber and concrete or the detrimental impact for the concrete industry

of the government's use of static modeling in SAP calculations are fundamental questions in their own right, but not unrelated to the threat posed by CLT.

How these inter-relationships can be mapped is not straightforward because of the number of connections that can invariably be made, but a process has to be devised that separates out the individual issues, such as 'are there any regulations skewing the construction industry's decision to adopt CLT?' from the more overarching tasks, such as 'how does CLT pose a threat to the concrete industry?' Both the individual issues and the strategic decisions will sit within their own hierarchies of how they need to be addressed, but until the individual issues have been defined as subsets of the more holistic strategy decisions and both have been defined as binary choices, little progress can be made in resolving the problems they represent.

Research the Unknowns: Once the issues have been defined as research tasks, each consisting of a number of questions, those questions have to be answered. These will either require further research and / or the gathering of evidence and will invariably include gaining a knowledge and understanding of the other sectors involved in the process, an operation already defined by Phase I of the tool covered in Section 4.4. This is very much a precursor to the following stages and ensures that all the necessary information is available before attempting to find a resolution. The creation of research tasks in the form of Option A .v. Option B is a critical stage in the process as all the questions associated with these binary choices can then be considered under those headings where they will emerge as either pros or cons for either option. Furthermore, each binary choice strategy can be set within a hierarchy of other binary choice strategies, with, for instance, the choice of Concrete over CLT being in part dependent on the outcome of another research task, the Dynamic .v. Static Modeling debate.

Resolve the Problem: The next and more far-reaching set of questions will centre around how these problems, once fully understood, can be resolved – which of the available options should be chosen. Again there are a some categories that emerge within this group that most approaches fit in to, and they too form a linear progression from the simplest to resolve to the most complex:

i) Is the message right? Any solution, innovation, proposition must be known to the market before it can be considered. Dissemination of that information, or ensuring that information is being delivered in the right language is therefore the first step and if that is all that is required, represents the easiest problem to resolve.

ii) Is the product right? A better understanding of the market being addressed and what it is that they want can provide a clearer vision of what the product itself needs to deliver, in terms of price point, functionality, regulatory requirements etc. If the product needs to be changed or improved this is the resolution that needs to be addressed.

iii) Is the market right? Establishing the right market where there are the strongest synergies with the product being promoted is fundamental to the success of any promotional campaign, especially when trying to compete against an existing solution. Recognising where there are mutual benefits also enables greater collaboration over projects that cannot be carried out in isolation.

iv) Are the policies right? If there are policies in place that represent barriers to progress for some whilst benefitting others, these need to be dealt with and will invariably require the assistance of collaborative partners who share similar goals, if not the same motivations. This is the most onerous option, even before any proposed change is resisted by those benefitting from the status quo, but for that reason often the most necessary.

Enact the solution: The fourth and final stage in the process is to define the overall strategy to be enacted based on the now comprehensive understanding of the issues and what their resolution entails. The reason for this being a separate stage to that of resolving the problems is because the previous stage represents a hypothetical exercise where the alternative courses of action are assessed for their feasibility and viability before deciding upon which route to take. Enacting should remain the final stage in the process based on the conclusions reached, not an experimental process in its own right.

information in	**what are the issues that need to be addressed?**	Deconstructing the Data	Defining the Questions	existing strategies, known concerns and opportunities
assessment of known facts	**what are the questions that stem from each of these issues?**			generate questions, break down into simple choices
	how do these question inter-relate and how can they be categorised?	Reconstructing the Data	Understanding the issues	group into categories, position within a hierarchy
assessment of unknown facts	**what information is missing that needs to be added?**			gather evidence
				further research
assessment of available options	**which option defines the most appropriate course of action?**		Resolving the problem	change message
				change product
				change market
				change policy
decision out	**what are the decisions that will deliver that strategy?**	Using the Data	Enacting the solution	house type and build process
				market and delivery method
				partnerships and promotion

Figure 5-13 Structure for the decision making process

5.4 The Decision Making Tool – phase II

The framework for the decision making tool now encompasses its full remit, in that it has deconstructed the questions derived from the industry interviews and other research streams into their simplest component parts and then reconstructed the findings from this process based on an understanding of their relative significance within a broad hierarchy of influencing factors. The resulting strategies that emerge can then be traced back to the research on which they were founded and adapted where necessary to reflect any change in the parameters over time.

As a process this answers many of the questions posed at the outset regarding the need for a more informed approach to decision making. It reduces the reliance on pre-defined solutions by strengthening the bond between research and policy making and encouraging the perspectives of other sectors to be considered as part of that process. As a result, it is expected that the emerging strategies, now only embarked upon with a full understanding of what that entails, will stand a far better chance of success.

What is less resolved is the physical incarnation of the tool itself. This is a critical factor as it delivers the final requirement, the need for a thorough yet efficient decision making process. From the outset it was recognized that a fundamental cause for poor decision making was the lack of time available for that process. Any tool that fails to respond to that most intractable of problems will in itself be seen as a barrier to progress. It is nevertheless a major obstacle to overcome, considering the degree of additional research that is being suggested as necessary.

Many approaches have been used to both test and visualize the concepts being proposed but how or whether these should be incorporated into a working tool is less obvious. This is partly due to the subjectivity of how individuals prefer to work and not wanting to be too prescriptive about processes, but also due to the need for the tool to be easily accessible and remain open to adaptation.

The underlying structure throughout the tool's development has always been a series of relational databases, due to the need to deal with multiple entries and allow for those to be searched and sorted. To some extent the 'front end' to this format of data storage could be designed to present a visual display of the information held, but for some, the database mindset will be alien to their working practice and be seen as a barrier. Similarly the use of causal relationship diagrams and mind maps as used to investigate the relationships between different concepts might be equally confusing to some, but represent an obvious way of working for others. Ultimately, however, different tasks require different tools and what is most appropriate should dictate what is used for each purpose. The real task becomes one of simplifying the use of each and creating an overall uniformity to the process that ensures it is easily understood, provides enough flexibility, and generates the right level of information.

The final complete process is mapped out in Figure 5-14 to help visualize what those tasks are so that the appropriate tools can be allocated to each one.

information in	**what are the issues that need to be addressed?**	Deconstructing the Data	Defining the Questions	existing strategies, known concerns and opportunities	**list issues**	delivers known issues that need to be considered. *what questions arise from these issues?*	Start by creating an exhaustive list of all issues, strategies, known problems, products requiring markets and markets requiring products. Base this on a SWOT analysis by each sector in turn
assessment of known facts	**what are the questions that stem from each of these issues?**			generate questions, break down into simple choices	**translate into questions**	delivers questions that need to be asked. *how can these questions be categorised into tasks?*	List all the questions that arise from each issue, relating each one to a task to be carried out. Any question that can be approached in multiple ways needs to be split into further questions until each question results in a binary choice.
	how do these question inter-relate and how can they be categorised?	Reconstructing the Data		group into categories, position within a hierarchy	**categorise into tasks**	delivers tasks that compare alternative solutions. *what unknowns arise from performing these tasks?*	Consider whether the individual questions fit within a hierarchy of tasks to be carried out, either in terms of the staged processes they involve, the different sectors they relate to or the scope of the task and need for wider collaboration
assessment of unknown facts	**what information is missing that needs to be added?**		Understanding the question	gather evidence further research	**research unknowns**	delivers research that needs to be carried out. *What emerges as a result of this additional information?*	Gather any evidence needed to substantiate the argument, or if that evidence is not available, carry out any further reearch needed to fully answer the questions being asked
assessment of available options	**which option defines the most appropriate strategy?**		Resolving the problem	change message change product change market change policy	**compare options**	delivers options than need to be considered. *which option provides the best outcomes?*	On the basis of a broader understanding of the problem being addressed, decide which of the available options is the most appropriate, feasible, likely to succeed. The solution may involve a combination of tasks, but each should be recognised as an operation in its own right.
decision out	**what are the decisions that will deliver that strategy?**	Using the Data	Enacting the solution	house type and build process market and delivery method partnerships and promotion	**define a strategy**	delivers a process that needs to be followed. *What is the strategy that best delivers this outcome?*	Once an approach has been decided upon a strategy for enacting it can be defined. This involves considering each of these six categories within the decision making process.

Figure 5-14 The completed process in table form

Deconstructing the Data is a systematic process best handled in a database structure, with placeholders predefined for the information being extracted from the issues being addressed.

Reconstructing the Data on the other hand, requires a level of oversight that is not possible within a database environment. The causal relationships, conflicting motivations and ontological viewpoints held by different sectors and the hierarchies of influence within them, all require a looser system of evaluation where multiple, value driven connections can be drawn.

Using the Data is again a relatively systematic procedure to follow that ensures all the necessary stages are covered, although the order and priority will change depending on the main drivers.

The solution finally arrived at for the reconstruction phase in the process was a combination of both approaches, with the need to switch between the formal categorization process offered by a relational database structure and the free thinking relationship model offered by the 'mind map' environment. Neither in isolation can deliver a model for restructuring the data into a meaningful format for defining strategies, but together that functionality could theoretically be achieved.

Figure 5-15 now shows the whole process from information in to decision out, incorporating all the methods applied throughout the research as the process has evolved to answer the question being asked. This is the structure for the Decision Making Tool shown diagrammatically in Figure 5-16 using the alternative market options of Housing Associations and Speculative house builders as a test case.

One further level of development discussed in the concluding chapter would be the integration of the two technologies to allow for the flow of ideas back and forth through this critical stage. Whilst it was not possible to incorporate this level of programming into this research, this final stage was seen as one that would deliver an essential level of functionality to the tool.

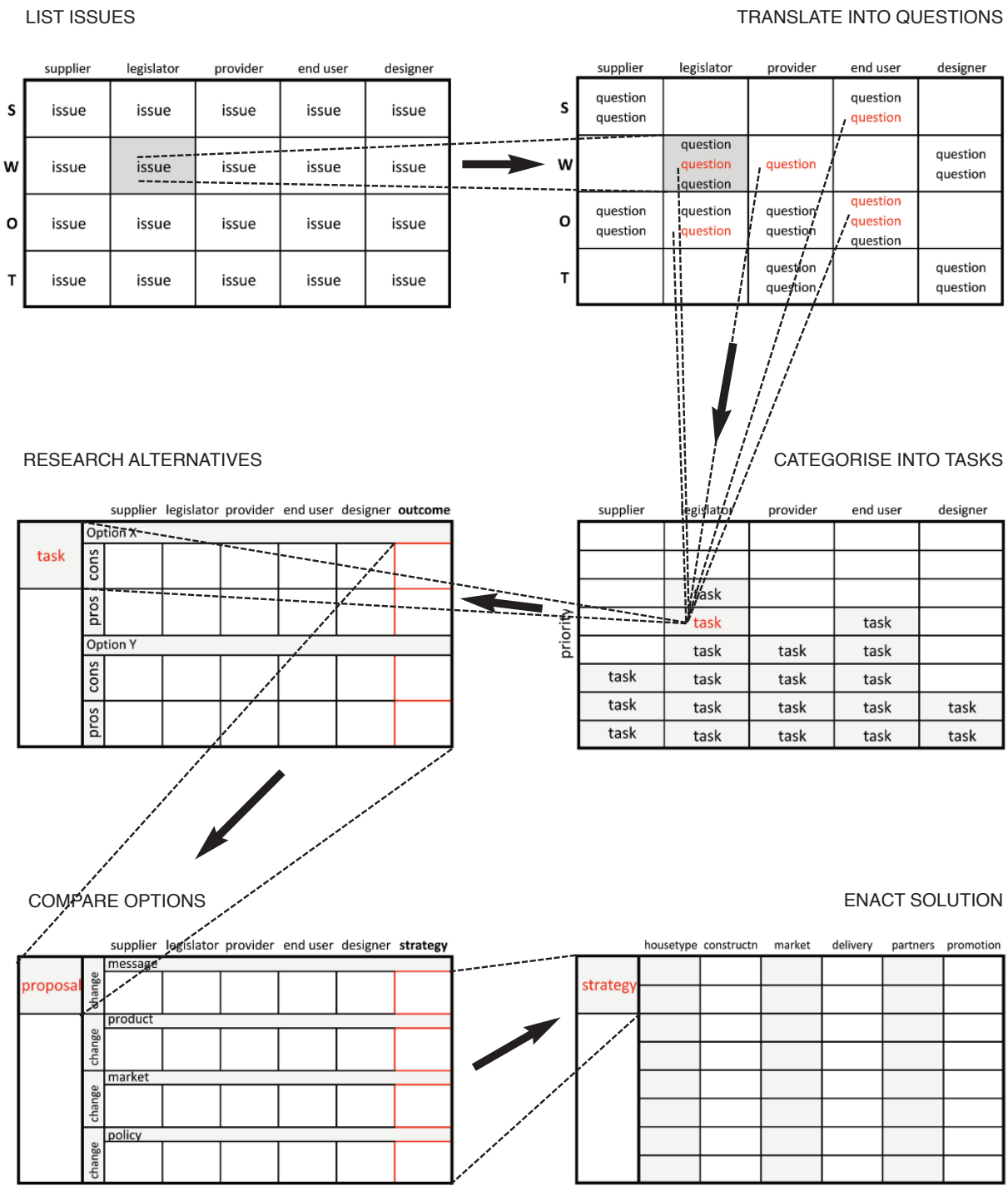


Figure 5-15 The Decision Making Tool structure

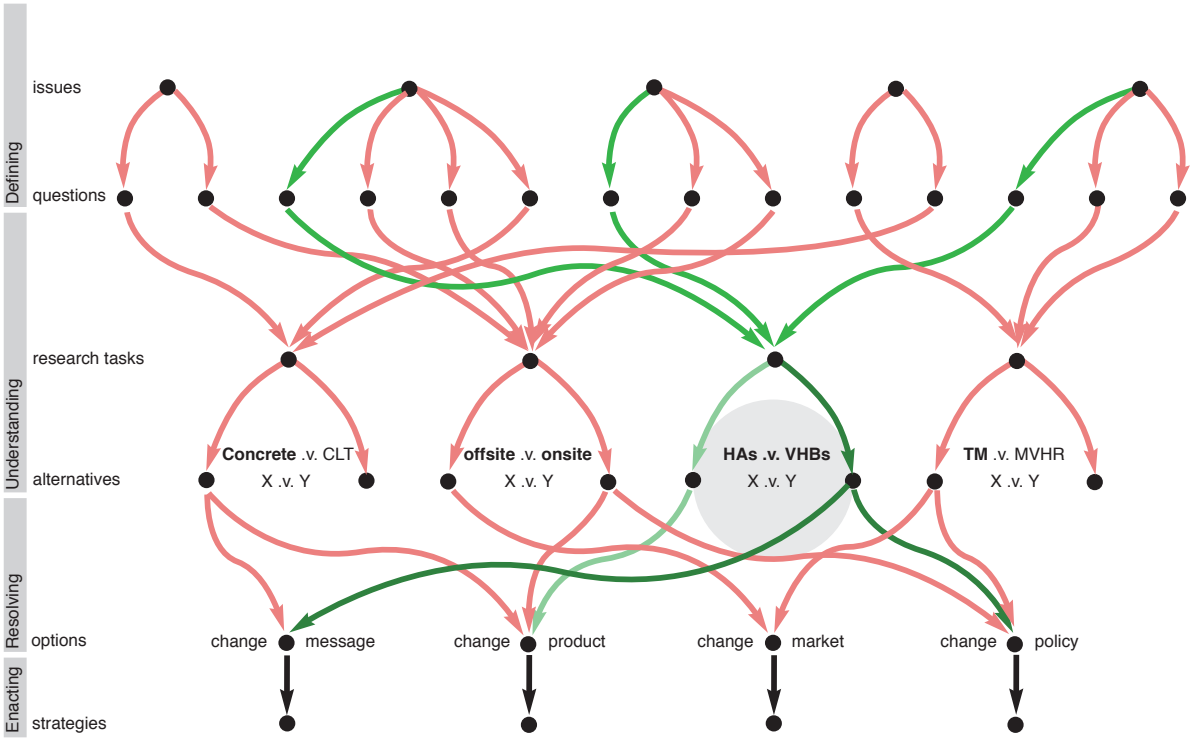


Figure 5-16 alternative model showing the six stages of the process

5.4.1 The benefits of assessing multiple strategies

Much has been made of the need to extend this process to holistically look at all strategies rather than each in turn or in isolation. This is a position arrived at as a consequence of attempting to isolate each strategy and recognizing how the inevitable interconnectedness of those strategies makes this an impossibility. What was less clear at the outset was how this could be beneficial to the process from a more practical perspective.

The model used in Figure 5-10 shows how these connections can be drawn to position all influencing factors within a hierarchy of causes and consequences, with some factors emerging as more pivotal than others and shown by the number of connecting arrows leading either to or from those factors. Specific strategies can be defined by drawing threads through these factors in a way that shows how certain tasks are dependent on other tasks being undertaken beforehand. Following these threads culminates in the root causes that must be either dealt with or accepted as immovable barriers to progress. Figure 5-17 shows the full range of issues relating to Tarmac's business model defined as binary choices and how they are interrelated. The issue of CLT as a threat to their industry is highlighted, showing the full scope of the actions that would need to be taken for this threat to be dealt with realistically. As a test case this is dealt with in Section 6.2.5, but the principle being made here is that it is only once the full extent of the undertaking is understood that a decision can be taken of whether or not it is feasible to proceed. And that decision needs to be taken within the wider context of how critical any of those factors are in the outcome of all other possible strategies. As can

be seen from this diagram, the higher the factors are in the hierarchy tree, the more likely they are to play an influential role in multiple strategies.

There are two ways in which this approach can reduce the workload once policies begin to emerge. Firstly, there will also be factors that are less interconnected and therefore of less overall importance to the success of a business. But there will also be entire strategies that are shown to require a level of investment in time and resources to tackle entrenched root causes that make them unfeasible for the returns they could deliver or the risks they entail. It is here that the real benefits of such a holistic approach at the outset are most apparent.

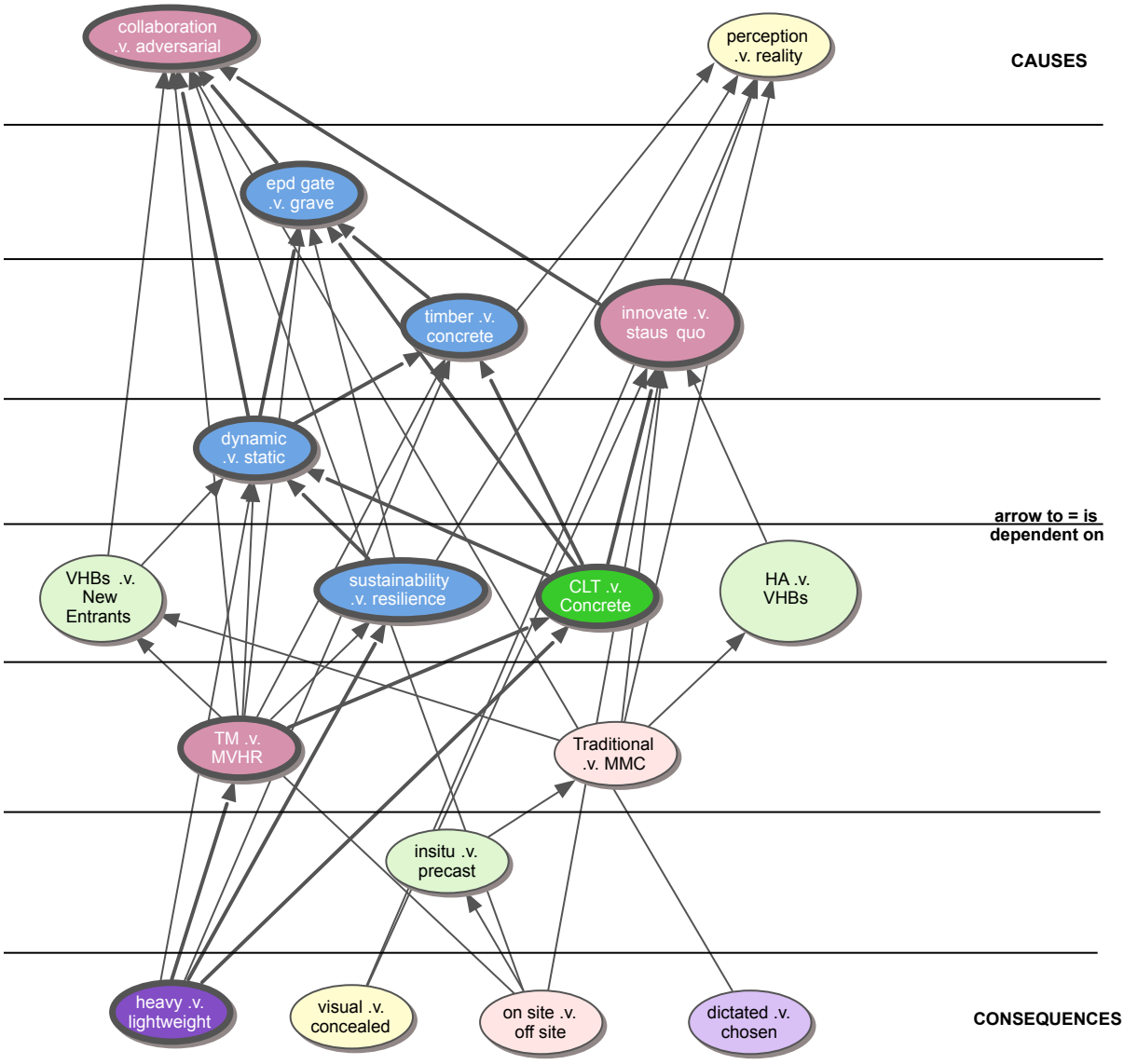


Figure 5-17 Key issues relating to Tarmac's strategic issues

5.4.2 Discussion: Ensuring successful adoption

The proof of this concept is in its usability, and how well it acts as a guide for better decision making. Whilst this cannot be easily incorporated into the research beyond the use of feedback from the funding partner, the methods needed to ensure its successful adoption quite accurately mirror the processes that the tool itself applies to the adoption of an innovative product: As with the promotion of any other innovation, it would be reasonable to suggest that the benefits such a tool can deliver are relatively straight forward to explain and understand. It is the barriers to that adoption that need to be addressed to ensure its success. It was therefore decided when introducing the tool as the main output of the research, to use a discussion around these possible barriers to its use as an analogy for the purpose of the tool itself and as a way of ensuring those barriers did not result in the tool being dropped or its methods being by-passed in any way. (Appendix L The Decision Making Tool Workshop)

Focusing on Knowledge, Motivation and Ability, knowledge of the tool was already established for some through their role in commissioning the research project. For them, motivation to use the tool, once the principles had been explained was clearly financial, in terms of growing market share, but there were also perceived benefits in terms of efficiency and time saving not just for the company but for individuals within the company. The process of actually ensuring its adoption, however, possibly represented the greatest barrier to be overcome.

That process, the ability of the company to embed a new way of thinking throughout an organization, represents the internal risk associated with adoption, (disunity), the others being industry barriers (complexity) and broader future event barriers (uncertainty). For the tool to be successful, there had to be 'buy in' at all levels – from those using the tool to define the necessary areas of research to those interpreting the results to define company policy. The perceived danger here was that of preset agendas from above preempting and over-ruling the findings from below. To reinforce the need for all to be involved in establishing where the problems to be assessed lie, and for the bottom up research to then inform the top level decision making and not vice versa, the hierarchy based structure of questioning that had been developed in phase 1 (Section 4.4) was further used to reinforce the way in which information needed to be passed up – and back down - through the company structure for a true integration of research and policy to take hold. By incorporating output fields into the design of the tool so that reports could be structured from the information entered at each level of this research, that link became part of the process, allowing policy makers to trace the thinking behind the choices made (Figure 5-18).

In addition to this method of auto-promotion, using the company's adoption of the tool itself to help explain how the tool focuses on the barriers to be addressed, the case studies in the following chapter, primarily devised to validate the tool, were also used to show how proposed strategies could be assessed for their viability and feasibility. These case studies, forming the bulk of the appendices are discussed here in the following chapter in terms of how they informed the development of the Decision Making Tool in its final stages.

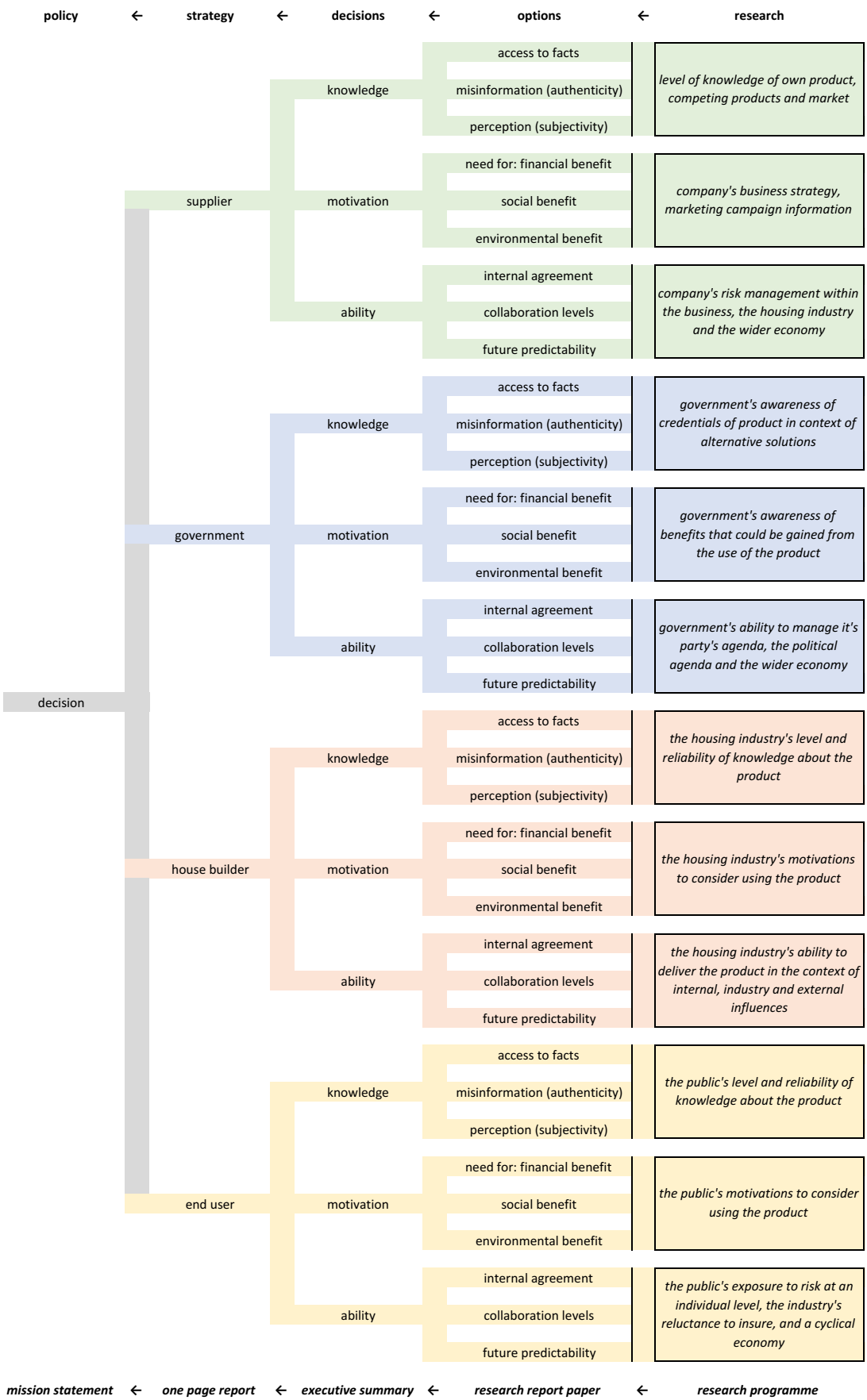


Figure 5-18 Flow of information from the Decision Making Tool.

Chapter 6
THE CASE STUDIES

A total of 20 case studies were carried out forming the culmination of this research and the fulfillment of the fifth objective, to validate and hone the process so far developed (2.2.2). These too were inductive, and can be seen to follow a narrative that reflects the process being developed in the Decision Making Tool – establish the level of knowledge and where it lies, consider the alternative motivations that exist and how these impact on the decisions being made, assess which markets are most able to deliver the innovations being proposed, and what partnerships would be needed to successfully promote those innovations to the most appropriate markets. Following this process was part validation, part adaptation, as the studies highlighted a number of areas where further development was needed, but the logical steps taken throughout result in a compelling case for the solutions that emerge towards the end of the chapter and also the need for further research in areas where the process was inconclusive.

6 THE CASE STUDIES

Aims of the Case Studies

In the tech industry, conventional wisdom says nine out of ten start-ups fail (Griffith, 2014), with 'failing fast' being preferable to a prolonged departure, and "the number-one reason for failure, cited by 42% of polled startups, is the lack of a market need for their product". This research has uncovered many barriers to innovation, some of which lie beyond the realms of what is normally considered to be relevant. It has also established that these barriers sit within a hierarchy of causes and consequences and that all barriers in that hierarchy have to be dealt with, one way or another, before any progress can be made.

What this research has aimed to develop for the housing industry as its main output is an assessment tool that simplifies the task of recognising those barriers that stand between the innovator and the successful adoption of their innovation, and help find the most appropriate way of dealing with them. The purpose of the case studies has been to test and validate this tool during its development, and for that reason each case study has been chosen for its ability to shed light on these many barriers from a range of industry perspectives.

The tree diagram used throughout this research to show the development of the concepts being applied to the Decision Making Tool is also used as the framework for these case studies. This is not a straightforward progression, and there are many outcomes that have resulted in the reappraisal of earlier decision making stages and the propositions put forward. Recognising the need to re-evaluate opinions as more and more perspectives were considered is central to how this research was carried out, as it is to the decision making process being developed. Similarly, these case studies have been structured to show how each argument feeds off the knowledge gained from the previous argument until a picture emerges of what is relevant and what is incidental to the initial question being asked. What is of interest here is how any one question seems to escalate very quickly and draw in a wealth of inter-related issues before narrowing in on some core issues that underlie many of the industry's problems.

It is these aspects of the decision making process, built on throughout the research, that are being interrogated by the case studies chosen, with the studies themselves being vehicles for that process. Informative as each one is in its own right, it has therefore been decided to limit the discussion in this chapter to what has been learnt with respect to the process being developed, with the studies in full being consigned to the appendices.

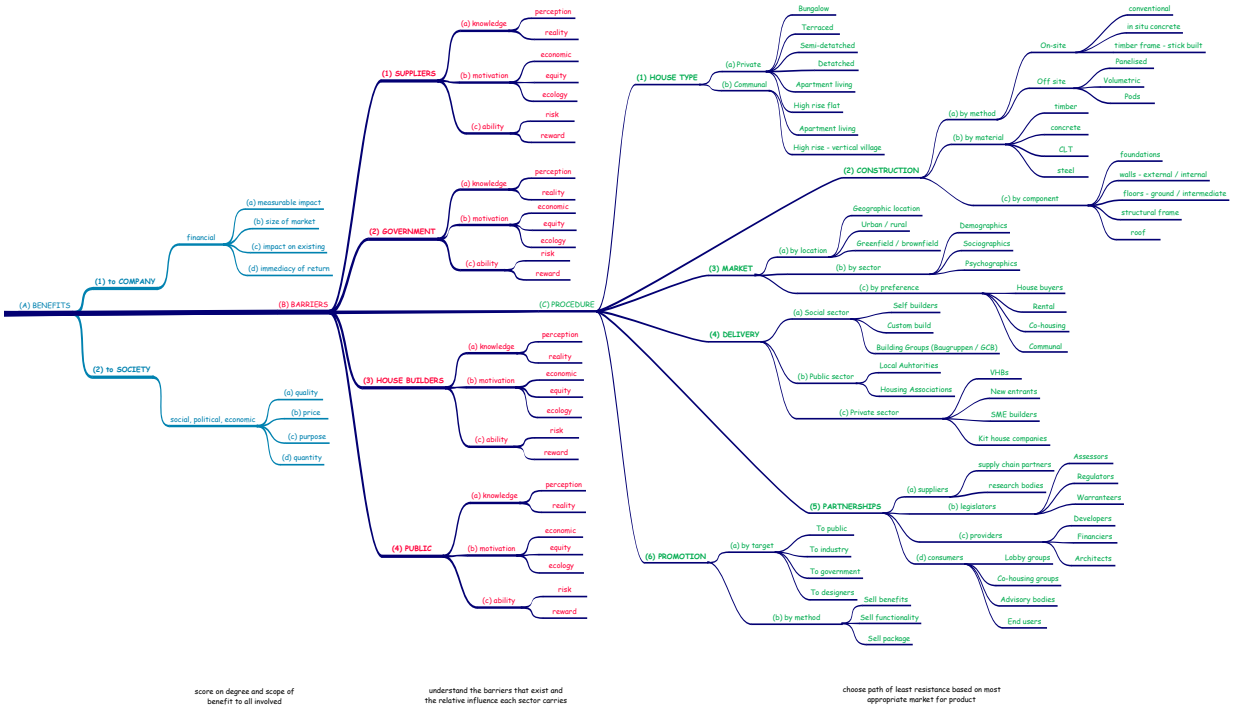


Figure 6-1 The evolving decision making process

The chapter is divided into four sections, and begins with studies that show the importance of data accuracy, and how gaps in our knowledge can result in poor decision making and ineffective outcomes. This is followed by studies looking at the influences that dictate what we build and how we build it - essentially looking at how to assess the benefits of, and the barriers to any particular proposition when considered from multiple perspectives. The third section looks at specific business models and shows how important it is to find the right model and the right market before promoting any product. Lastly we look at the wider issues that can still prevent innovations from being adopted and the importance of ensuring that those barriers have been addressed before progressing down any particular path.

To summarise that framework to the case studies,

Section 1, knowledge: The importance of full facts and a broad perspective

Section 2, motivation: Understanding the key motivating factors behind how and what we build

Section 3, ability: Matching business models to markets – what are the delivery options?

Section 4, enactment: Ensuring the support is there and the environment is conducive

Figure 6-2 relates these four case study sections back to the Decision Making Tool that they are designed to validate and shows how they follow through the process from ‘information in’ to ‘decision out’.

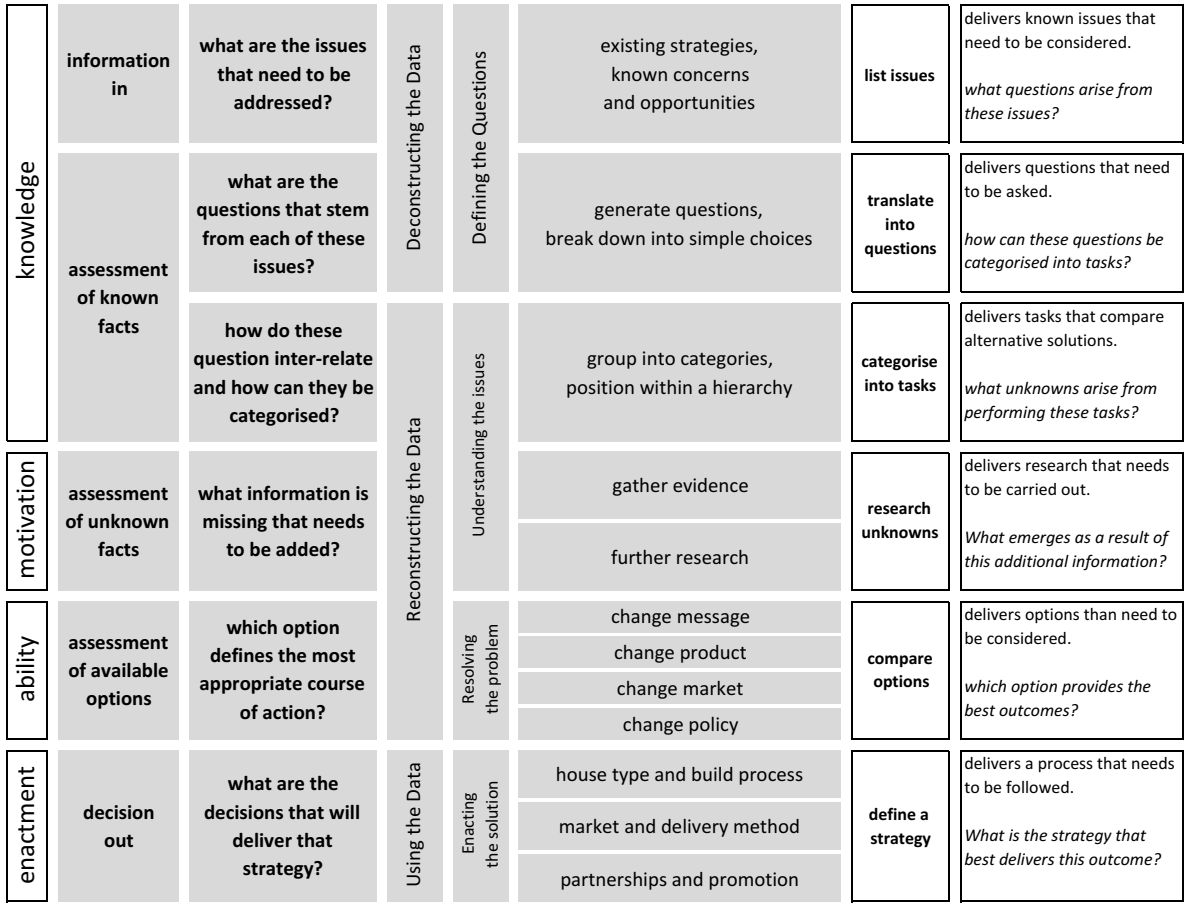


Figure 6-2 The Decision Making Tool

As part of the validation process, each case study is assessed for the evidence it provides backing up the need for a better decision making process, and also how well the process being developed answers that need. The following table shows the full scope of these studies and how they relate to the concepts that have been introduced over the previous chapters. In this chapter the findings from each case study are discussed, with the evidence from the actual studies held in the related appendices.

6.1 Knowledge based Case Studies – the importance of full facts

To what extent does working with a subset of the information needed change the outcomes, and how can this be avoided?

advisory bodies & info sources (2.3.1.0) **- how data is accessed and used**
(understanding own industry)

public survey data (2.4.1.0) **- what is known and by whom**
(understanding the client)

timber .v. concrete (2.1.1.2) **- challenging the 'facts'**
(perception & reality)

static .v. dynamic (2.2.0.0) **- the need for evidence**
(hierarchy of barriers)

Understanding Government Process **- alternative perspectives**
(confront, avoid, accept)

6.2 Site based Case Studies – key motivating factors

Understanding the specific reasons behind the decisions made to choose one material or method of construction over another.

Residential towers: Trent Basin & Nottingham One **- dictated by the site**
(key motivating factors)

Affordable housing provision: Nottingham City Homes **- dictated by the client**
(client side motivators)

The London market: 1, Hyde Park **- dictated by the location**
(indirect motivators)

Tokyo's story: Deregulation **- dictated by the economy**
(flawed comparisons)

Innovator sites: Dalston Lane, Hackney **- dictated by the material**
(binary comparisons)

6.3 Business based Case Studies – matching business models to markets

understanding alternative business models and when they are appropriate for promoting different innovations.

European models **- UK v overseas experiences**
(learning from the importers)

Established .v. disrupter business models **- existing v new entrant**
(matching risk with risk takers)

Alternative market models **- mainstream v minority**
(defining appropriate markets)

OSM based innovation **- evolution v revolution**
(defining long term strategies)

Whole package solutions **- holistic solution v piecemeal products**
(defining holistic solutions)

6.4 Issue based Case Studies - changing the system

Bringing about change cannot be done in isolation. Making the right partnerships is a necessary step in creating the right environment and de-risking a fragmented and adversarial industry

The role of the New Entrants **- crossing the chasm**
(defining the players' roles)

New drivers for sustain **- the need for a vision**
(defining the beneficiaries)

BIM, EPDs and OSM **- creating the right environment**
(defining the policy priorities)

Collaborative concerns **- leadership and guidance**
(defining the key players)

The land question **- the political end game**
(defining the parameters)

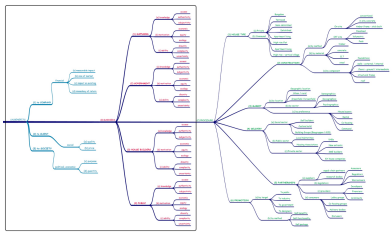
6.1 Information based case studies

One of the fundamental precepts of this thesis is that decisions made based on a subset of the available information will be poor decisions, prone to failure. Availability of information, however, is only one of many potential barriers to being in full command of the facts. Accuracy and possible subjectivity of information; time available - or the permission to spend time - to research all available sources; knowing at what point all relevant information has been addressed; these are all factors to consider. There may always be some 'known unknowns' left un-investigated or some 'unknown unknowns' yet to be discovered, any of which could render the final decision flawed, but this research also looks at the 'known knowns' not recognised as being relevant that also need to be brought into the discussion to ensure a better decision making process. These first five case studies aim to show how often inadequate information is used to make important decisions, and how much better those decisions might have been were there more time available for that research or the time available used more constructively (Luigi Toma and Gheorghe, 1992).

The examples in this section highlight how attitudes towards information have become increasingly dysfunctional as the amount of information at our disposal has grown, and asks how that can realistically be addressed bearing in mind the increasing complexity of the decisions we are expected to make and the decreasing amount of time we are expected to spend making them. In other words, the question is not just one of whether we have enough knowledge to answer the questions being posed, but also one of how to realistically go about filling those knowledge gaps once they have been recognised.

All the problems faced by the housing industry, as with individuals or the government, can be seen as sitting within a hierarchy of problems, with causes above and consequences below (Chapman, 2004). Sometimes those causes will be beyond the industry's gift to influence, and sometimes the consequences will be too insignificant to concern them, but understanding that hierarchy is fundamental to solving those problems, and these case studies all exemplify the need to gain that knowledge before deciding how to proceed. Knowledge transfer is a two-way street, and before selling products to clients, promoting solutions to the public or making a case to government, those sectors' own stories need to be heard, and their motivations understood.

This process starts with knowing one's own industry, and central to that is knowing where the sectors within that industry get *their* knowledge from.



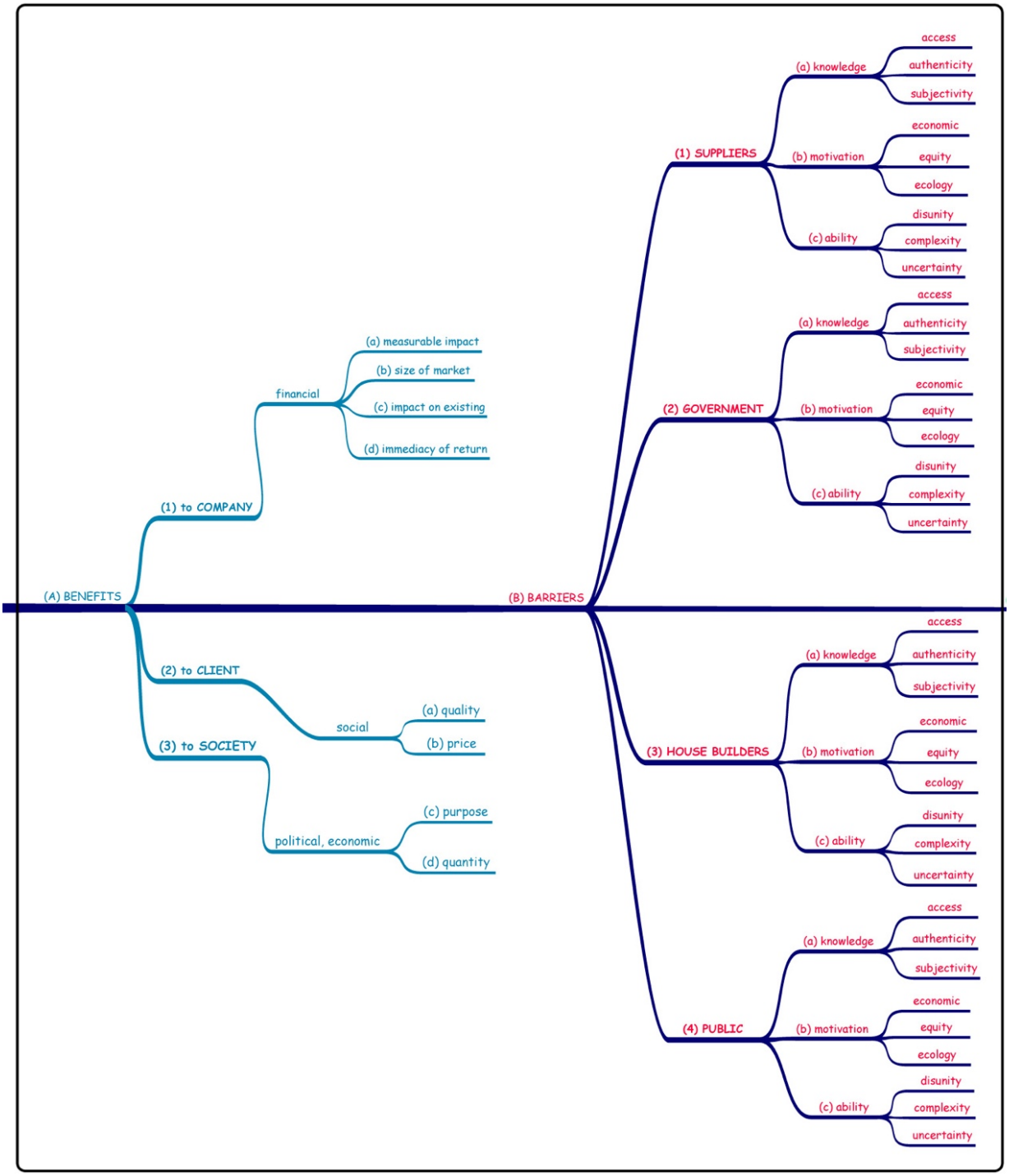


Figure 6-3 Knowledge based barriers to innovation.

6.1.1 Advisory bodies and information sources.

The objective here was to show the degree to which each sector's knowledge can vary depending on the sources they use. Availability and access to information is often not the main barrier to knowledge, with all reputable sources, and some less reputable now having a web presence. Authenticity and subjectivity, however, can be far harder to define or filter out from what can be found all too easily. A review of information sources was carried out with a view to establishing how to find those organizations most beneficial, not only as data sources but as potential collaborative partners going forwards. This looked at objectivity, connectivity / reach, clarity & depth of information and currency (Appendix M1).

By adopting a process similar to assessing the reach of academic papers through the frequency of their citations, it was possible to create a 'map of relevance' based on each body's connectivity and impact on either government or industry policies.

The bodies covered were categorized by their source, being either government, business or public affiliated and also by their purpose, defined as either research, lobby, advisory or assessment. Many covered more than one purpose, but often had separate arms to deal with those different roles. The conclusions drawn from this search were that whilst each body had a clear objective, invariably stated on their home page, and for that reason providing different perspectives, there was a large degree of overlap in the information provided. The transparency of their agendas was also sometimes unclear, as was the level of bias in their arguments or the reliability of the data provided, making it difficult for users to make direct comparisons. Understanding their funding mechanisms did not necessarily correlate with any degree of impartiality, but those that were collectively funded by an industry to promote companies within that industry were treated with caution. Also unclear from a web presence was the level of activity of the board members. Many bodies boasted an impressive array of names from industry and government, but there were some names that appeared on many boards, especially those that were defined as umbrella organizations, who may have had little regular or current involvement (Appendix A).

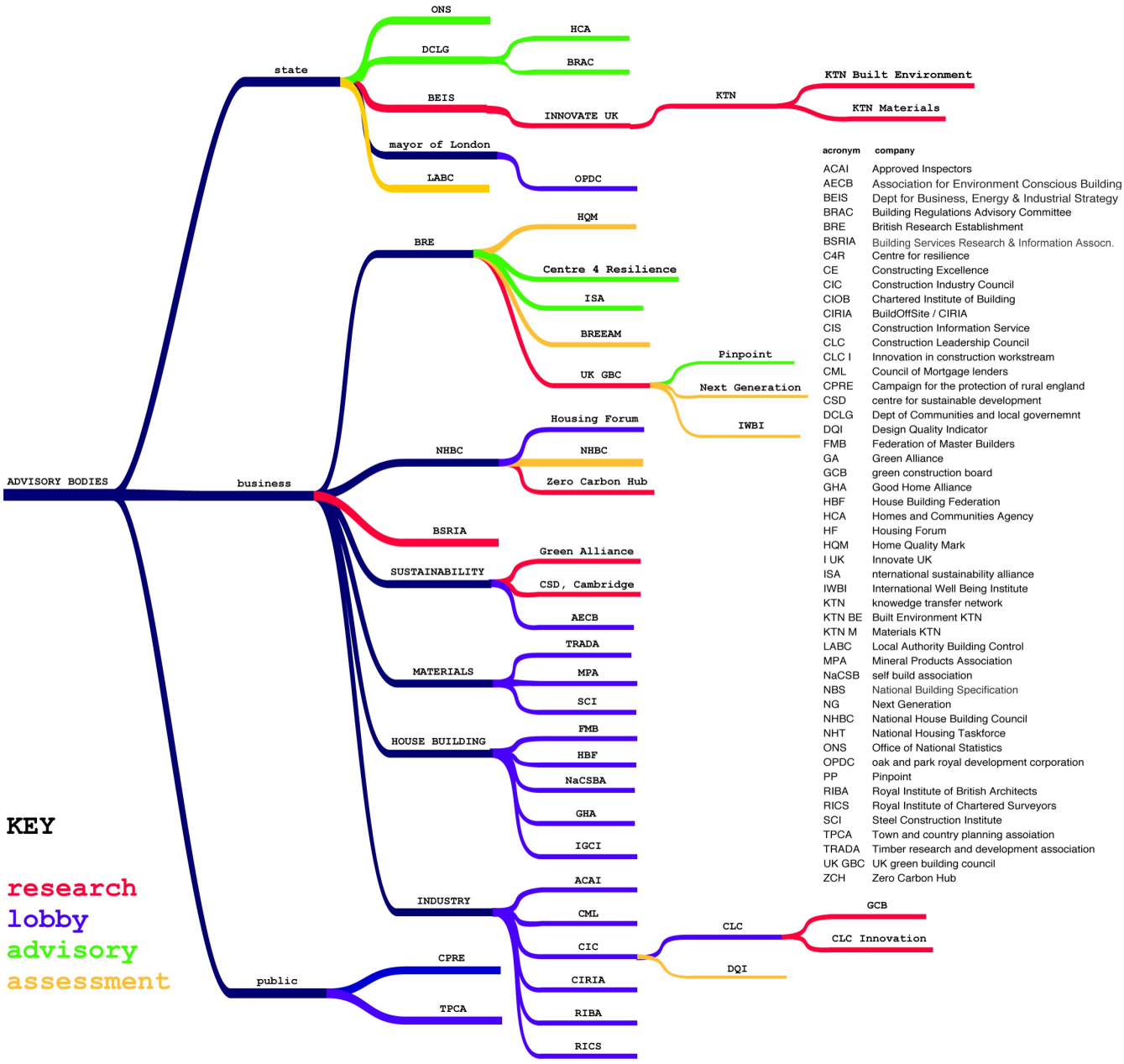


Figure 6-4 tree map of advisory bodies in the construction industry

Figure 6-4 shows how many of these bodies inhabit the same ground, and are effectively fulfilling very similar roles, even if reporting back to different core groups within the industry. The level of fragmentation across the industry that this exemplifies was one of the key findings of the Farmer Review:

"The construction industry is often characterised as an example of 'market failure'. This usually refers to its highly fragmented structure (both vertically and horizontally), introverted nature, and unusually high levels of self employment" (Farmer, 2016, p. 17)

Whilst 'defragmenting' the industry may be an end goal, in the meantime, knowing which ones of these many 'arterial routes' have the best reach and connectivity will be necessary for the purpose of generating productive networks.

Of equal importance, it was decided, was knowing where the rest of the industry went for its information, and what kind of information was seen as relevant to their sectors. To establish this, a questionnaire (Figure 6-6) was devised and sent out to gather that data and compare it against the perceptions known to be held from the industry interviews discussed in Chapter 3.

The feedback from this trial launch suggested that the internet was indeed the most commonly used point of access, and that much of the industry's knowledge was coming from the type of intermediary sites populating the previous model in Figure 6-4.

Together these two areas of research have helped show how the housing industry can grow its knowledge of its own industry's sectors, and what they themselves know. The causal loop diagram in Figure 6-5 shows the outcomes that could therefore be expected from this kind of intervention.

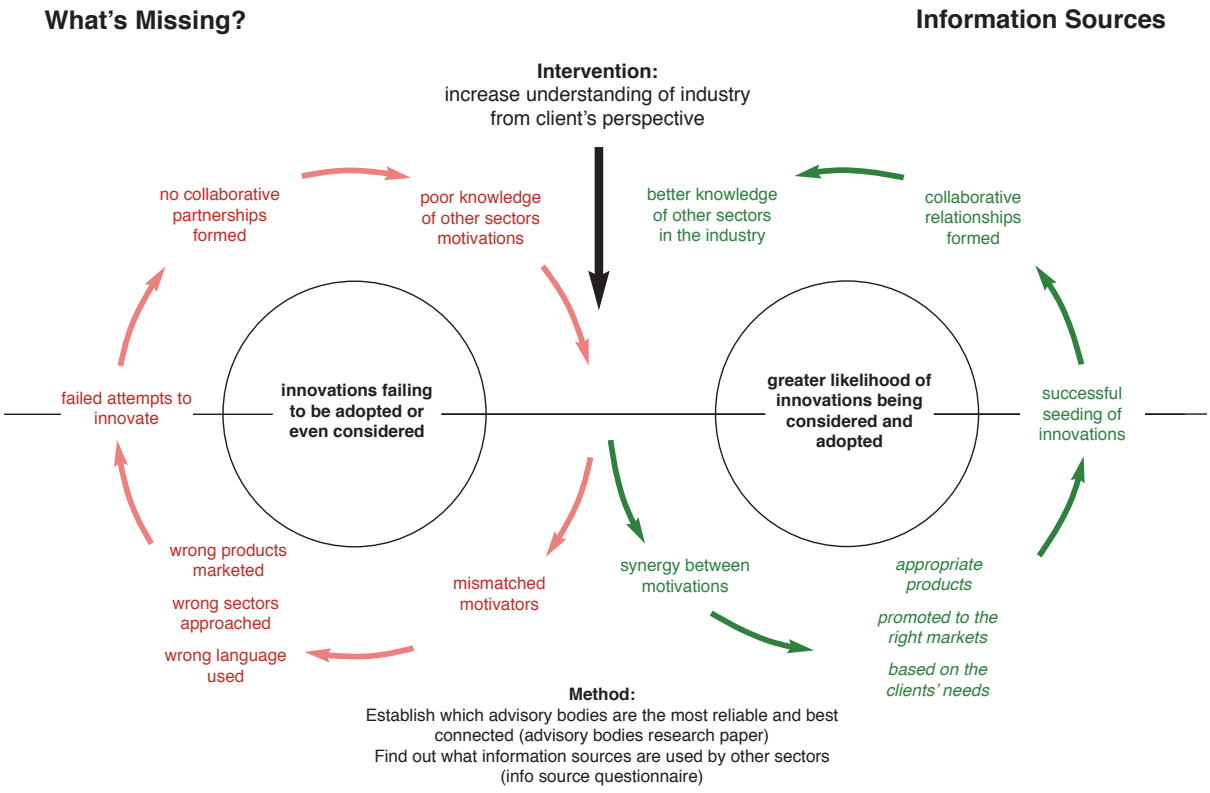


Figure 6-5 Causal loop diagram of industry knowledge

Information Sources Questionnaire

As part of my research I need to establish where the housing industry gets its information from. The following questions are set out in a format that will allow for direct comparisons, but will not necessarily work for everyone, so please ignore boxes that are not relevent to your sector.

0 = not applicable 1 = slight 2 = average 3 = considerable - or just a tick or cross if that is more appropriate

please state your industry role:

SUBJECT MATTER:

What subject areas are of most concern to you?	materials / method of construction	policy / legislation	house building / company news	public opinion / trends	*comments / other*
	19	18	12	14	

SOURCE:

Where do you usually find this information?	Academic papers	Government publications	Industry literature	general media	*comments / other*
materials / method of construction	8	11	13	6	
policy / legislation	2	20	12	11	
house building / company news	2	5	15	13	
public opinion / trends	2	7	9	17	

INTERPRETATION:

At what level do you get this information?	full publication	executive review / summary	commentry / analysis	in conversation	*comments / other*
academic papers	1	12	6	4	
government publications	13	14	10	5	
industry literature	13	11	9	4	
general media	4	5	7	6	

FORMAT:

In what format do you access this information?	printed form	websites	digital media	conferences / meetings	*comments / other*
academic papers	0	13	9	6	
government publications	0	15	9	10	
industry literature	6	15	9	10	
general media	2	12	14	1	

VALIDITY:

How much of your knowledge do you feel is down to:	cumulative experience?	original thought / innovation?	trust in authorities / procedures?	gut instinct / perception?	*comments / other*
materials / method of construction	17	8	8	5	
policy / legislation	7	1	14	1	
house building / company news	6	1	9	3	
public opinion / trends	6	1	9	10	

Figure 6-6 Information sources questionnaire responses

6.1.2 Public survey data.

Extending the mutual knowledge base within the housing industry was the first step towards understanding the clients' needs and motivations, so that the right message could be aimed at the right audience. The objective of this next study was to highlight the lack of information held about that other sector, the public's opinions, and how much those opinions can vary.

The known gap in the housing industry's knowledge base, gained from the industry interviews was the views of the general public. The fact that the rest of the industry were of the opinion that the public's opinion was of little consequence meant this was something that had to be resolved, resulting in the development of an on-line public survey, that was fully completed by over 150 people. Its aim was to triangulate three areas of information: what the public know about the construction of their housing, what they want from their housing, and who they are - demographically, psychographically and sociographically (Appendix M2). Without this information, 'the public' are an amorphous mass of people who are assumed to not only have little say in what is ultimately being built for them as clients, but who are also assumed to all think alike: (E.04.2)

INT "where do the public sit in all this - how much control have they got?"

PA04.02 "They're not even in the room."

The hardest age groups to attract to an on-line survey were the over 65s (18% of the UK population), and those educated up to GCSE level only (almost 50% of the UK adult population), but the fact that this information was captured meant that this can either be addressed in the future or allowed for. Being aware of such limitations is critical to the way in which the data from public surveys is used, and in this case the failure to attract over 50% of the country's demographic meant that, without an extensive caveat, the results gathered were of limited use outside of a pilot study to be built upon at a later date. The results obtained regarding the public's opinions of concrete (Section 3.3.5) were nevertheless compelling enough to justify considering further focus groups or a full omnibus survey.

The question of whether or not it was necessary to undertake this survey itself raised a number of issues about the need for a wider knowledge base. It is true that the public's voice is seen to be of little consequence in the housing debate as it currently exists. The public are however the end user and ultimate client for the housing being produced, so this must be seen as an imbalance to at least be investigated if not redressed. The extent to which the public's voice can impact on how the housing industry operates was exemplified by the recent internet campaign waged against Bovis Homes by a group of dissatisfied home buyers, resulting in a 40% drop in the company's share value (Evans, 2017). If the public are to find their voice through such means, evidence will be needed about what constitutes 'the public' before any meaningful use can be made of this information. And from the perspective of the innovator, that meaningful engagement means knowing how to collaborate with that voice to further their cause.

Again, a causal diagram is used to show the possible outcomes to be expected from this kind of intervention, and how a rebalancing of the influence that each sector has in the debate can have the effect of turning a vicious cycle into a virtuous one. Figure 6-7.

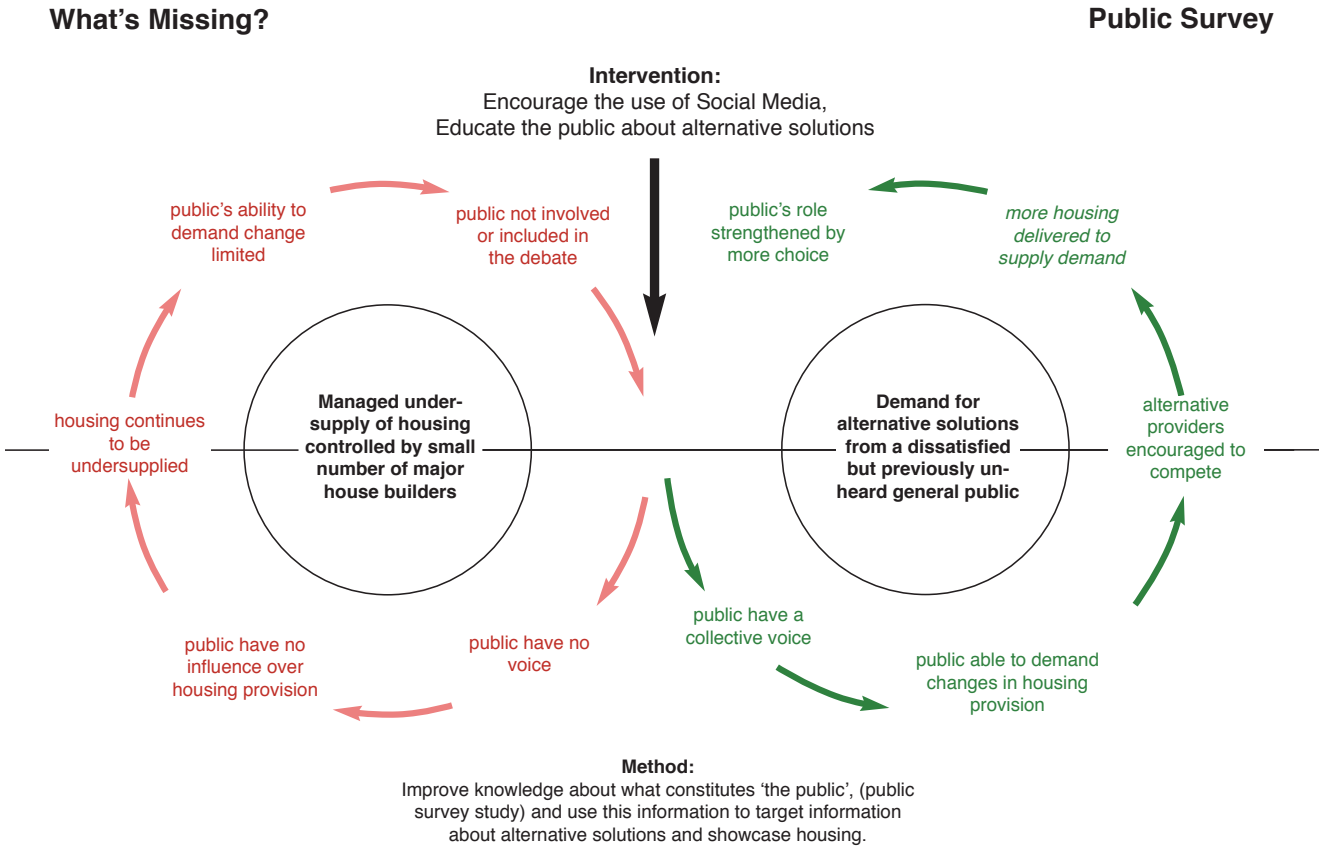


Figure 6-7 Causal diagram for improving public knowledge

6.1.3 Timber .v. Concrete.

Filling in the gaps in the knowledge base, as the previous two studies have attempted to do, begins to show where some of the flaws are in the promotional messages currently being used. In this case study, the realization from the public survey that concrete's Achilles heel is its eco credentials (Appendix H), exposed the need to find a counter argument to timber's sustainability claims, something that represented a gap in the concrete industry's own knowledge base.

An important aspect of knowledge is its reliability. Even pier reviewed evidence is fallible, and under scrutiny, some 'facts' can be shown to be little more than long established perceptions, which when left unchallenged can become accepted as reality. The public survey highlighted that the public's knowledge of concrete is surprisingly accurate and positive, except for when asked about its environmental impact. To apply the proposition of one barrier being as detrimental as ten, this needs to be challenged – something that is rarely done, so strong is the belief that concrete can never be shown in a positive environmental light. This case study addressed this issue by establishing the carbon footprint associated with a typical family house built of timber compared with that of an equivalent house built of concrete (Appendix M3). The results are revealing, but also unearth the incredible difficulties associated with proving the environmental case for timber. If this widely held

perception of concrete as an environmental disaster is indeed a major barrier to its adoption as a building solution, it is a barrier that deserves more attention.

This case study is therefore important for many reasons. It exemplifies the need to follow issues of concern back to their root causes, and to ensure at the outset that they can be dealt with, before expending time and energy on issues that sit beneath them. It also exemplifies the power of perceptions over factual evidence, and how important it is to question long held beliefs. If this is to be tackled, however, it also exemplifies the need for collaboration between bodies who might have a vested interest in seeing a change in currently accepted policies. Without that broad support, even with the backing of empirical evidence, this might still prove to be an accepted 'fact' that cannot be displaced, due to competing industries mounting a strong defense. Lastly, from studying the evidence from the public survey, it was recognized that perceptions are possibly best fought with counter perceptions which can operate on a similar level. Complex factual arguments, whilst necessary to provide the evidence needed, are not necessarily the right vehicle for changing opinion (Figure 6-8).

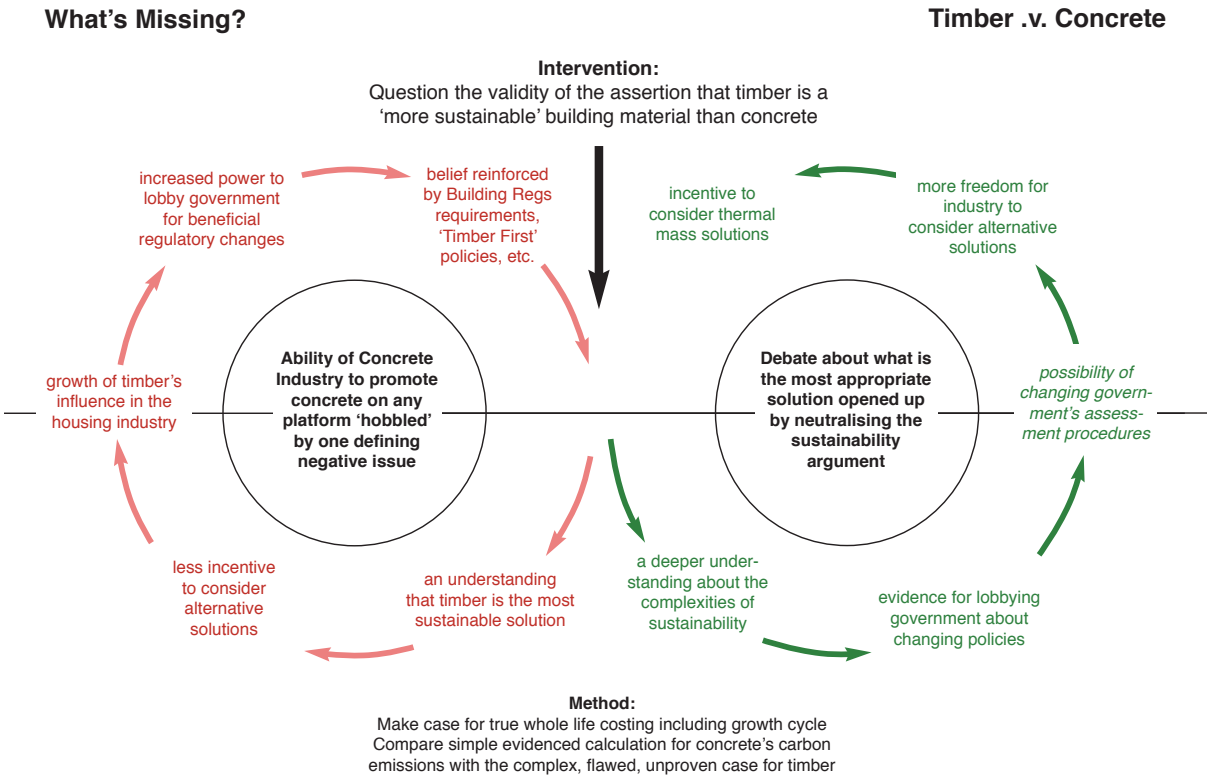


Figure 6-8 Causal loop diagram for questioning timber's eco credentials

6.1.4 Static .v. Dynamic.

The debate about the comparative sustainability of timber and concrete and the need to question the validity of the facts behind the perception leads on to a further barrier of how those facts then influence policy decisions at a higher level. One of the findings from the Information Sources

Questionnaire was the degree to which government based information was treated with a higher degree of trust than was information from industry sources, which was perceived to be less objective. What this presumption overlooks however, is the veracity of the research carried out at a governmental level: Policy decisions are often based on partial evidence gathered from the very same sources that the industry itself deems to be unreliable, backed up by lobby groups from the more powerful sectors promoting their own solutions: *"Evidence would never be the sole determinant of policy choices."* (Institute for Government, 2012). To exemplify the importance of gathering empirical evidence, this case study uses the argument over static versus dynamic modeling to show how a reliance on information from other sources, even governmental sources, without a true understanding of either the basic facts or how that information was gathered, can result in no change to the status quo. A similar reinforcing loop diagram to that in the previous example can be drawn to show how the current use of the Standard Assessment Procedure (SAP) has become fixed as 'the methodology', despite there being strong arguments questioning its accuracy and the detrimental impact it is having on innovation within the sustainability market (Figure 6-9).

To break this cycle, there needs to be empirical evidence of the impact that Dynamic Modelling could have, and the structure of that evidence needs to be driven by an understanding of those who need to be convinced that change is both possible and necessary. This case study follows that process to show how the real task of bringing about change requires evidence that is geared around the needs of those who will ultimately make that decision (Appendix M4).

A broader observation taken from this study was that whether a barrier is perceived to be one of public perception or industry inertia, it would seem that it will invariably need to be dealt with at some point at a governmental level. Promoting the benefits of thermal mass is no exception, and the case for change needs to first be made not with the public or with the housing industry but with the government bodies responsible for the regulations that dictate the decisions being taken. If Thermal Mass (TM) is to be used as a promotional tool for concrete construction, then the regulations must first be changed to reflect that benefit. That requires evidence, not just of the science of heat absorption, but of the social benefits, the financial savings to be made and the environmental impacts of not adopting this as a solution. It also means proving the feasibility of making the required changes, none of which can be done without the support of some influential allies, and at least the awareness of the public.

The main outcome from this case study therefore was to define a strategy that would result in the desired policy changes from the concrete industry's perspective. It also exposed the enormity of the task however, and led to the alternative courses of action being considered under the principle of remove, avoid or accept. If a task is deemed to be too great a challenge, is it an option to either accept or avoid the barriers by changing either the marketing message, the product, or the markets being addressed? This is a theme that is raised again when looking at the appropriateness of different markets in section 6.3.

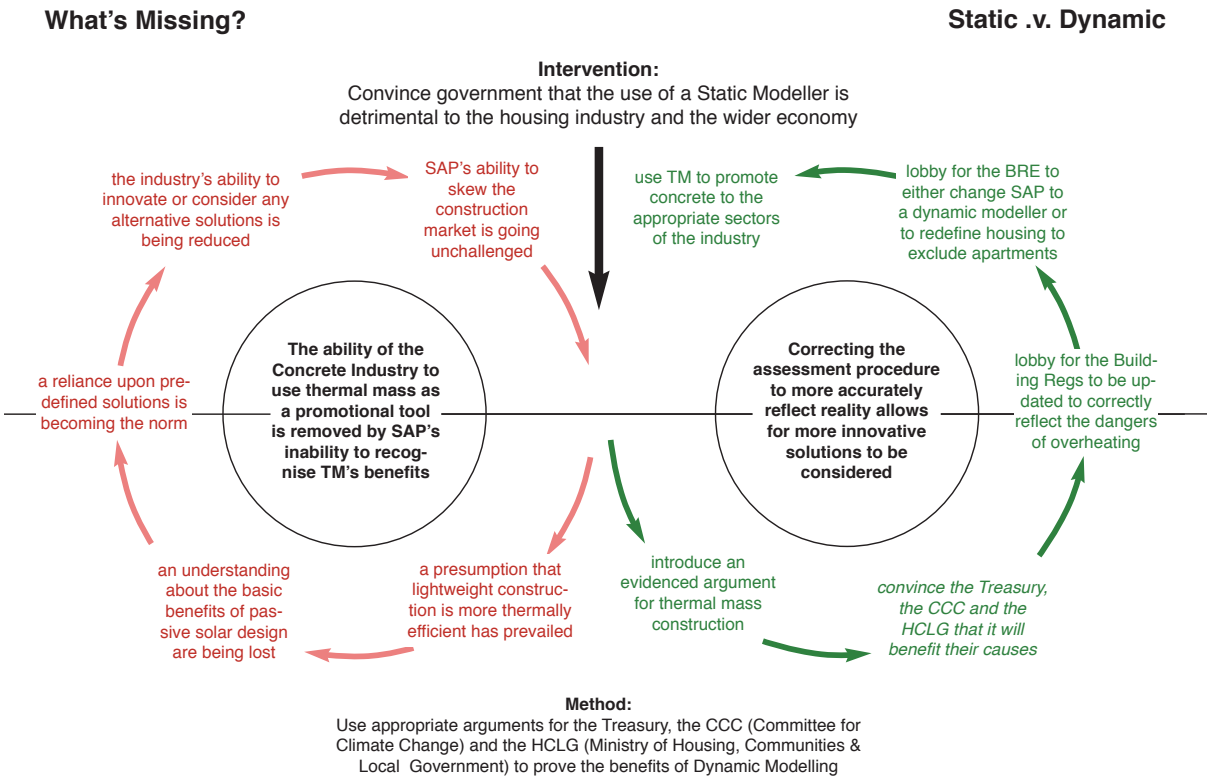


Figure 6-9 Causal loop diagram for the use of SAP

6.1.5 Understanding the government process

If the decision arrived at is that government policy is the systemic barrier that must be confronted, knowledge of that process becomes as important as was the knowledge of competing suppliers, the housing providers or the general public's opinions. This forth sector, however, can be the most difficult to penetrate, as was discovered during the industry interview process. Information about policy decisions and the debate that can be had around those decisions is carefully controlled, limiting what can be achieved to minor changes within the narrowly defined parameters deemed to be open to discussion, known as the 'Overton Window' (Clayman, 2017). But even before attempting to penetrate this process, an even more fundamental question needs to be asked: Is it the government's level of understanding, motivation or ability to bring about change that is the real barrier being addressed?

The concept of 'alternative realities' is what happens when different sectors are driven by different motivations, or in academic terms, different ontological viewpoints. The previous study was predicated on the understanding that government needs proof in order to act. Establishing the true motivations of a government and how much knowledge that government already holds however, is a precursor to collecting that proof, and extremely difficult to ascertain. When facts become hard to pin down, perceptions often flourish, and this can result in even the most well researched industry policy decisions being based on perceived political motivations. The purpose of this study into the history of government reports on the housing industry is to highlight the danger of reliance on political policy

decisions that promise more than minor adjustments to the existing system (Appendix M5). Without fully understanding a government's objectives and ability to bring about change, as opposed to its manifesto promises, reliance on political policies can be shown to be a very high risk strategy.

A causal relationship diagram defining government policy decisions would be far more complex than any of the diagrams used so far. The outcome of the previous study was to recognize the different needs of the three major departments that impact on housing policy and understand those departments' drivers, and also the hierarchy that exists between them. Those departments were the CCC (Committee for Climate Change), MHCLG (Ministry of Housing, Communities & Local Government) and The Treasury. Whilst the Treasury arguably makes the ultimate decision of how the government's resources are to be allocated, it is the other two departments that will be making their own cases at that level. In the case for Dynamic Modelling, the process of lobbying needs to be focused on the environmental benefits to be gained from thermal mass solutions, and the broader benefits of an increased supply of housing to be realized by opening the market up to more solutions and therefore more providers.

How that lobbying should be progressed however, depends on whether the barrier is a lack of knowledge, motivation or ability at that governmental level. Until that is established, as with any other sector of the industry, the likelihood of engaging productively on any matter will be minimal (Figure 6-10). The messages to come out of this study therefore are threefold: To ensure the evidence is there to provide the knowledge; to understand the motivations of the departments being addressed – and adapt the message accordingly; and to ensure that above all else the economic argument is strong enough to match the timescales that the treasury needs to work to.

In addition, collaborating with those who have similar aspirations, regardless of their motivations, will be a necessary part of the process, including at a governmental level. The Institute for Government, a think tank charged with making government more accessible to industry is an example of a body that can play an influential role in any campaign, if for completely different motivational reasons. The use of Select Committees as a point of entry is highlighted by The Institute for Government as the most effective strategy, and one potentially being used already by other sectors making their own inevitably subjective cases to further their own causes. Once that process is understood and the danger of not participating seen as being actively detrimental, the option of merely 'accepting' the barrier of government policy can seem less benign than it otherwise might. (Select Committee on Economic Affairs, 2016, p. 10)

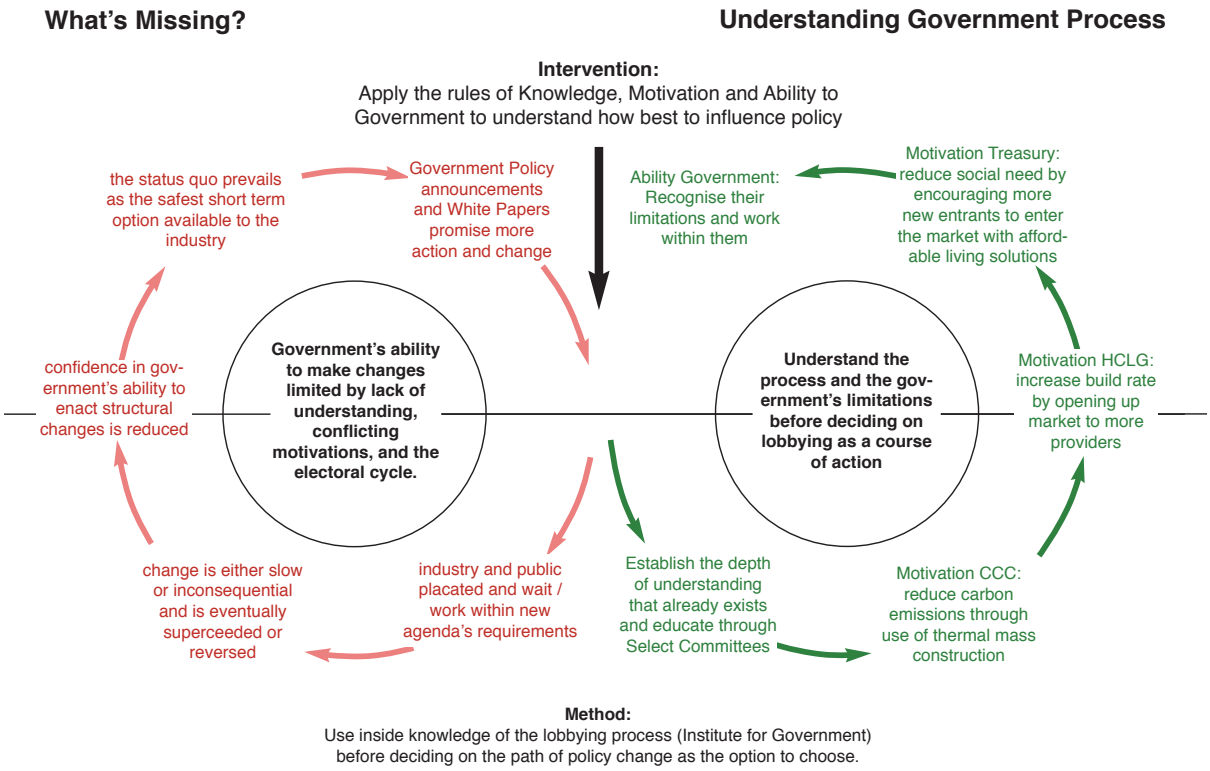


Figure 6-10 Causal diagram of better understanding the governmental process.

6.1.6 Conclusions

Fundamentally, the message from these case studies is that all barriers to innovation need to be understood at the outset, and that understanding first and foremost requires knowledge, not just of the product being promoted, but of all sectors involved in the housing delivery process, how they operate and what level of knowledge they possess. In a fragmented and adversarial industry, consisting of many small businesses, this represents a considerable barrier to overcome, but also an essential 'first base' on which to build. The next section looks at the motivations that drive those sectors to make the decisions they do, and how this knowledge of how those other sectors operate can be used to improve the communication channels between the supplier and the customer by ensuring the message is being delivered in the right language.

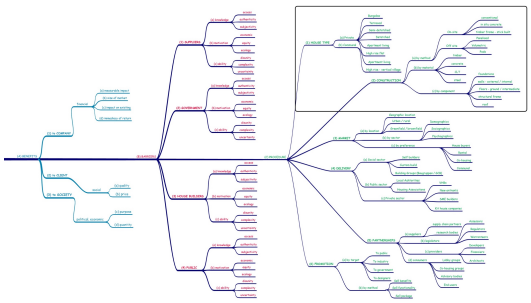
The use of Causal Relationship diagrams was useful in this first section in showing what interventions would be needed to change an existing vicious cycle into a virtuous one. Understanding the purpose behind an intervention is an important part of the process, as is fully understanding what that intervention might entail in terms of time effort and expense. How that can be better calculated is considered in the following sections.

6.2 Site based case studies

The next condition put forward in this research as central to knowing how and where to promote any new innovation is an understanding of the specific reasons behind the decisions made when choosing one material or method of construction over another. The next five studies show the extent to which this decision making process is often influenced by factors outside those usually considered by those promoting innovative new solutions.

The purpose of this exercise is to show through a variety of site based case studies the importance of understanding a client's motivations before attempting to promote any particular solution. The five studies chosen cover decisions heavily influenced by (1) site conditions, (2) the client's needs, (3) the location within the country, (4) the national economy and finally (5), by the factor often considered to be the sole determinant, the actual material's credentials. What is of interest here is that the outcome in some of these cases has not been chosen so much as dictated, and often by one overriding factor. defining and then questioning the validity of that one factor is therefore a logical starting point for understanding the decision making process and how sometimes questionable choices could be challenged in future.

Getting to the root cause behind any decision of what or how to build, whether that be influenced by an alternative viewpoint, a preference based on embedded knowledge or just a lack of knowledge on which to base that decision, this is the next step in the process, defined here as an investigation into the 'key motivating factors'. The need to define these stems from the point made in the previous section, that with finite time and resources available, some knowledge gaps may prove to be of more importance than others when trying to gain a better understanding of decisions being made. Central to this is the influence that each sector has over the decision making process, as a key factor for a sector with little overall influence may still be of marginal interest. For that reason the models used in this section are 'hierarchy models', used to shed light on these often obscure priorities. The way in which they work is to fix one of these variables in turn (the site, the client, etc.), so that the impact of the others can be more easily studied.



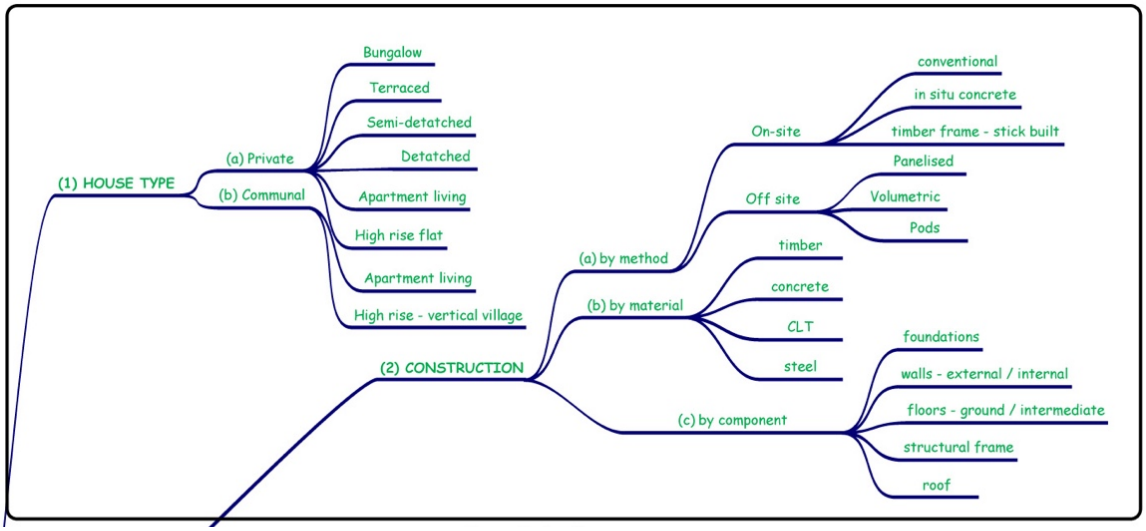


Figure 6-11 Motivation based barriers to innovation – what and how to build

6.2.1 Residential towers: Trent Basin & Nottingham One

- decisions dictated by the site

This first study looks at two residential towers, both in Nottingham, both built recently by contractor Willmott Dixon, one concrete frame & concrete panels, one light gauge steel frame. The question asked was why they had been built the way they were, and given that the sites were 'fixed' at the outset, what was that decision based upon? The purpose was to show that material choices are rarely made because of a preference for a material per se, but because of what that material can deliver, something that can change from project to project. Any attempt to influence that choice therefore requires an understanding that goes beyond the credentials of the material being promoted and includes an understanding of the needs of the client, the developer, the planners or a specific site – whichever represents the major influencing factor (Appendix N1). The decision taken at Trent Basin to use a light gauge steel frame solution was one based on cost – but what factors dictated the client's definition of cost? Nottingham One, on the other hand, a site close by within the city centre, was designed as a concrete construction for one defining reason that overruled all other considerations.

Trent Basin residential tower.

Key Motivating Factor:

A lack of confidence in the strength of the market due to wider economic concerns meant that the project was phased making the setting up of an onsite concrete production plant unviable

Figure 6-12 Trent Basin tower – light gauge steel construction

Nottingham One residential tower.

Key Motivation Factor:

A high water table combined with a planning requirement for two floors of underground car parking meant that no other solution had the weight required to counter the uplift from the water pressure.

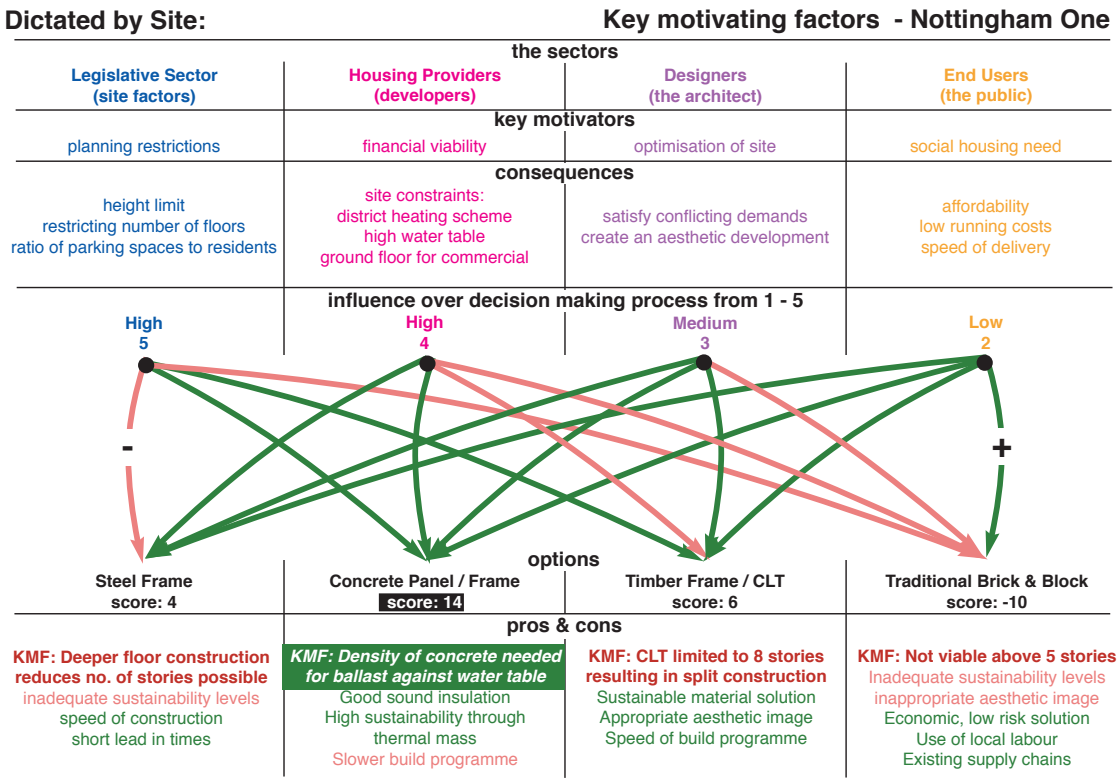
Figure 6-13 Nottingham One tower – concrete construction

In both of these cases there was a key motivating factor that overruled all other considerations, one in favour of concrete, the other against it. In neither case was this information discussed openly as being central to the decisions taken, and certainly not used as part of the promotional story developed later. Discovering these key motivational factors was not a straightforward process even after the event, let alone at the point when those decisions were being taken. To influence those decisions therefore requires an active involvement from the outset, not only to ensure that all possible options have been considered, but also to understand which sectors are dictating that decision and why.

The following hierarchy diagrams are an attempt to visualise both of these factors – the comparative benefits of the material choices being considered and the motivations behind each sector's preference for each one. (Figure 6-14). The green arrows represent a positive motivation and the red arrows a barrier to adoption. A simple grading for the relative influence of each sector, between 1 and 5 provides a score for the pros and cons relating to each material option. Theses scores are clearly debatable, as they are dependent on the assumed relative influence of both the sectors and the conflicting positive and negative factors listed under each option. In the case of Nottingham One, the concrete tower, the highest scoring solution also correlates with the solution that was adopted due

to the key motivating factor, but for the Trent Basin tower, the scores suggest that overall a concrete solution would have been more appropriate, were it not for the key issue of phasing that was deemed to make that solution unviable. The point being made here is that in some instances a key motivating factor will trump any score that might seem to suggest an alternative solution as more appropriate – and potentially be far easier to ascertain.

This principle is tested through the other case studies in this section to see whether focusing on these key motivating factors is indeed a more reliable as well as a more direct route through to understanding what constitutes the most appropriate solutions, or whether it is merely a starting point and a possible short cut in some circumstances.



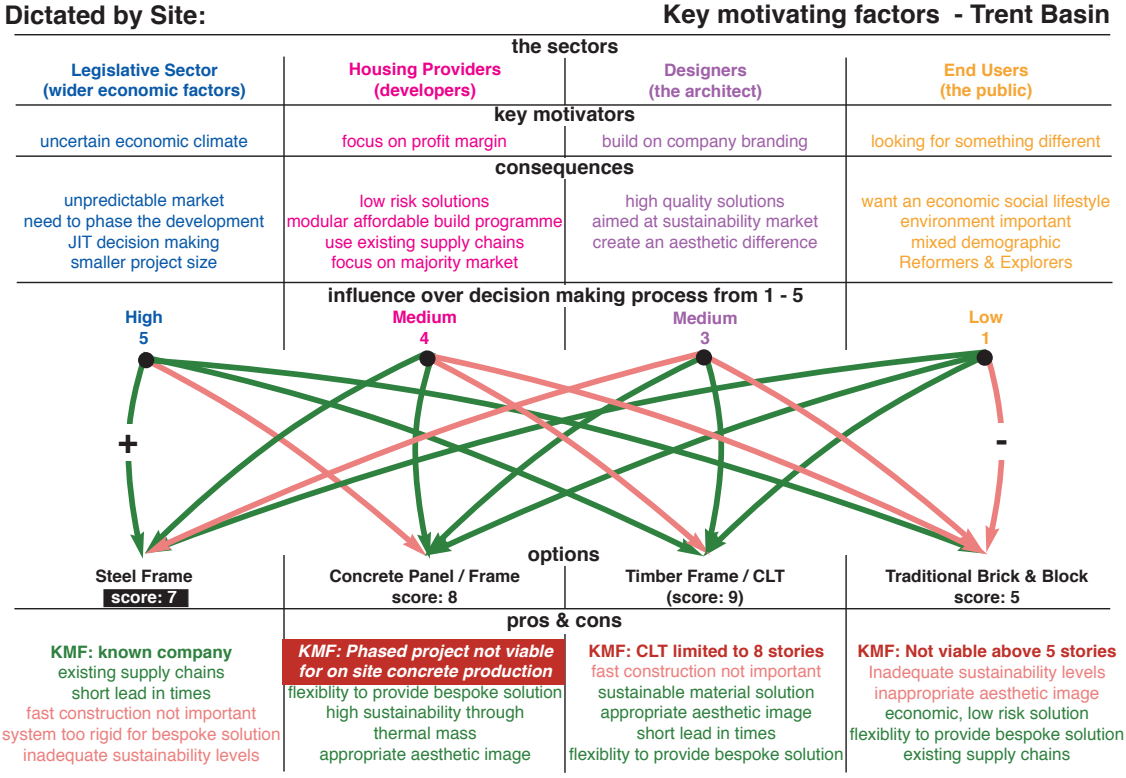


Figure 6-14 Hierarchy diagram comparing sites

6.2.2 Affordable housing provision: Nottingham City Homes

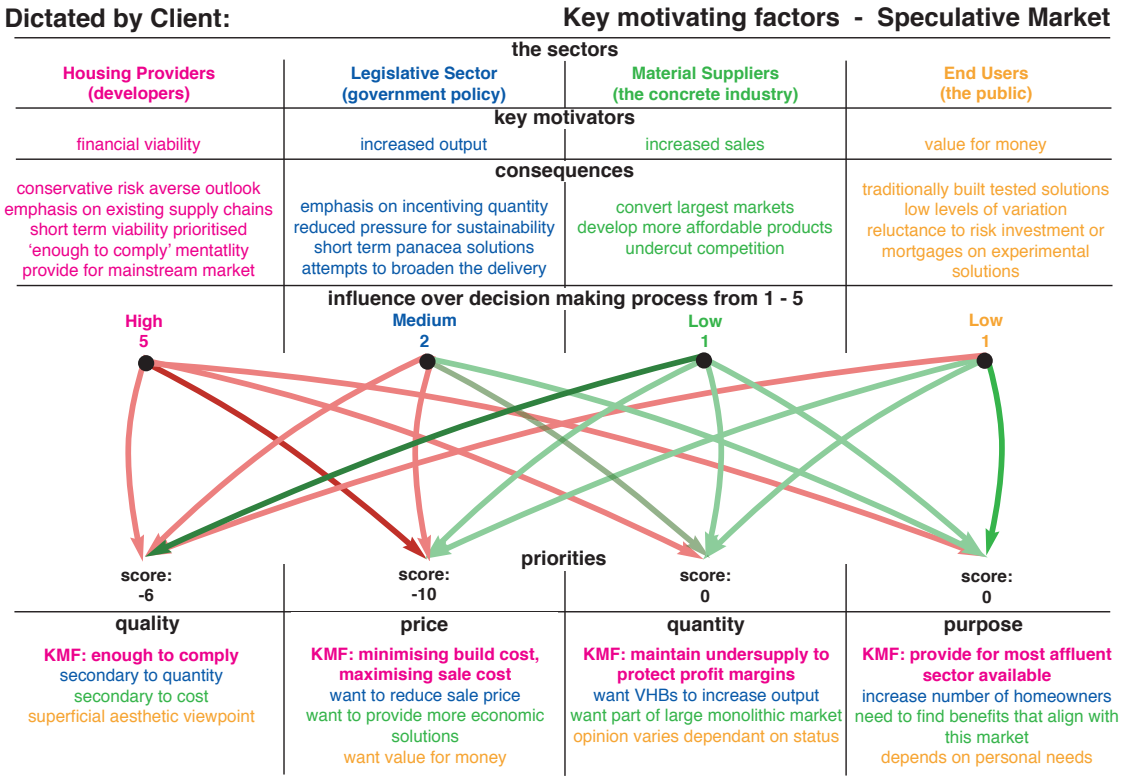
- decisions dictated by the client

This case study was chosen to show how much a client's objectives can influence their choice of material solutions. Whereas all sites can differ in their requirements, if a client has a clear policy developed around their needs, that represents a market that can be defined and worked towards. In this instance the head of development at a Housing Association was interviewed to discover what they saw as the positives and the negatives of concrete as a material choice. Again, the answers given highlighted the importance of understanding a sector's motivations before attempting to promote any particular solution.

Housing Associations represent approximately 20% of the housing market (NHBC, 2018), and for this reason amongst others, have not historically been the concrete industry's main focus of attention. Social Housing is however set to become a growth market, with new build homes now unaffordable to 83% of working families who rent privately, even with Help to Buy (Jefferys and Lloyd, 2017, p. 6), and represents a market which can be shown to have more synergies with what concrete can offer than can be found in the more mainstream volume house builder market. As before, there is a complex set of pros and cons to consider, together with a different emphasis on which sectors have the most influence over the decisions being made. In this instance the two markets – social housing and speculative housing - are compared by looking at the emphasis both put on the four areas used to define the benefits to be gained through innovation – in terms of price, quality, quantity and purpose (Section 4.1.7).

In the speculative market the housing providers are shown as having the most influence, whereas in the social housing market, this position is held by the legislative sector. The scores here (Figure 6-15) correlate with evidence from our current housing market, with the affordability and quality of speculative housing being a recurring theme, with social housing being held to higher quality control benchmarks.

Within these scores however, lie far more important indicators relating to the way in which the social housing market operates from which a comprehensive marketing strategy can be constructed. The details of this can be found in Appendix N2, stemming largely from the industry interviews undertaken, but the key findings relate to how concrete needs to be promoted and supplied to site in a way that ties in with the needs and motivations of the providers of social housing: Their need is for a solution that delivers value for money – a given – but though housing that is durable and resilient, with low running costs, that can be built with local labour with the flexibility to work for all sites, large or small. In addition to this they have an aim to define a new standard for housing based on their own space standards and attention to the social needs of their customers, something that has also been shown to be mutually beneficial as it reduces the turnover of their tenants. Like many housing associations, now being encouraged back into house building on a substantial scale, they want to work with suppliers who can provide complete solutions rather than individual products, and are very keen to collaborate at this level. And in response to the concerns often raised about their market share, they are keen to point out that their demand is less cyclical – even counter cyclical – and that many councils are part of wider networks of councils who share knowledge and best practice experiences.



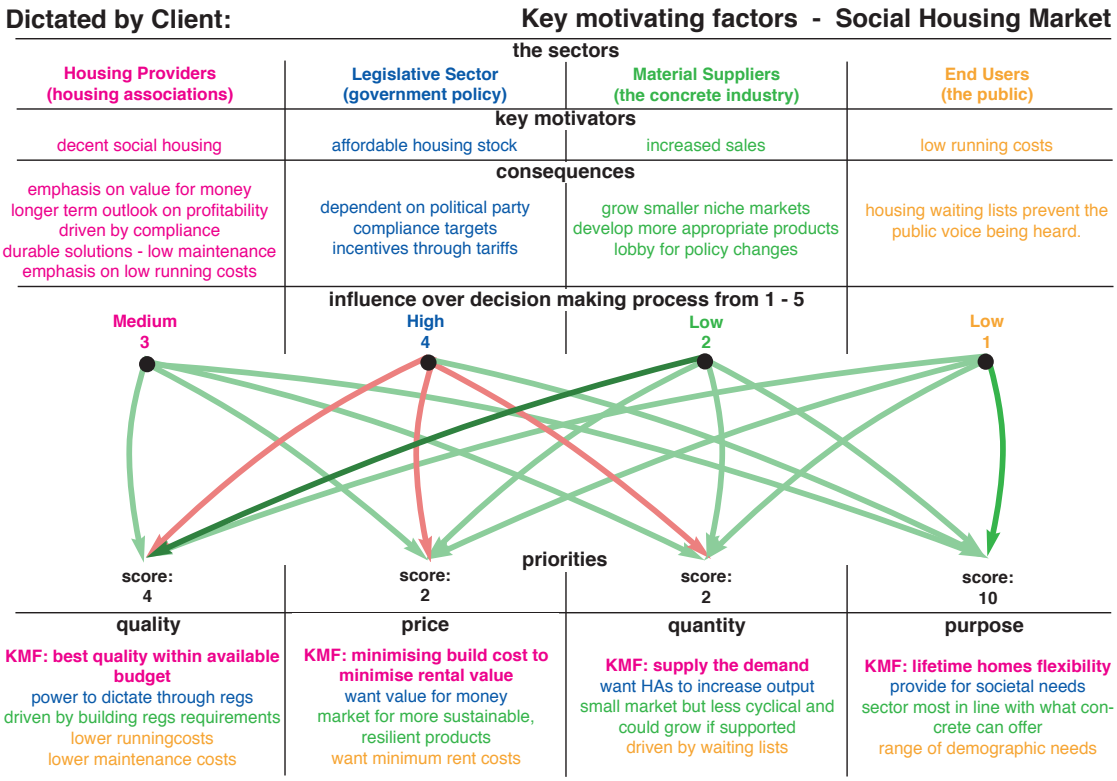


Figure 6-15 Hierarchy diagram comparing markets

6.2.3 The London market: 1, Hyde Park

- decisions dictated by the location

The objective of this case study was to show the importance of understanding the local economy and how much location can dictate the decision making process. London is clearly a special case with the value of property in London being more than the UK's next 20 largest cites combined (Dorling 2014, p.181), but the principles discussed here are equally applicable elsewhere in the UK. 1 Hyde Park was chosen as a case study because it is one of the most expensive real estate developments in the UK, and is also a predominantly concrete construction. In this instance, the disproportionate value of land as a percentage of the total property value distorts the decision making process, in that material cost becomes less important than material benefits. London is a special case in other ways too, with its high labour costs and its own Mayoral powers allowing the introduction of fine-enforced carbon emission targets (Braidwood, 2016). What is being investigated here is whether London's 'special case' factors are beneficial for the concrete industry, and if so, could they be used as promotional tools in other parts of the UK?

Figure 6-16 Site plan showing 4 repeating floorplans, increasing in size to optimise the site (Light, 2011)

An attempt at a hierarchy diagram to show the powers at play in a London-centric decision making process show a very dysfunctional set of outcomes, with very few positives to draw on, other than an explanation for why the most expensive real estate in the UK has been built almost entirely from concrete products: The disproportionately high land values mean that material costs become insignificant against performance – in this case the flexibility offered by concrete for maximising the footprint of the site by incrementally growing the structural grid. Proximity to ports means that bulky imported materials and components are less of an issue both in terms of logistics and sustainability targets. High labour costs and a shortage of skilled labour also encourage the use of prefabricated solutions that minimise the need for local labour. The sustainability benefits offered by concrete through its thermal mass were not a major consideration however, as the city's Carbon Tax has been set too low to be of any incentive in this respect, being seen more as a revenue stream for local government through the payment of the comparatively low non-compliance fines (Appendix N3).

Beyond the findings relating to this development however, the purpose of this case study was to understand how location influences the material choices being made and how this knowledge could be used by the concrete industry both here and elsewhere in the UK. The conclusions drawn were that location, like many other factors plays a part in the decision making process, and the degree to which this is significant is dependent on the comparative importance of all other factors in that particular instance. London is indeed a special case, with its high workload, shortage of labour and proximity to ports making it of particular interest to overseas manufacturers of bulky precast products, and consequently a harder market for the UK's concrete industry to compete in (M.03.3). Other UK cities with less immediate access to ports might therefore provide more fertile ground, especially if carbon taxes were to be introduced and set at more realistic levels – something that the concrete industry might consider putting its weight behind. The many other factors at play that this suggestion relates to – the pros and cons of off-site manufacturing, the need to adopt a system of dynamic modelling, the drive for EPDs – all of which need to be addressed alongside the issues discussed here, are dealt with in case studies in the following sections.

6.2.4 Tokyo's story

- decisions dictated by the economy

Examples from overseas are often used to suggest how the UK's housing industry could operate more productively, but false comparisons can easily be made without first gaining a full understanding of other countries' economies. Northern European countries, because of their similar climates, lifestyles and societal structures are often thought to offer potentially workable solutions for our housing industry (6.3.1). Even Japan is potentially of interest because it could be seen as having similarities with the UK's future, should current economic and demographic trends continue (Chan, 2017). This study looks at how Tokyo chose to solve the problem of its own housing shortage through deregulation, and compares that with our approach in London where house prices have increased in value by over 10 times that of Tokyo's over the same twenty year time period (Robin Hatin, 2016) (Appendix N4). The degree to which a government chooses to control its housing market is a major

factor to be considered when developing a strategy for promoting innovation, irrespective of whether or not those policies can be influenced or just have to be accepted.

Figure 6-17 Typical 'Pencil House', Tokyo, Japan.

What this study was attempting to compare was the economic influences on the decision making process at different scales – from the customers' perspective, the business perspective, the industry and the wider economy. Whilst this is not dissimilar to comparing the perspectives of the end user, the supplier, the provider and the legislator, it provides a different way of recognizing how motivations can vary even on a purely financial footing.

The order these have been placed in reflects the increasing scale of the perspectives and the consequential decrease in influence that can be brought to bear. This is an important factor to consider and a complex one to unravel. As well as the level of influence and the motivations driving the actions, there is also the effectiveness of those actions to consider. The model below (Figure 6-18) assumes that each sector is behaving as ideally it should whereas the following model (Figure 6-19), arguably more realistically shows government policies not applying targets for sustainability, and not ensuring there is enough land to satisfy the demand for housing. As a consequence, this model shows the housing industry failing to provide either the quality or the quantity of housing required, resulting in a very different set of scores, with quantity dropping from the key motivating factor with a score of 41 to the lowest scoring target on 14 points.

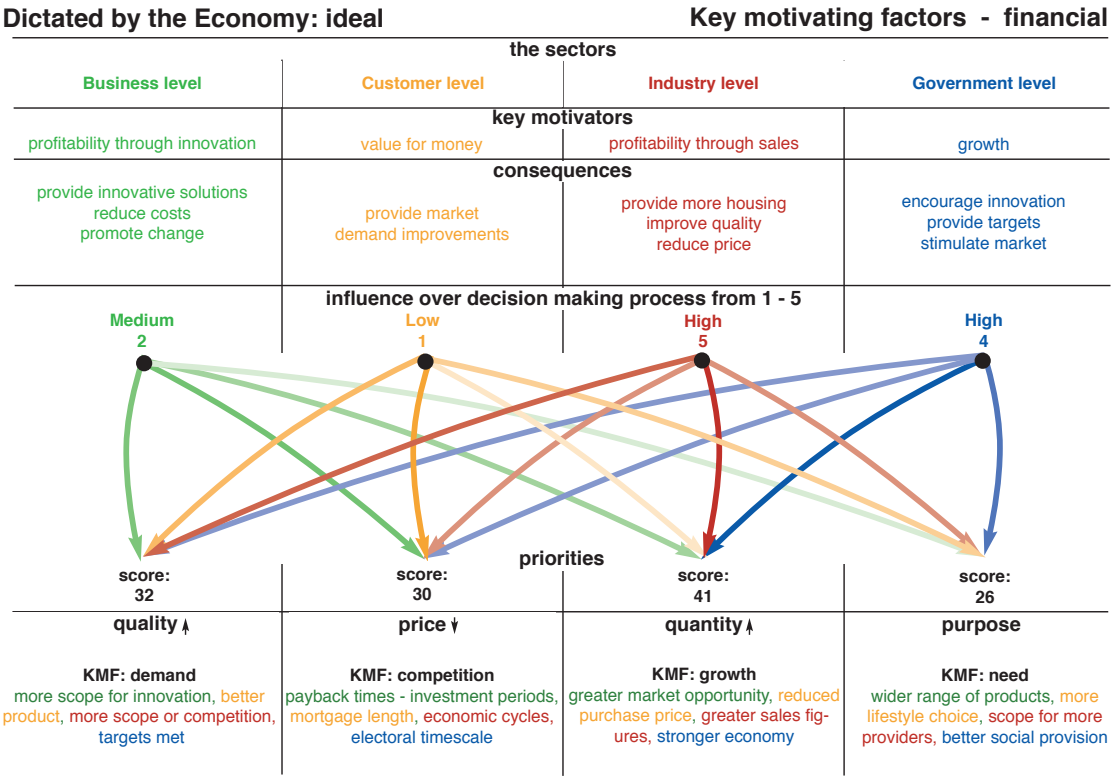


Figure 6-18 Hierarchy diagram of ideal state

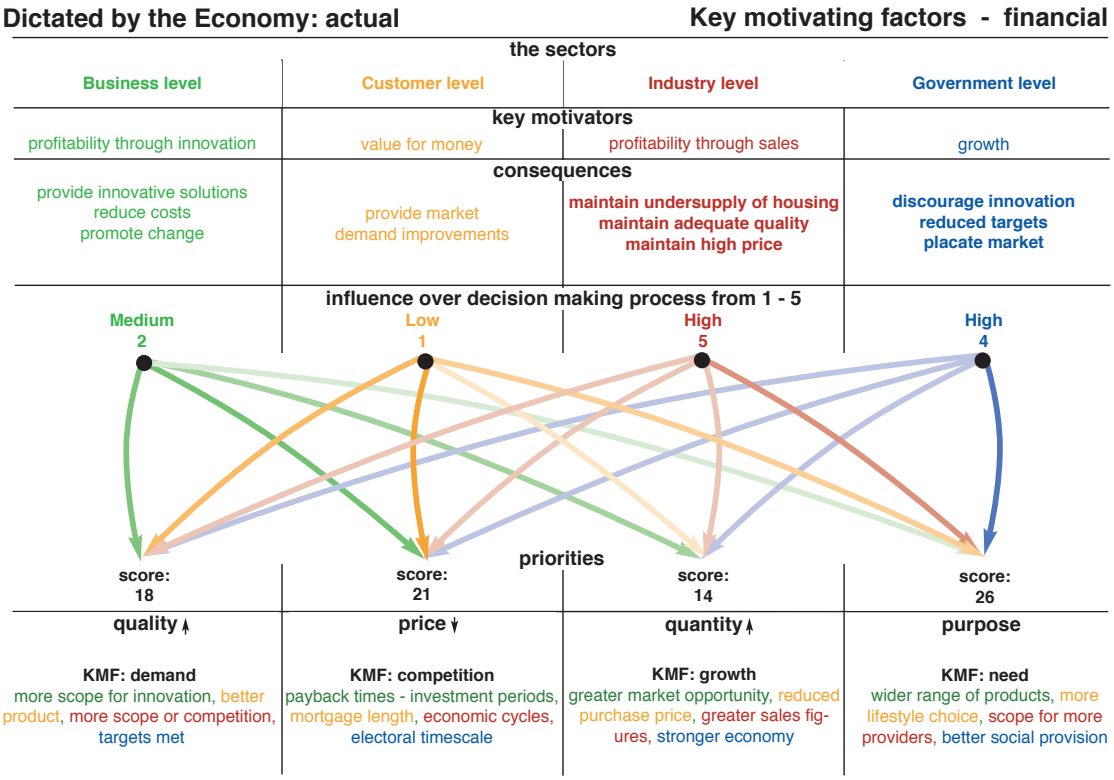


Figure 6-19 Hierarchy diagram of actual state

Returning to the 'success story' of Tokyo, the Japanese government's policy of absolute deregulation, with minimal intervention in the form of planning requirements allowed the market to find its own balance of an adequate supply to meet a pent-up demand. If we are to assume this is not a viable option for the UK, this balance of financial motivating factors needs to be understood in a UK context as it will impact on any proposed strategy. How does our government intend to deal with the very real issue of our capital city not being able to house the people needed to maintain economic viability? Their options are limited and increasingly polarised, but to Ignore the financial implications of potentially radical changes in government policy would be to ignore the sector most likely to dictate the housing industry's future trajectory.

6.2.5 Innovator sites: Dalston Lane, Hackney

- decisions dictated by the material

The Borough of Hackney acts as a special case even within London with its decision to adopt a 'timber first' policy (Chartered Institute of Building, 2012), promoting timber as their preferred construction material. How dangerous are policies like this in general, let alone to the concrete industry? Can they even be justified? CLT (cross laminated timber) is undoubtedly seen as a threat by the concrete industry and this needs to be fully understood in terms of the markets, the housetypes and the clients it can be of benefit to. Going head to head with CLT is an exercise that should be done with all material solutions to define the space where there is a clear advantage for one over the other. Dalston Lane, at the time of writing the largest CLT residential development in the world, provides a case study for this and shows how these often complex comparisons can be broken down into manageable decisions.

Figure 6-20 Dalston Lane development, during and after construction. (Davies, 2018, p. 11)

Listing the many benefits that CLT can claim over concrete would suggest that it is only a matter of time before concrete is consigned to history, but the barriers to its adoption paint a very different picture. This case study led to a way of simplifying these many parameters into known benefits and barriers but with the addition of unknown benefits and barriers – the 'known unknowns'. These tend to represent future risks, which instead of being dismissed as 'not yet known' should if anything be factored in as being of more concern than those barriers already established.

This way of categorising the barriers as risks (Table 4:5) allows for expected and potential barriers to be included alongside those already known to exist and leads onto how those barriers can then be either dealt with, avoided or accepted, as discussed in the final section of this chapter.

Benefits of CLT over Concrete			
credential	known **benefits**	unkowns: **disputed** (lack of knowledge)	known **barriers**
adoption (early)	timber first policies		not a UK product investment costs OSM barriers public perception of fire risk public perception of rot MMC warranties supply chain risk
material (current)	80% lighter safer, cleaner quieter on site faster on site (inc. second fix) more accurate (CNC cutting) flexibility of design error correction routing of services airtightness exposed finishes breathable construction weather independent	carbon emissions fire resistance glue / VOC	maximum height of build (less thermal mass) (acoustic performance) needs external insulation (Grenfell) above ground only structural span of 8m 3m panel width
potential (future)	UK production economies of scale	longevity proximity security of supply	catestrophic event reassessment of environmental impact.

Table 8 Comparative benefits of CLT over concrete

Seeing the facts set out in this format helps to focus attention on the barriers than can be challenged (disputed) and the benefits that need to be accepted and worked around. What is noticeable is the degree to which the major barriers are potentially temporary or perceptual whilst the benefits are unlikely to change, with the added concern that CLT's greatest material barrier, height of build, is already being challenged, most often with hybrid steel frame constructions.

The key areas of investigation should therefore be regarding CLT's performance, focusing on those areas that are seen as the most contentious (Appendix N5). This is not the material's thermal or acoustic performance, or even its durability, which are ultimately part of a wider financial cost benefit analysis, but the emotional factors of environmental and fire performance. These are not areas for detailed analysis here, but both are areas where the facts can be contested. CLT buildings have burnt out of control, albeit mostly during construction or due to procedures not being followed, but the claim that CLT can only char is only true in the right conditions. Similarly, the claim that CLT is environmentally superior to concrete is only true under the current accreditation system (section 6.1.4) and this is, by the BRE's own admission, no more than a guide based on a set of basic assumptions (Henderson, 2017).

6.2.6 Conclusions to section 2 case studies

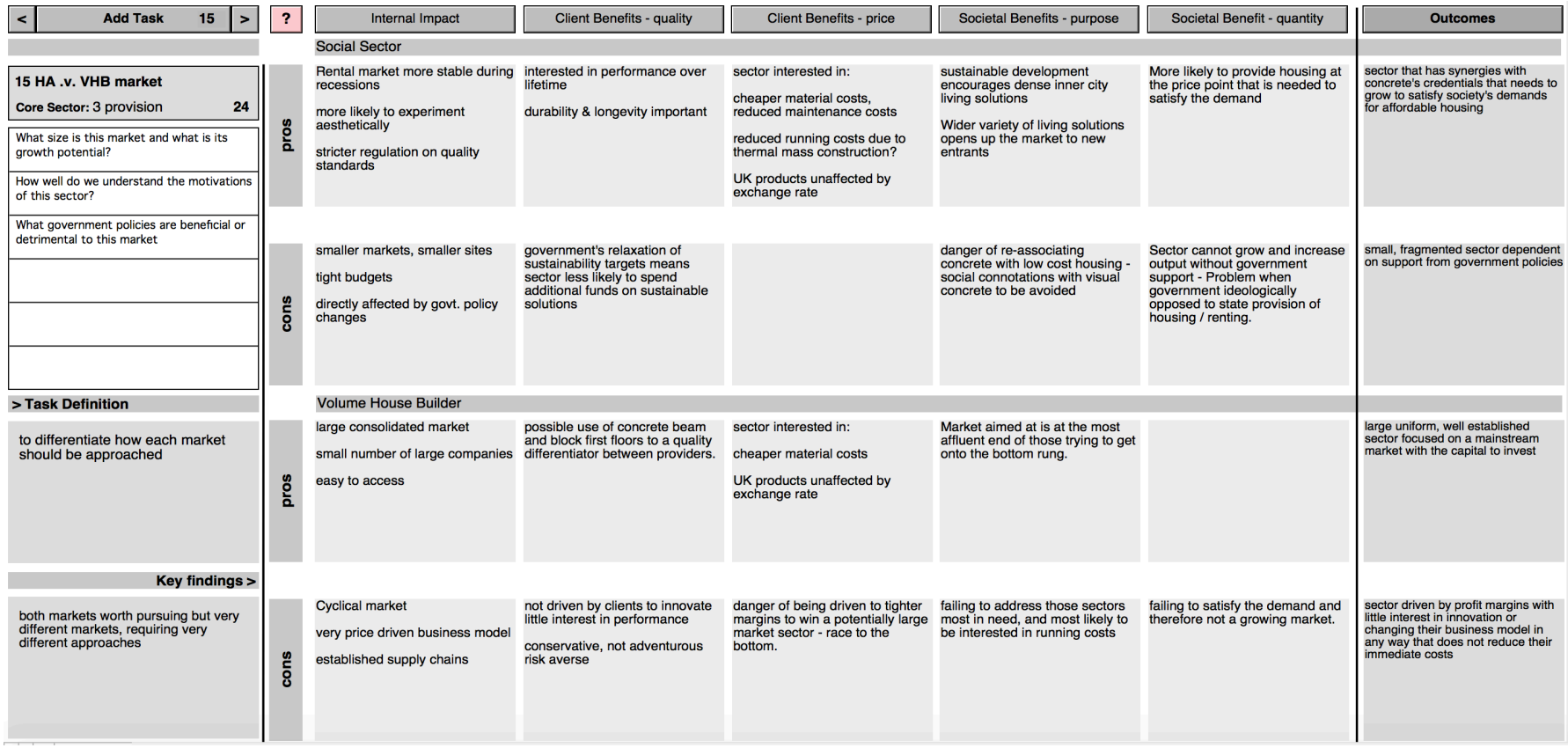
These studies have helped develop the case for using a robust process for choosing the most appropriate solution for any one project, or alternatively, assessing the most appropriate projects for any one solution. By highlighting the broad range of factors that are often involved in the decisions being made, the process has shown how many of these factors or their relevance to other sectors are often overlooked, resulting in poorer, less informed decisions being taken.

A number of different models have emerged from this process in an attempt to create a hierarchy amongst the issues being encountered in each case. The constant throughout has been to consider the issues from all perspectives within the industry, and to try and reach some conclusion regarding which factors are most likely to be driving the decisions being made. This involves combining the influence that each sector has over that decision, with the emphasis put on each of the factors being considered. By looking at this decision making process from a number of different perspectives, these case studies have effectively 'fixed' one of the variables, allowing the others to then be interrogated more objectively. In the first study the site is pre-determined, followed by the provider, the location, the wider economic conditions and finally the material choice. In each case that interrogation has been carried out using different parameters depending on the context, but has also involved a direct comparison to help draw out the choices that need to be made. This is an important part of the process being developed and is shown here to consolidate this as the approach adopted in the decision making tool.

	Issue	fixed	example	counter	comparators
1	*Site Determinants*	site	Trent Basin	Nottingham One	material choices
2	*Client Priorities*	provider	Housing Association	Spec Housing market	benefits
3	*Locational factors*	location	London (actual)	London (ideal)	benefits
4	*Economic Drivers*	economic conditions	Current	Ideal	benefits
5	*Material Comparisons*	material choice	CLT	Concrete	known / unknown risks

Table 6:1 Table of Hierarchy models

In the tool this translates into a matrix of pros and cons in database format (Figure 6-21) to be considered before condensing that information down into the most important factors to be addressed by further research. That next step, of more accurately defining the most appropriate markets for innovation and which business models are best placed to access them is tested in the next section of 'business based' case studies.



<	Add Task 15	>	?	Internal Impact	Client Benefits - quality	Client Benefits - price	Societal Benefits - purpose	Societal Benefit - quantity	Outcomes
				Social Sector					
15 HA .v. VHB market			pros	Rental market more stable during recessions more likely to experiment aesthetically stricter regulation on quality standards	interested in performance over lifetime durability & longevity important	sector interested in: cheaper material costs, reduced maintenance costs reduced running costs due to thermal mass construction? UK products unaffected by exchange rate	sustainable development encourages dense inner city living solutions Wider variety of living solutions opens up the market to new entrants	More likely to provide housing at the price point that is needed to satisfy the demand	sector that has synergies with concrete's credentials that needs to grow to satisfy society's demands for affordable housing
Core Sector: 3 provision		24	cons	smaller markets, smaller sites tight budgets directly affected by govt. policy changes	government's relaxation of sustainability targets means sector less likely to spend additional funds on sustainable solutions		danger of re-associating concrete with low cost housing - social connotations with visual concrete to be avoided	Sector cannot grow and increase output without government support - Problem when government ideologically opposed to state provision of housing / renting.	small, fragmented sector dependent on support from government policies
What size is this market and what is its growth potential?									
How well do we understand the motivations of this sector?									
What government policies are beneficial or detrimental to this market									
				Volume House Builder					
> Task Definition			pros	large consolidated market small number of large companies easy to access	possible use of concrete beam and block first floors to a quality differentiator between providers.	sector interested in: cheaper material costs UK products unaffected by exchange rate	Market aimed at is at the most affluent end of those trying to get onto the bottom rung.		large uniform, well established sector focused on a mainstream market with the capital to invest
to differentiate how each market should be approached									
Key findings >									
both markets worth pursuing but very different markets, requiring very different approaches			cons	Cyclical market very price driven business model established supply chains	not driven by clients to innovate little interest in performance conservative, not adventurous risk averse	danger of being driven to tighter margins to win a potentially large market sector - race to the bottom.	failing to address those sectors most in need, and most likely to be interested in running costs	failing to satisfy the demand and therefore not a growing market.	sector driven by profit margins with little interest in innovation or changing their business model in any way that does not reduce their immediate costs

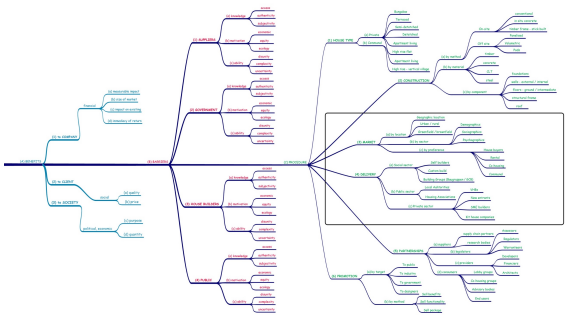
Figure 6-21 Issue based case studies translated into the DMT

6.3 Business based case studies

Objective: *to match the right products to the right markets using the most appropriate business models*

This section is where we look at the different markets and methods of delivery. We've looked at the pros and cons of innovative solutions from the perspective of the innovator, and then from the perspective of those in the industry and what motivates them to consider – or resist - something different to the mainstream option. Now we need to look at how to use this knowledge to ensure the best chance of success for an innovation by matching the right products to the right markets using the most appropriate business models. The following five case studies focus on different aspects of how business models can differ from the accepted norm by comparing that norm in turn with (1) overseas models, (2) with disrupter models, (3) minority 'alternative' markets, (4) models for how the housing market used to operate through incremental organic change, and finally (5) holistic solution models.

Much can be learnt from understanding alternative business models both here and abroad, to see how they became established, and in hindsight, to what extent their success is due to the choices they made, or the environment they found themselves in at the time. Each of these studies is based on current projects chosen to show how their experience can help inform the housing industry today and also help develop a process that matches the right business models to the right markets.



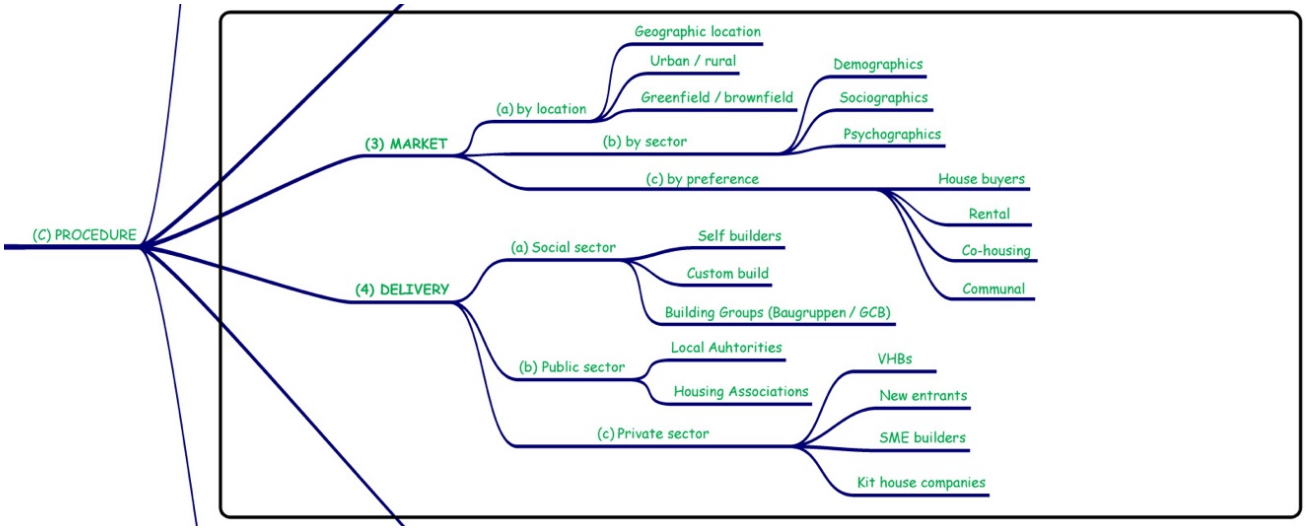


Figure 6-22 ability based barriers to innovation.

The method that has been developed for this stage of the decision making process is to compare the options available having assessed the pros and cons of the alternatives on offer. Analysis of these options from the research undertaken suggest that they can be categorized under four alternative courses of action – the change the message, the product, the market or the policy. The five case studies here cover those options in turn, with changing the market broken down into changing the provider and changing the customer. As before this is a validation process which aims to both test the model and justify the need for it by example. The policy of considering each option from the different perspectives within the industry continues and is visually defined here as a process that starts with the defined objectives of each sector and ends with the collective method adopted for pursuing that policy. The model allows for situations where more than one policy emerges, as it is quite likely that, for instance, changing the target market, in this case for Thermal Mass products, would also result in changing the message used to deliver the product, but each policy still benefits from being defined in its own right.

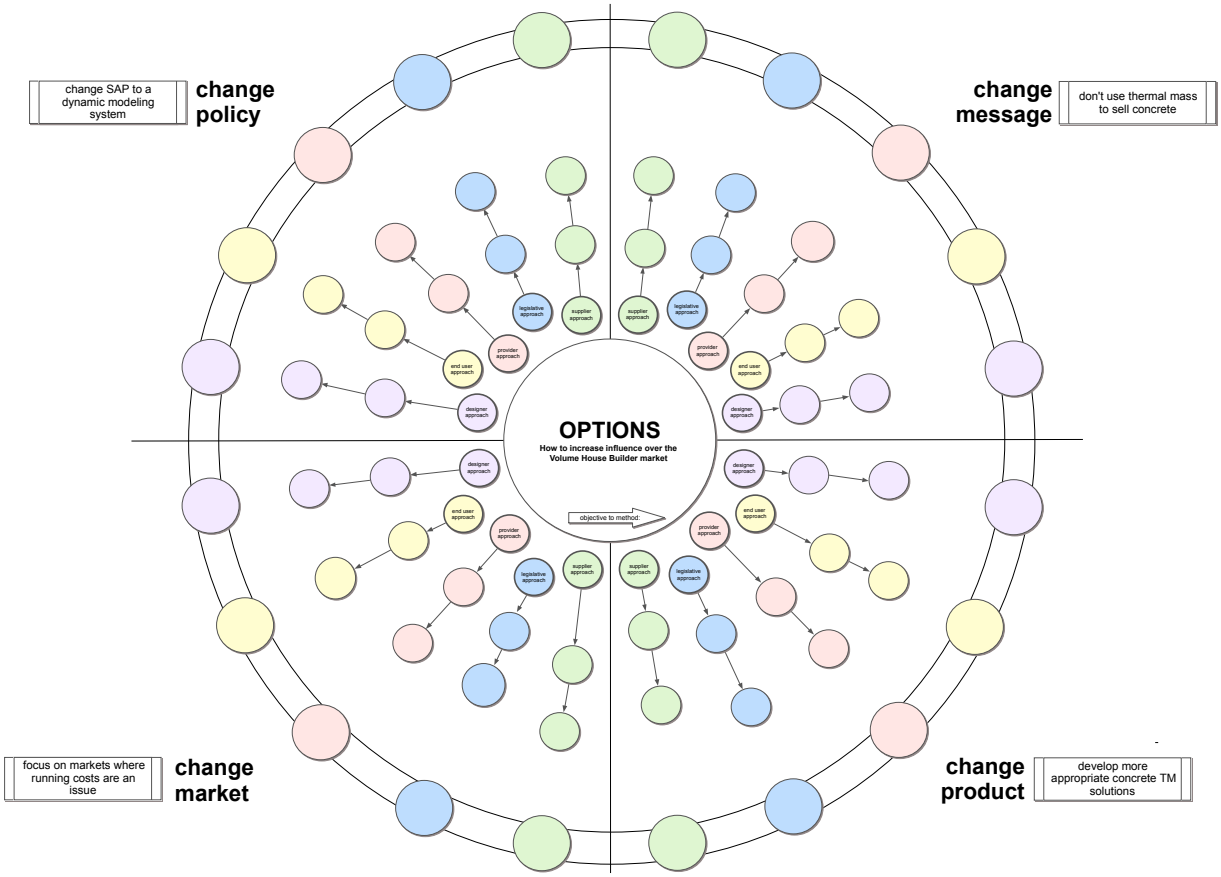
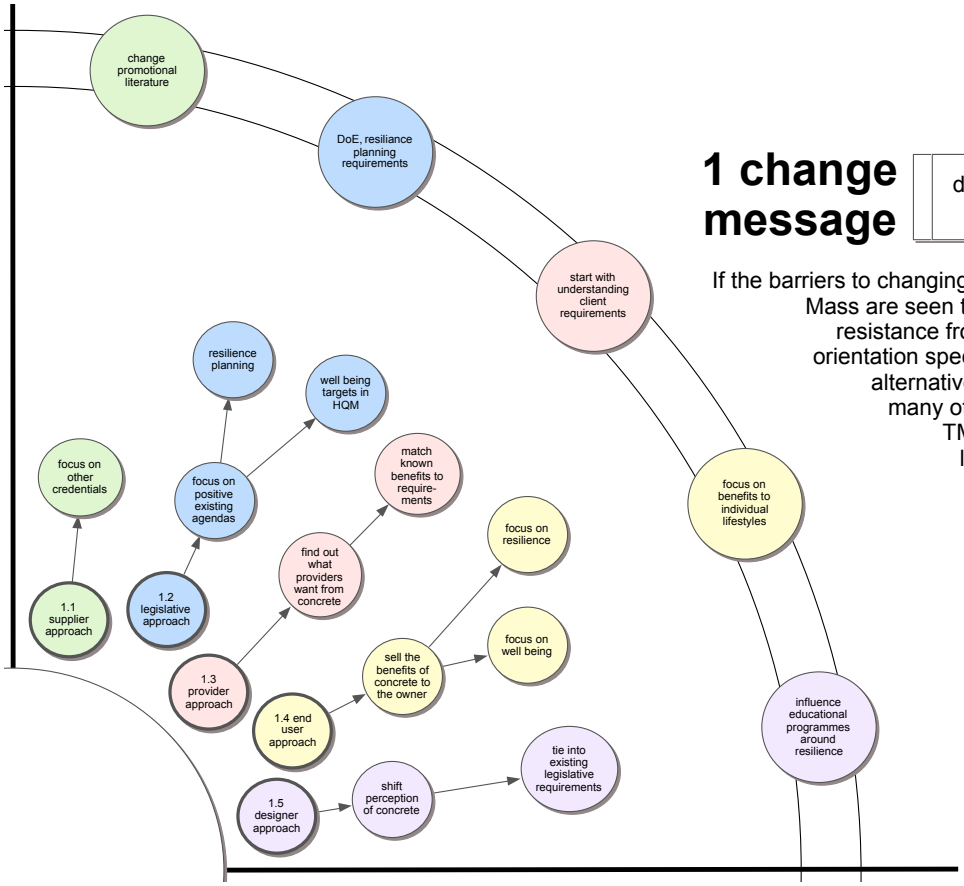


Figure 6-23 Example options model for the role of Thermal Mass as a promotional tool



1 change message

don't use thermal mass to sell concrete

If the barriers to changing policy regarding Thermal Mass are seen to be too onerous, and the resistance from house builders against orientation specific design too strong, the alternative is to focus on concrete's many other positives, and to drop TM as a promotional tool, at least for spec. developers.

6.3.1 European models

Change the product

Figure 6-24 Typical concrete panelised kit house design, Wuppertal, Germany

This case study looks at three European companies that are exporting their products to the UK housing market – concrete block components, panelized cladding solutions and complete kit houses. Each of these industries has a history particular to its own country of origin, and each has had different experiences in trying to influence our housing market. It would seem reasonable to assume that replicating these products in the UK would be more profitable than importing them, but a deeper understanding of their business models would suggest otherwise.

This case study therefore reiterates the need for a full understanding of the facts but also shows how businesses importing products can be used as a barometer of a market's maturity, the appropriateness of a product for that market, and also as a gateway into that market if and when the time is right.

The three businesses studied were all importers of products for the UK house building market, and yet none of these companies have been successfully replicated here in an attempt to undercut their considerable import overheads. There are multiple lessons to be learnt from this one statement, which have been fed into the questions database forming part of the Decision Making Tool: Markets take many years to mature, and products go through many phases of development before arriving at what might appear to be a simple transferrable solution. Importing companies have not only more experience, but more supportive markets to depend upon during downturns, especially with exporting to near neighbours also being a straightforward option. Their choice of London markets as a focus means benefitting from a buoyant, easily accessible location where transport costs are comparable to those of many UK based competitors, further shifting the balance in favour of the importer. In addition to these benefits favouring importing, there are also many barriers particular to the UK which those

companies did not have to overcome when they were starting out. These are more specific to the businesses themselves and discussed in detail in Appendix O1, but are often overlooked when making direct comparisons between our industry solutions and those on the continent – the limitations of kit housing solutions being a good example of this. Finally, moving into the field of future uncertainty, there is also the often unrecognised threat of other overseas businesses entering the competition and undercutting the market at the moment when that market appears to be maturing and more capable of sustaining a UK based supplier.

This is not to say all importing companies are success stories. The UK does not have a monopoly on failing to recognise the differences between our environment and that on the continent. One of the companies covered imports a calcium silicate block that is used widely in Holland as a replacement for brick and block construction. On paper the advantages are undeniable, but the large format block comes in a size that does not comply with our 225mm brick module. Were the blocks 675mm wide (225mm x 3) rather than 645mm the system could be easily trialled on existing house plans. As it is their use would involve a complete redesign of existing housetypes, something that our speculative housing market is not willing to contemplate, even if it were to become a successful transition (P.03.4). This represents an opening for a UK based alternative production plant. For the sake of 30mm, changing the product could in this instance be the solution that is needed.

6.3.2 Established .v. disrupter business models

Change Market provider

Figure 6-25 Urban Splash volumetric house, Manchester. (Urban Splash, 2018)

Figure 6-26 Urban Splash volumetric house, Manchester. (Urban Splash, 2018)

This study is based on the interviews held with both established, traditional developers and 'new entrant' innovating developers. The picture that emerges is far more complex than normally perceived, with both having important roles to play in bringing innovation to the mainstream market (Appendix O2). The level of risk associated with an innovation will dictate which market is the most receptive, but risk takers are not necessarily more acute at reading the potential for a new product. They can just be less aware of the risks they are taking, and it is worth considering that the failure of a start-up developer to deliver can be just as damaging to the innovator's reputation as it is to the start-up company's finances.

There is a tendency in many business environments to oversimplify the role played by mainstream established companies and be dismissive of their contribution to innovation in comparison to that of the plucky start-up companies, and this is no different in the UK housing market.

"It is often said that start-ups are better at creating new things. They are not; they are better at exploiting them. Successful start-ups almost always begin with an idea that has ripened in the research organization of a large company. Lose the large companies, or research organizations of large companies, and start-ups disappear." (Lazonick & Mazzucato 2013)

The message to take from this study is that where to promote an innovation is as much about the synergies that product has with the company delivering it as it is about the market it is being promoted to. Whereas the synergies with the market are about matching motivations, synergies with the provider of that housing are more about matching roles to the stages of development. The many roles that are needed to fully promote an innovation are discussed in detail in section 6.4.1, but this is about ensuring that a product is seeded in the appropriate environment for its stage of development. If a product is truly innovative and experimental, it needs to rest with a company that also sees itself as a forger of new paths, and in turn appeals to an early adopter market. If on the other hand, the product is reaching a point at which it has been proven by these market leaders, it needs to be seeded amongst companies that are not risk takers, but open to tried and tested innovations that could benefit them financially. These companies sit in the 'early majority' sector, and are best defined by the 'New

Entrants' – those companies that have entered the market from elsewhere, are well established but open to alternative solutions. Next in line, but still within the definition of early majority would be those mainstream companies that have invested in their own research into the options that are on their radar but not of immediate interest. Understanding their motivation to investigate these options is important however, as they may not be as open to change as may at first appear. Interviews with companies within this sector would suggest that their research is undertaken as a security measure rather than as a precursor to action. Their incentive to change is not driven by a need to compete, due to their near monopolistic position within the market, but by the need to comply with changes in the building regulations, or respond to customer demands, neither of which are currently, in their opinion, a cause for concern.

The conclusion to draw from this case study is that innovations need to be matched to delivery models. If an innovation presents a simple cost saving alternative that requires little or no change to their existing systems of delivery, the mainstream market suppliers will be receptive. The same applies if it answers a need that is being mandated upon them by new legislation. Otherwise, it falls into the category of 'change that needs change', requiring more complex longer term arguments to be invoked. In this scenario, it is either the New Entrants who are prepared to, and can financially afford to take the longer term view, or the younger innovative companies who are prepared to take the greater risks. Which of these two options presents the greater certainty of success depends on the validity of their business models and the potential of the markets they are attempting to break in to, discussed in the next section.

6.3.3 Alternative market models – mainstream .v. minority

Change the Market Customer

The speculative housing market may represent almost 80% of the entire housing delivery system (Figure 6-27), but size of market is only one of many factors to consider when promoting an alternative solution. Appropriateness, receptiveness, potential for growth, as well as governmental needs and public appeal are all equally important considerations. This study looks at group custom build, a relatively small and unrecognized sector and shows how it could be far more beneficial to the concrete industry due to the combined impact of these other factors.

"In the UK, speculative production of new housing is dominant, with about 79% of new homes being provided by developers. Some 13% of homes are built for non or limited-profit organisations, and about 8% are self procured" (Venables and Courtney, 2004)

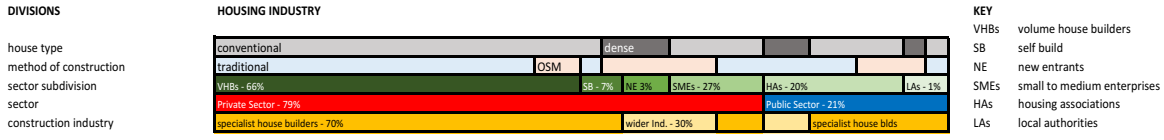


Figure 6-27 approximate breakdown of housing delivery in the UK.

The top 8 major volume house builders are responsible for over 50% of our housing output (Communities and Local Government Committee, 2016, p. 3), making them an appealing sector for any marketing campaign. They are consistent in their methodology, they have honed their product over decades to appeal to a majority market, and they have buying power. The reasons why this is not enough in itself to justify focusing on this market alone were discussed in section 6.2.2 from the perspective of Housing Associations, one of the many alternative sectors making up the remaining 50% of the market. Their needs differ from those of the VHBs, and despite representing a far smaller market share, the closer synergy between their needs and the concrete industry's products means that as a sector, they could potentially represent a more profitable proposition. Within that other 50% also sits the somewhat related communal living (co-housing) and self-build markets. What, if anything is their appeal to suppliers? Why do they continue to be such minority interests in the UK whilst efficiently providing much needed affordable housing elsewhere in Europe? And to bring this back to the overarching case study that is the concrete industry, what relevance could these markets have for the solutions that the concrete industry has to offer?

What should be of interest to the concrete industry and to innovators in general is the substantial difference between the size of this 'social economy' market (Figure 6-28) if measured by its physical presence, about 8%, or by its general appeal, put at 53% (the percentage of the UK population who, given the opportunity would like to build their own home) (Brown *et al.*, 2013) (Communities and Local Government Committee, 2016). That is one measure to be considered. Another is the degree to which government policy has been affected by the lobby groups promoting these solutions (P.03.11, p1), and a third, the degree to which this market is appropriate for the concrete industry's solutions. In broad terms; the questions that need to be asked as represented in the Decision Making Tool are; what are the benefits to the supplier, the market being supplied, and society as a whole? Are there any substantive barriers preventing this sector's growth, and if not; what are the products and solutions that present the best fit with this sector's needs?

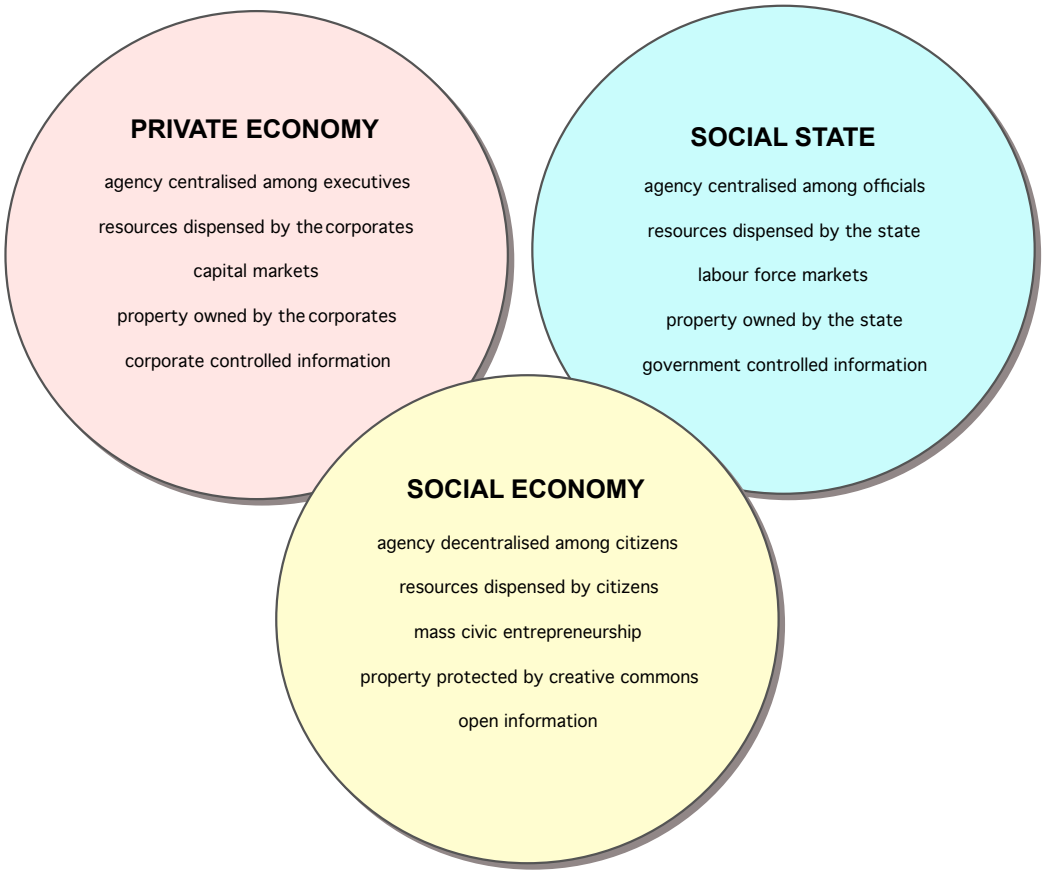


Figure 6-28 the alternative European 'social economy' model

This case study answers those questions and shows how the process can be used to define the most appropriate solution for any given market (Appendix O3). It is only by pursuing the argument to that final conclusion that a market can be assessed for its worth in comparison with more mainstream options. In this instance, the proposed solution, a crosswall framed shell for a co-housing apartment development provides a viable, unphased development opportunity whereby the concrete industry could provide a fast, economic, aesthetically diverse housing solution to a growing, government supported sector on relatively unappealing brownfield sites in a way that no other material supplier could match in terms of resilience, durability, fire compartmentation, thermal mass and soundproofing (Figure 6-29).

This represents one solution for one market condition, but acts as a good example for how a market can be defined by its appropriateness for one built solution over any other, and as such increases the likelihood of that solution becoming adopted.

Figure 6-29 Example of crosswall custom build development, Almere, Netherlands

Alternative markets also need to be put into context beyond our recent history, which has tended to limit our horizons to what is deemed acceptable to the public:

"The deal done was to develop the land under one unified style, with Wood himself designing the famous frontages of Queen Square. Sites were then divided into individual plots to be sold to different local builders and masons, who were given a two-year limit to complete their plot before being hit by a substantial rent increase (to incentivise fast and unified development and reduce risk to Wood). He thus pioneered a form of early custom build while strongly influencing the architectural style of those who came after him. The City of Bath is now a UNESCO World Heritage Site." (Jefferys and Lloyd, 2017)

Figure 6-30 Early Custom Build at Queen's Square, Bath.

6.3.4 Off-site innovation - evolution v revolution

Change the Policy

There is a strong argument for the concrete industry not engaging with the off-site manufacturing (OSM) revolution, as it may not benefit from OSM's success to the same degree as its competition stands to. But if OSM's time has now finally come, not engaging is not an option. This study looked at two companies' very different approaches to the same solution, Laing O'Rourke, with their as yet unproven, but headline grabbing answer to the nations' housing shortage, and LoCal Homes, interviewed by the author, who have spent the past 20 years evolving a sustainable housing model that has already survived two recessions, the details of which can be found in Appendix O4. The concrete industry arguably needs a policy for how they will engage or not engage with this unpredictable market, and should be basing this on the experience of others.

"recent developments suggest that industry confidence [in OSM] is growing and major investment decisions are being made"

"It is clear that the level of housing and infrastructure required in the capital cannot be delivered through local resources alone and a strategic approach to creating national interconnected supply chains must be a priority." (London Assembly Planning Committee, 2017)

The government's agenda for promoting off-site manufacturing is increasingly being seen by many as the only way for the housing industry to significantly increase its output. Historical attempts by the off-site manufacturing industry to break into the volume housing market have followed a now familiar cycle, whereby off-site businesses flourish as the economy recovers from a recession when skilled labour and traditional material supplies are low, only to falter towards the end of a boom when supplies of both recover, the need for speed on site reduces, and developers revert to more economic traditional on-site methods. The investment needed to set up these offsite factories and the subsequent need for a continuous throughput means that many OSM businesses then fail as the next recession takes hold.

"At the time of writing this review, there is considered to also be a danger that the current apparent increase in awareness, media interest and to an extent, the actual physical adoption of 'off-site' or 'modular' pre-manufactured solutions, is being driven by some clients having an immediate need for a cheaper, quicker outcomes at a time in the cycle when labour costs have been high and project delivery failures have increased in frequency. There is a chance this appetite for new approaches may wane if the labour market cools and build costs reduce." (Farmer, 2016, p. 36)

Whilst no iteration of this cycle is identical, there are still fears of a repeat performance come the next recession, despite there now being far more awareness of the barriers to overcome. Confidence in a positive outcome comes more from the desperate state of our existing industry, with the imminent collapse in our labour force due in part to the low public image that has grown out of this cyclical failure, the low investment in training, poor working conditions and the lack of job security it can offer. Despite there being some new funding initiatives behind this current wave of offsite manufacturing, the concern is that many of the underlying issues that have made this transition from conventional to off-site working practices so hard to embed are still present (Figure 6-31).

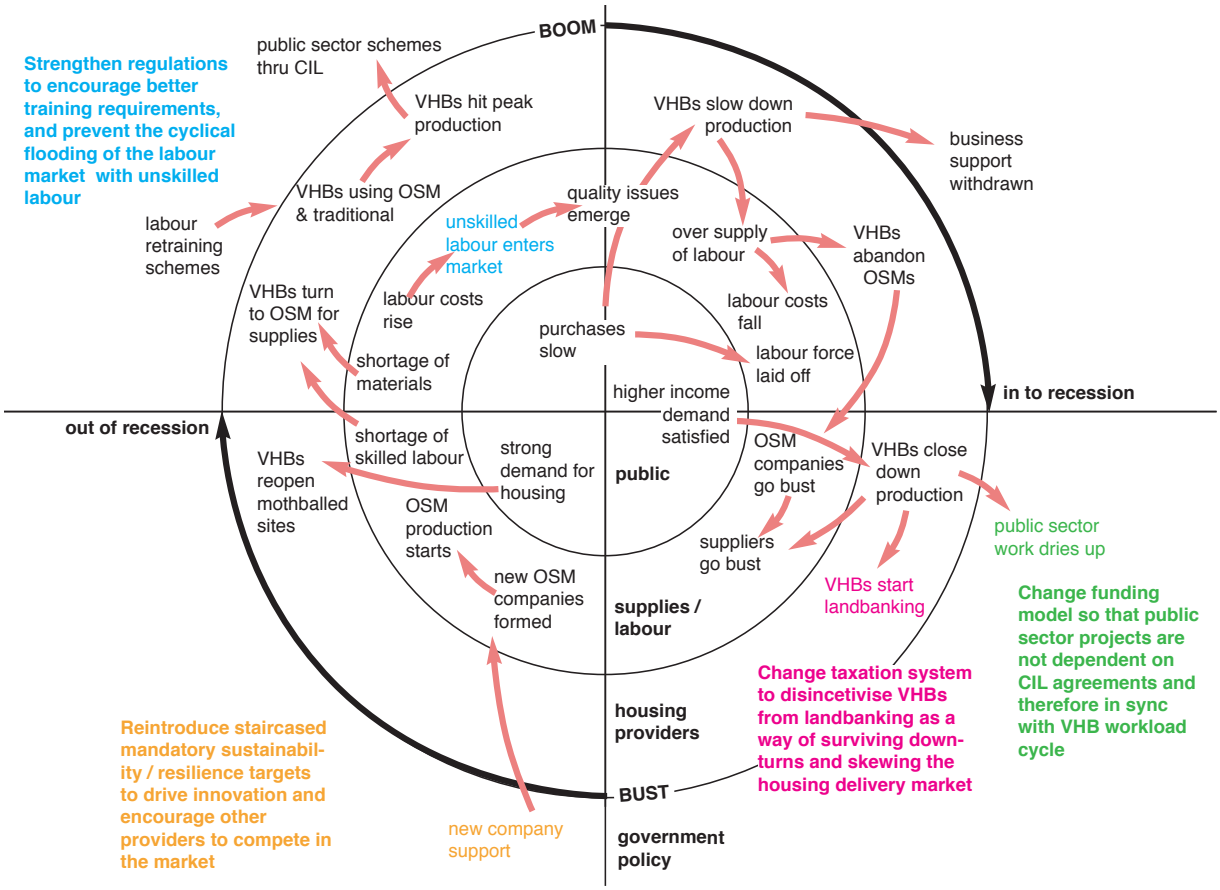


Figure 6-31 OSM vicious cycle and proposed government interventions

This case study is on the one hand looking at the option of OffSite Manufacturing and how the concrete industry should engage with that, whilst on the other hand moving into the realms of changing government policy as a way of dealing with the issues being discussed. OSM has been chosen as a vehicle for this option partly because of the government's role in portraying this as a panacea for 'our housing crisis' and partly because of the degree of political intervention that will be needed to ensure off site manufacturing can sustain itself. The purpose of raising this is not because it should necessarily fall upon the concrete industry to lobby government for these changes (discussed in the final section), but because the concrete industry should be aware that without this input, OSM may well collapse alongside the next recession as it has before. If this is the conclusion reached by considering the interventions needed to the vicious cycle portrayed above, what are the options left open to concrete industry? Should it fully support the initiative, including lobbying government, whilst finding a niche within OSM that is beneficial to concrete, or should it maintain a safe distance and continue to service its onsite defender markets?

If the decision is to engage with OSM, the question still remains 'how can that be made to work for the concrete industry?' As a simple question this encompasses much of what has already been discussed and is fundamental to how the concrete industry sees its involvement in housing. One

option of how to define a market for off-site manufactured concrete where concrete is the most appropriate solution is picked up in the next case study, 6.3.5.

6.3.5 Whole package solutions. holistic solution v piecemeal products

Change the Message

An alternative to totally controlling an internal vertical market – exemplified by Laing O'Rourke's business model discussed in the previous case study is to gain a full understanding of that market by forming a chain of collaborative partnerships. Promoting packaged solutions by this method, both in terms of products and services, allows for multiple benefits to be brought together to make a more convincing case, and also reduces the risk levels by securing consensus throughout the delivery chain. Bill Dunster's Zero Bills Home (Figure 6-32) is an example of this approach and shows how a concrete solution might not need to be promoted through the use of concrete alone, but through a package of benefits where concrete plays an essential but not necessarily a primary or even a visible role (Zed Factory, 2017).

Figure 6-32 Bill Dunster's Zero Bills House, BRE site,Watford

In some respects this approach is not dissimilar to the vertically integrated market philosophy of the New Entrants, who aim to control the entire process by bringing all operations under one roof, whereas providing a packaged solution only requires those businesses and their motivations to be understood rather than owned. In this scenario, it is the concept of shared goals that is important, because it brings together many small positives to make an irrefutable case for the whole, where the individual pieces of the jigsaw on their own could be less convincing.

This is of particular significance for the concrete industry who have a product that performs many different roles, none of which in isolation are often seen as 'key motivating factors'. It is only by combining these to define more appropriate, if smaller markets that the case for concrete becomes strong enough to dictate the outcome. But the concept of the packaged solution does not have to stop at defining the material benefits. How that end product is promoted and which markets it is promoted to can also be used to define a niche market that incorporates many other peripheral benefits that can strengthen the overall message. The approach taken by Dunster, discussed in full in Appendix O5 shows how a broader understanding of the markets and how to appeal to them on their terms can lead to hybrid solutions combining different materials and utilizing the benefits of both on site and off site construction in ways that could be very beneficial to the concrete industry and how it could be marketing its products.

6.3.6 Conclusions to section 3 case studies

	Issue	option	example	comparators
1	*European models*	change product	HuffHaus, Kertkstoel, Zella	- UK v overseas experiences
2	*Disrupter business models*	change market (delivery)	Taylor Wimpey, Urban Splash	- existing v new entrant
3	*Alternative market models*	change market (customer)	Spec. housing, Group Custom Build	- mainstream v minority
4	*OSM based innovation*	change policy	Laing O'Rourke, Local Homes	- evolution v revolution
5	*Whole package solutions*	change message	The Zed Factory	- holistic solution v piecemeal products

Table 6:2 Table of Options models

Following on from the previous section where the case studies were aimed at gaining a better understanding of the motivations driving the markets being considered, these case studies were chosen to explore the options available regarding how to approach those markets (Table 6:2). The approach taken was to compare binary alternatives in much the same way as was adopted for material and constructional options in the previous section: Is a PLC business more appropriate for launching innovations than a start-up?; can a minority niche market be more valuable than an established mainstream market?; are holistic solutions more likely to succeed than piecemeal products?

The outcome has been to broaden the scope of markets there to be addressed, whilst realizing the importance of choosing those most appropriate for any specific product and of using the right language to communicate the mutual benefits effectively.

The final section now looks at how to enact these strategies once the right markets and delivery mechanisms have been chosen for the products being offered.

6.4 Issue based case studies

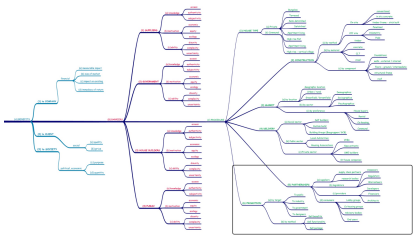
The objective of this final section is to discuss the 'bigger picture issues' that must also be resolved before change can happen, and how to deal with them as part of the process of enacting the chosen strategies from the previous stage.

Bringing about change, it has been established, cannot be done in isolation. Forming the right partnerships is a necessary step to paving the way for innovation by de-risking a fragmented and adversarial industry. Knowing how, where and when to promote new solutions requires an understanding of the bigger picture and the changes that might be needed at that higher level before innovations can be successfully introduced. These last five case studies look at some of those issues that are all too often seen as too distant or intractable to confront and instead dismissed as unimportant. If a decision is reached that those distant barriers are relevant but also intractable, then any policy decision made should reflect the fact that those barriers still exist. Ignoring barriers is not the same as accepting them.

Having looked at the many factors that play a role in the decision making process and recognizing a series of barriers to change, becoming ever more distant from the initial question of material choice, there comes a point at which a new question must be asked. When do those barriers become too distant to either affect or to have an effect over the decisions being made? That is two very separate but important questions, because it is these distant, often political decisions that can dictate the success or otherwise of the strategy that is chosen. Against this, an individual or company's ability to affect those high level political decisions must be assessed, and may involve at the very least a long term campaign requiring the involvement of many others.

The real decision, therefore, which this last section of case studies aims to explore is how to differentiate between those distant barriers that should be accepted and worked around, and those that need to be confronted – in which case how can they be removed, and what partnerships need to be fostered to improve the chances of a successful outcome.

The five case studies chosen follow a narrative that starts with the question posed but not fully answered by the Farmer Review about the role of the New Entrants and whether or not their alternative approach can be used to influence the existing industry model, currently our mainstream market. This is turn raises the question of what will drive this mainstream transition to a more sustainable, possibly off-site manufactured solution, if it is no longer driven by government targets? The recognized barrier that is preventing this, especially from the concrete industry's perspective, is the lack of the necessary infrastructure on which to build a campaign for change, and the need for BIM (Building Information Modeling) and EPDs (Environmental Product Declarations) in particular to be progressed. The next studies look forwards to how the Farmer Review's prescription for a new era of collaboration might work, and how a change in the structure of the industry might also change the influence that certain players will have over the decisions being made, and what that might mean for the partnerships formed. Finally, to end on the scenario of immovable barriers and how they must also be dealt with, the question of land values is used to define the limits to what can be achieved within the parameters of 'acceptable change'.



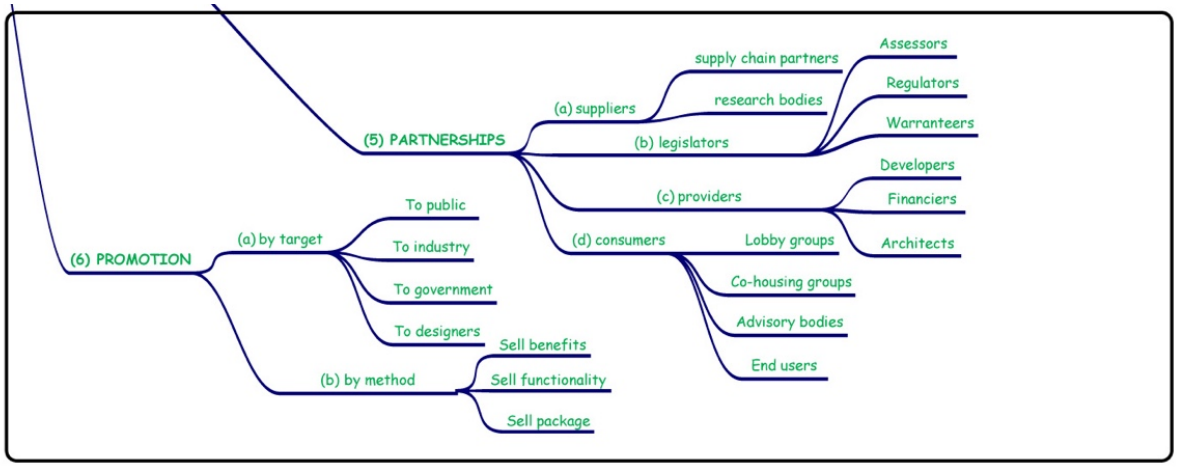


Figure 6-33 enactment of the chosen strategies

6.4.1 The role of the New Entrants - crossing the chasm

Objective: *to highlight the need for innovations to be 'managed' as they move from the early adopter market into the mainstream market.*

Choosing the right market for promoting a product based on a market's attitude to risk was discussed in section 6.3.2 (Urban Splash), where a differentiation was made between those innovations that require changes in policy and those that will be adopted on the basis of a simple financial benefit. The point being made was that those innovations that require structural regulatory changes – that need the ground to be prepared – also cannot just be seeded and left to grow. They need to be nurtured throughout this process and that requires a knowledge of how innovations are promoted by the industry itself – or not, in the case of 'crossing the chasm', a term familiar in other disciplines and applied here to the housing industry.

In business terminology, the term 'crossing the chasm' is used to describe the point at which many innovations fail in the marketplace due to the disconnect between the 'early adopters', the risk takers, and the 'majority' for whom "*the word risk is a negative - it does not connote opportunity or excitement but rather the chance to waste money and time"*. There is in fact a continuum right up to the late adopters or 'laggards' which on the whole works to promote new ideas due to the way in which each sector informs the next until eventually everybody has adopted the new technology, or 'caught the contagion'(Figure 6-34). The only point at which this process fails is the chasm, because at

this point, the early adopters, who strive to be different, have nothing to gain by promoting their 'new find' to a mainstream audience.

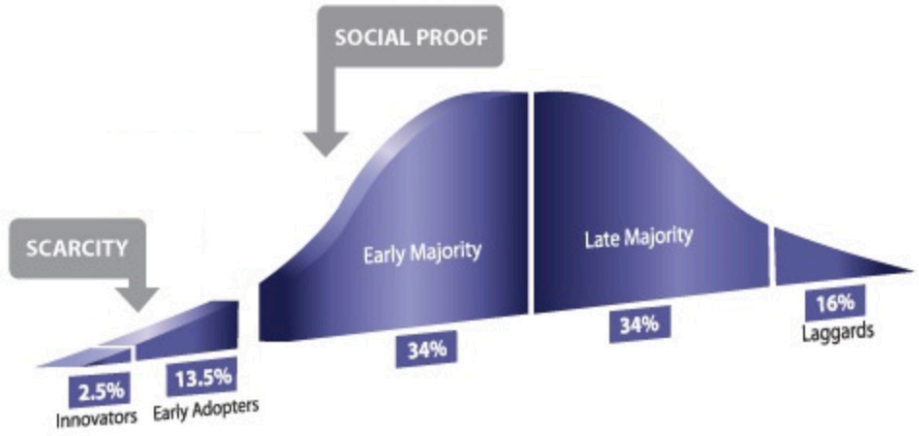


Figure 6-34 Malcolm Gladwell's adoption model (Morrell, 2010, p. 170)

Figure 6-35 attempts to overlay the knowledge gained about the different sectors within the housing industry with the model of adoption shown to be relevant in all business scenarios (Appendix P1). The need to seed an innovation within the correct sector for its stage of development was discussed in section 6.3.2, but this study focuses on the 'chasm' and the need to intervene at this stage to ensure an innovation's progress does not halt at this stage. The translation of this theory into the physical roles that need to be enacted is relevant to all innovators but can also be applied specifically to the concrete industry in terms of what needs to be done at each step of the way. The chasm could be said to occupy the space between 'demonstrator site' status and 'mainstream acceptance, something that many movements, including PassivHaus, off-site manufacturing, self-build and co-housing could relate to.

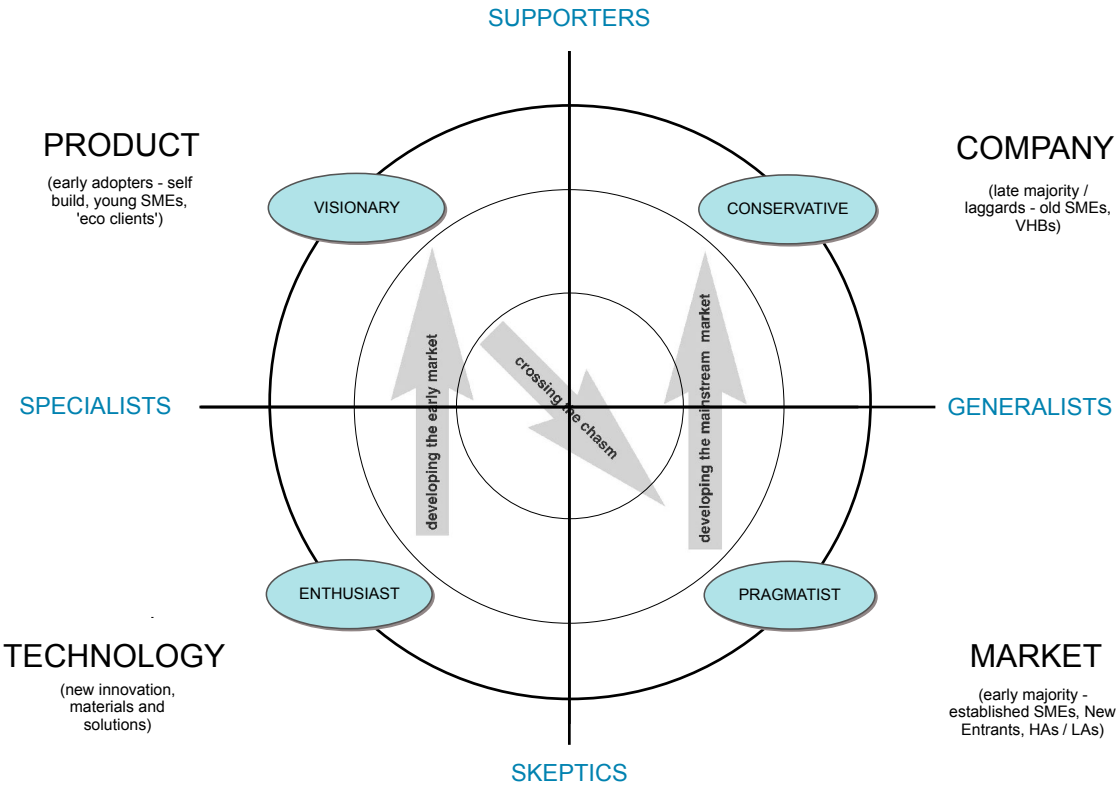


Figure 6-35 defining the character types responsible for the adoption of innovations

For the concrete industry, the chasm exists for the adoption of the principles of thermal mass, and how that chasm can be crossed using these principles is the subject of the next case study.

6.4.2 Driving innovation and the sustainability agenda.

Objective: *to ask who is now driving sustainability, and whether this could be the concrete industry. If so, how should they go about such a task?*

Many of the innovative solutions currently being promoted within the house building industry are predicated on a need for the industry to become more sustainable, and the concrete industry's agenda, predicated on the benefits of thermal mass, is no exception. The government's long term objectives on this front are therefore central to knowing how to proceed. Will a 'staircasing' of sustainability requirements be written into new legislation or does the housing industry now need to find new drivers to ensure there is a commitment to a zero carbon future. If so, could that be the task of the concrete industry and what would they need to do to further that cause?

For the ten years following the launch of the Code for Sustainable Homes in 2007, the sustainability agenda was driven by the requirement for all government funded housing to meet regularly increasing targets for compliance. The long term agenda was for the private sector to eventually be coaxed into at least matching these standards either through competition amongst themselves or pressure from a public becoming increasing aware of the comparatively high quality of more affordable social housing. Whilst this effect was taking far longer to materialise than expected, it was beginning to

impact on the quality of housing in the private sector. In 2017 however, the government decided to abandon the targets for zero carbon homes and replace the Code for Sustainable Homes with a voluntary system of assessment geared around the current Code 4 levels, the Home Quality Mark (HQM).

This abrupt policy change had a number of detrimental effects, beyond the obvious loss of a driver for the sustainability agenda. This case study looks at those effects, the reasons why the government felt it necessary to take such drastic action, and what steps the housing industry will need to take if sustainability is to continue to influence the design process. This is again of particular interest to the concrete industry as concrete's sustainability credentials are central to how it is currently being promoted as a building solution.

The main conclusion drawn from this study is that the sustainability industry can no longer depend upon government incentives to push a reluctant industry towards change, but should instead endeavour to make that change financially viable in its own right, starting with an assessment of who stands to gain from such an approach.

The public survey discussed in section 6.1.2 addressed this question by trying to establish where the support for sustainability lies within the public, broken down by as many parameters as a short survey would allow. The same exercise has been carried out from a material perspective looking at what credentials concrete can offer and how they can be used to support this agenda (6.1.3, 4), and what should and what does motivate governments were both discussed in section 6.1.5. Armed with these insights, it should therefore be possible to define a series of markets where a sustainable agenda would be of mutual benefit to all three of these sectors and subsequently stand a far better chance of success.

This case study follows the development of the Hockerton Project (Appendix P2) and its efforts over the past twenty years to make the case for sustainability (Visit Nottinghamshire, 2018). It concludes that there is a market for their unique thermal mass solution but that it cannot be realised without the involvement of many parties, not necessarily with the same agenda, but all benefitting from similar outcomes. This follows on from the findings in previous studies regarding the need to collaborate, combine multiple benefits, and deal with the root causes preventing change from being adopted, even if that means lobbying for changes in government policy. The concrete industry needs to be part of that form of collaboration, not only to further its own cause, but to help define the most appropriate markets for its products.

Figure 6-36 Hockerton Housing Project, Leicestershire.

6.4.3 BIM, EPDs and OSM – creating the right environment

Objective: *to show the importance of establishing an appropriate framework for change as a prerequisite for adoption.*

Taking over the wheel from legislative enforcement and driving home an agenda such as sustainability requires far more involvement than just providing the solution to a problem. Collaboration between all those with similar objectives is a necessary prerequisite, and creating the right environment for collaboration the prerequisite for that (Brown, 2012). BIM (Building Information Modeling) is the key to this change of gear in that it paves the way for the collaboration needed to adopt the changes the sustainability agenda needs to progress, like EPDs (Environmental Product Declarations) and off-site manufacturing (Appendix P3). But BIM also requires communication between the sectors before it can become fully integrated into the building process, something which is proving difficult to achieve – without BIM already being there to pave the way (House of Lords 2018, p.226,419).

This case study sets out a hierarchy for change beginning with the full adoption of BIM, and shows how important it is for the concrete industry that this is successful, and then asks what the concrete industry's role should be in encouraging this. By this stage of the case studies, the interconnectivity between the many courses of action proposed has become very apparent. Whereas BIM is theoretically of benefit to all sectors within the housing industry were it to be enforced tomorrow, EPDs and OSM both represent interventions where there will be winners and losers, making their adoption far less straight forward. Understanding the allegiances that will need to be made is therefore critical to how these barriers are confronted, or whether in fact they are best left and accepted for what they are. It is worth noting at this often political upper level in the hierarchy of decision making, the third option of avoiding these barriers becomes increasingly tenuous, but the

choice of focusing on the New Entrants, with their in-house ability to enforce BIM into sectors where governments fear to tread is still an option worthy of consideration.

6.4.4 Collaborative concerns – promoting the solution

Objective: *to consider the implications of collaboration, how that might need to be managed, and what impact that might have on the partnerships the concrete industry should make.*

If the policy changes discussed so far are integral to the success of the concrete industry's objectives – the use of EPDs, the acceptance of thermal mass benefits, the environmental case for concrete – the concrete industry might have to be at the forefront of these campaigns. Not all industries require such fundamental changes at a governmental level to further their cause. Leading change at this level can be a costly and time consuming exercise, making the choice of the right partners even more critical. This study looks at some of the issues around collaboration taken from the housing industry's recent history, and suggests a way forwards based on shared objectives.

More collaboration is the overriding message to be taken from the government's latest drive to improve productivity within the housing industry. This follows calls from numerous white papers for the adversarial nature of procurement practices to be reassessed:

The construction industry's 'collaboration problem' is at the root of its change inertia. It prevents itself scaling up, sharing risk more appropriately and creating more business plan certainty. The industry is currently conditioned to using adversarial margin protection and expansion tactics. (Farmer, 2016)

There are however, downsides to more collaboration, and this case study looks at the industry's recent history and how 'embedded knowledge' can become an overriding factor in the decision making process when too much emphasis is put on building up relationships within the supply chain (Appendix P4). Whilst this can be equally beneficial as it can be detrimental, it is not the preferred outcome of more collaboration, and if a repeat of the anti-competitive bid-rigging activities of the early 2000s are to be avoided, some additional checks will need to be introduced (Figure 6-37).

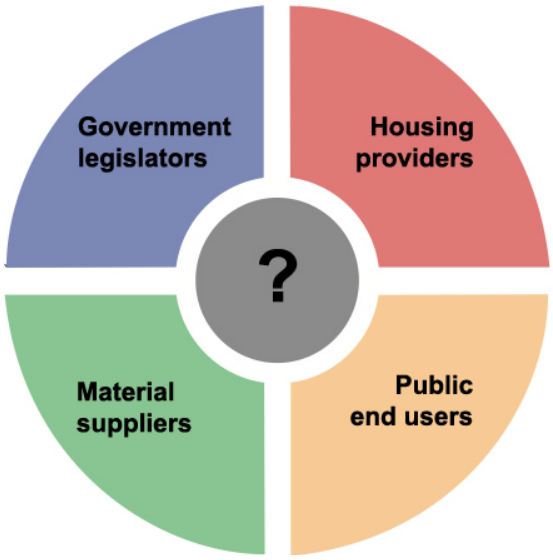


Figure 6-37 the five sectors making up our housing delivery system?

The proposition being tested in this case study follows on from the last study's recognition of the importance of BIM for the concrete industry, and a related question asked of the construction industry, which was *"do you agree that architects should be responsible for BIM co-ordination on construction projects?"*, to which 80% said yes (BD and Morrell, 2014). Whether this is a vote of confidence or more a passing of the BIM buck, this would seem to suggest that the now widely recognised need for collaboration might result in the architect becoming reinstated, not so much as Master Builder, but as Master BIM co-ordinator.

The relevance of this for the concrete industry, the study goes on to suggest, lies in the fact that not only are architects seen as the independent arbiter for our new collaborative industry, they are also in a pivotal position for promoting concrete, and best placed for understanding and championing the benefits of thermal mass. To follow this through to the strategy needed to support such a cause, the outcome put forward here is to invest heavily in architectural education and ensure that the next generation of architects are fully aware of the benefits concrete has to offer.

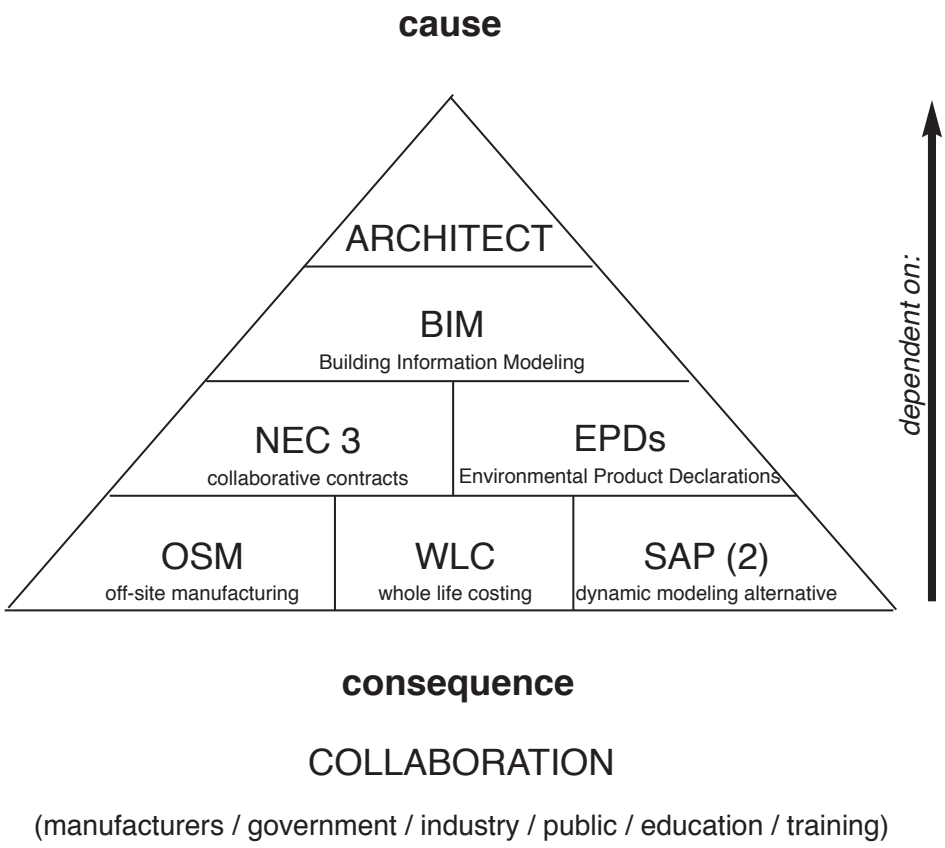


Figure 6-38 Hierarchy of factors that need to be in place for change to take place

6.4.5 The land question – the political end game

"Buy land, they're not making it any more." Mark Twain.

The theory that all barriers to innovation must be dealt with before any change can take place is best exemplified by the way we have collectively and consistently failed to address the issue of land valuation in the UK. Land speculation is the ultimate 'barrier at the end of the road' which is currently seen, even by governments, as immovable. If it is not dealt with, however, it can be argued that no level of innovation will bring about either a reduction in the value or an improvement in the quality of our properties, because of the residual land value calculation we use absorbing any additional profit introduced into our housing delivery system (Bentley, 2017, p. 17). This last study looks at the history behind this barrier to change that sets us apart from most of Europe (Appendix P5), and discusses how the concrete industry could play a part in its removal, whilst also showing how the decision making process being proposed successfully guides the user to this conclusion.

According to the VOA (Valuation Office Agency), the average price of agricultural land in England is £21,000 per hectare, whilst land with planning permission for housing is around £6m per hectare. To take the most extreme example,

“If a hectare of agricultural land in London’s green belt was given residential planning status, with no requirement for affordable housing, then its value would increase around 1,000 times.” (Jefferys and Lloyd, 2017)

The relevance of this to the concrete industry lies in the fact that towns and cities are where the housing revolution we need, needs to happen (Zero Carbon Hub, 2015). Sustainability in terms of the communities we live in requires it, but the solutions that will make this achievable – densification, standardization, modular off-site construction, all contentious in their own right, are still not seen as mainstream options. But they are the solutions where the concrete industry can capitalize and provide truly affordable housing by pioneering alternative visions for how we live, such as by reinventing aspirational communal living solutions.

This case study looks at the political conundrum of land reform and shows how it is central to all these issues – the quality and affordability of our housing, the lack of diversification and the stunted role played by the public and the architectural profession in this debate. It then goes on to look at how and why these are not such contentious issues on the continent, and what changes would need to be made here to allow a European-style collaborative housebuilding movement to flourish. The question therefore becomes – for this and all the other scenarios so far discussed - one of whether the changes needed are achievable, what partnerships would be needed to make those changes, and whether in fact the markets these changes would open up justify the effort involved.

The conclusion reached, after examining the UK’s history of attempted land reform since before the First World War, is that, more than any other factor so far discussed, the odds are strongly in favour of the status quo, whilst the argument for change is perhaps stronger now than it has ever been. In such a scenario, it is suggested that the concrete industry, through its ownership of land, much of which arises from depleted quarry sites, is in a unique position as a private industry to break the correlation between land and property prices. Whether it decides to take such a radical course of action is for the industry to decide, but the simple calculation below will define the housing industry’s inability to both innovate and satisfy the country’s housing need until that correlation ends.

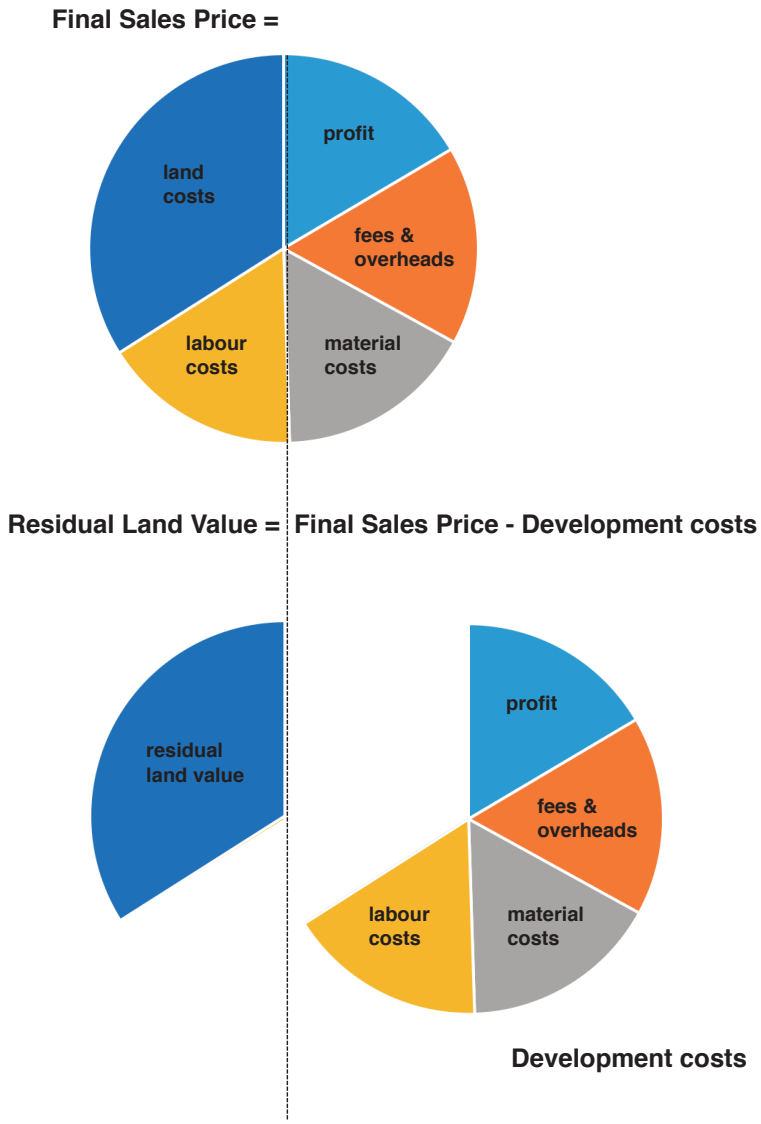


Figure 6-39 Residual Land Value calculation

"Britain's housing crisis results from the failure of politicians to ensure that markets work in the public interest rather than to the benefit of the unproductive few." "The institutional arrangements of the land market have meant that landowners benefit at the expense of society, a bias that policy must eliminate if there is to be a transformation in housebuilding." (Aubrey, 2015)

6.4.6 Conclusions to section 4 case studies

This last section of case studies has taken much of the evidence from the previous three sections and shown how the knowledge gained forms the evidence needed to tackle the more systemic issues that are the real barriers to innovation. As suggested earlier, these broader issues tend to be political and will require political solutions, but that in no way represents a relinquishing of responsibility. To bring about a political solution that will lessen the barriers to innovation requires collaboration across the housing industry to provide the necessary empirical evidence, both in terms of scientific proof and the benefits to be realised by all sectors involved in a change's implementation.

To be of genuine benefit to the industry, the Decision Making Tool needs to help formulate these arguments and bring together the component parts of a task as a logical sequence of events. At the outset, the role was thought to be merely one of raising awareness of these factors and how they might impact on the decision making process, but as the complexity of their inter-relationships grew, it became necessary to categorise them and measure their relative importance and impact upon each other.

This last section has therefore been used to test that ability to bring many issues together into discrete strategies for change, and show how these in turn sit within a hierarchy that dictates an order to how they should be approached. The need to consider so much in such detail before embarking on any action might seem too onerous to justify the time needed, but the justification comes in the approach's ability to reduce the final workload. By considering the implications of each action - in terms of time and effort, collaborations needed, likelihood of success and potential returns - whole threads of research and live trials can be dismissed at the outset under the banner of 'barriers to accept' and separated out from more productive paths of research and development.

6.5 Conclusion to Case Studies – Causes and Consequences

These case studies have all been used to test a theory about the barriers to innovation and how to deal with them to encourage adoption. The studies have been structured in a way that builds a picture of the cumulative inter-relationships between the barriers that need to be overcome, culminating in Section 4 with those that sit at the end of the road where there is no alternative route to take. This is not to say that dealing with the final barrier will make all those preceding it fall away, but rather that not confronting the final barrier at the outset could render all other efforts futile.

It was suggested at the outset that any problem that is recognized as needing attention sits within a hierarchy of related problems, with causes above and consequences below. Analysing these will show that at some point the consequences below will become inconsequential and not worthy of consideration, and the causes above will become too far removed to affect. Taking the speculative housebuilding industry as an example, the consequences of overheating are not their concern, since this is not, as yet, seen as a failure under the NHBC warranty scheme, and the buying public have little influence as a lobby group whilst there is a shortage of housing to choose from. Neither are the causes behind our inability to deal with that shortage of housing - specifically for those on lower incomes – the volume house builders' concern, as their business model has never pretended to provide a public service. The degree to which causes and consequences are seen as relevant to any one sector is therefore dictated by motivation. The more altruistic the motivation, the broader the reach of causes and consequences that are of concern. Looking beyond short term profit motives, into longer term equity benefits and ultimately at even longer 'generational term' sustainability needs, brings these more holistic arguments into play.

Innovation does not automatically fall into this category of the 'long term return' problem, as it can sometimes operate on a directly financial footing, offering a similar solution but at a lower price. In this circumstance, the innovation can flourish within the existing policy framework, paying little attention to the broader causes or consequences. But for those innovations that cannot compete on price alone, and require a new perspective on how benefit is defined, the task immediately becomes more far reaching. It is these innovations that are the focus of this research, as it is in these circumstances that the barriers begin to mount up. It is also in these circumstances that innovation fulfills a societal need, above and beyond the short term financial benefit to the innovator. Any innovation that aims to improve the social or ecological environment will by definition demand a longer term financial argument and call upon broader concepts to counter the short term financial cost of delivery.

If the downstream consequences of an innovation are seen as the benefits accrued, then the upstream causes that prevent its adoption are the barriers to be overcome. It would seem to be an unfortunate truism that the greater the benefits to be accrued, the greater the barriers to adoption, the path of least resistance most often being represented by the fastest route to financial gain (Figure 6-40). What this does not mean however is that the path of least resistance is the route to the greatest profit, only the fastest. The aim here therefore is to make those innovations producing more beneficial outcomes at least as adoptable as the 'quick fixes', by pre-assessing their feasibility and more accurately defining their place in the market.

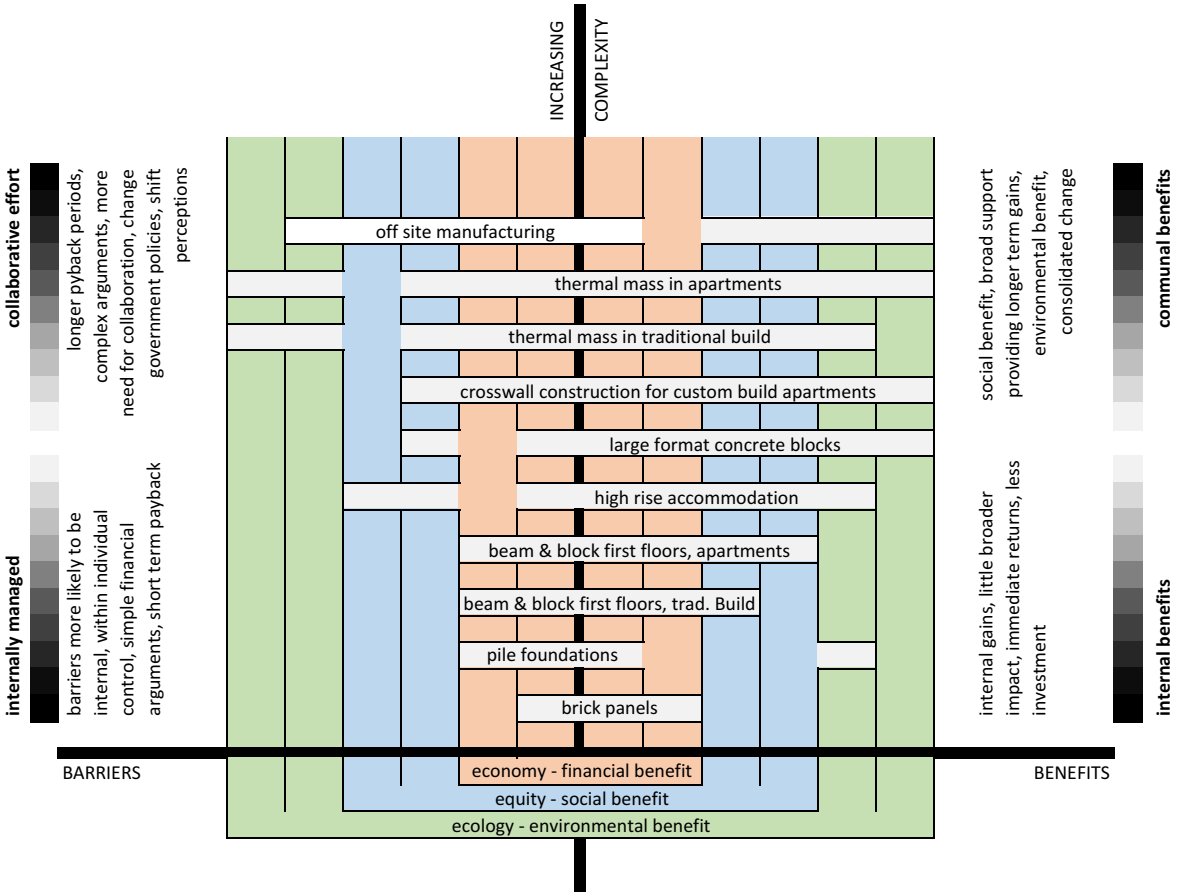


Figure 6-40 Synopsis of the concrete industry's options

The outcome of these case studies is therefore a far more nuanced picture of how innovations need to be managed if they are to be successful. The grouping of the case studies into four sections followed the structure of the initial proposal of a linear process designed to ensure all the relevant questions were being asked. The first section focused on existing knowledge - the level of knowledge, its breadth and its depth; location of that knowledge - who knows what and from where; and the quality of knowledge – its accuracy, reliance on perception and the existence of alternative realities. The second section looked at the motivating factors behind the decision making in order to better understand how those decisions are made. With that information it was then possible in the third section to recognize which markets and delivery systems were best suited to any particular innovation so that the message could be tailored to suit those markets' needs. And finally the likelihood of that innovation being adopted could be assessed within the constraints of the system as it currently exists, and if necessary, steps taken to change that system to make it more conducive.

Each case study therefore outlines a possible course of action that has evolved out of the deeper understanding gained by following this process. As the sections add further levels of understanding, the necessary actions become more far reaching until the final section, looking at the economic and political landscape in which the industry operates, suggests that there might be some crucial barriers at the end of the road that will need collective action if they are to be removed.

Ultimately, the decision that has to be made is whether or not the effort involved is worth the returns this might deliver, and whilst this whole process might be seen as just emphasizing the negatives, it is

merely highlighting the barriers that need to be taken into consideration. If the outcome is a decision to focus only on solutions that can be promoted within the existing regulatory framework, and without having to confront the wider implications associated with more altruistic innovations, this is at least a decision arrived at through a true understanding of the enormity of the task that has been avoided, rather than after having invested many unproductive years only to prove the same point.

Chapter 7
DISCUSSION AND FURTHER DEVELOPMENT

In this final chapter an assessment is made of the entire research process and the extent to which it has been successful in its aims and objectives. Throughout the work it has been stated that the underlying objective was to develop a process for asking the right questions rather than providing 'the right answers'. Answers to complex, Wicked Problems are ephemeral and cannot be 'banked' for later use. As a consequence there is much in this research that has been left open for further investigation, the main purpose of many of the case studies merely being to highlight the importance of considering the entire spectrum of possible influencing factors before making any decisions on which strategies to pursue. There are nevertheless some key findings that have been covered here alongside the variables that will in time require a reassessment of what constitutes the most appropriate response. For this, the Decision Making Tool will remain a valid process to follow.

7 CONCLUSIONS AND FURTHER DEVELOPMENT

The UK housing industry has been accused of complacency because of its apparent inability to increase its productivity levels and provide more, better quality, truly affordable housing (Farmer 2016, p8). As a diagnosis, this does little to suggest a way forward, and is more a statement of exasperation with an industry that seemingly refuses to be helped, and is making it very difficult for the government to deliver on what the industry and the wider economy needs.

This research has focused on trying to understand why it is that the housing industry, and specifically its sustainability agenda is proving so difficult to influence, let alone guide in a direction that we can be sure is appropriate for our needs. Such strong resistance to change cannot readily be explained by a refusal to accept the need for improvements in these areas, suggesting that there might be a more nuanced explanation for why the housing industry has been placed by successive governments in the 'too difficult to deal with' box (Stephens, 2014).

7.1 Originality of research

As an aim, that alone makes this an unusual thesis for the sheer breadth of the research that it has needed to encompass. But this was necessary to ensure that the author could legitimately claim to have investigated all likely causes that might be behind this accusation that has dogged the housing industry for the past fifty years, if not longer (Goodier and Pan, 2010). The justification for attempting this however, and looking beyond the conventional range of issues debated in the many government white papers studied, is well founded. Our housing industry is now in near critical decline (Farmer, 2016, p. 9), and whilst the last major review by Mark Farmer acknowledges this, its proposals go little further in resolving this than consolidating all that has been proposed before. If the root causes of the industry's problems lie outside the scope of what has hitherto been considered relevant, a broader analysis needs to be undertaken, taking into account research from other fields and disciplines that might shed light on what, in the world of social policy research, constitutes a 'wicked problem'.

If the issues confronting our housing industry do constitute a wicked problem, the emphasis needs to shift from finding solutions to gaining a better understanding of the problems, and also from trying to help the housing industry, to trying to help the housing industry help itself.

The main output from this research has therefore become a decision making tool to help those sectors within the housing industry recognize the full scope of the problems they need to confront, so that they can create their own solutions based on that broader understanding of the factors that need to be considered, rather than conforming to predefined mechanisms that limit the opportunity for both conceptualizing and trialing more innovative solutions.

Much of the research this builds from comes from outside either the housing industry, the concrete industry or outside the UK, and with respect to the methodologies used, often from outside of all three. There was also a decision made early on to include non-academic sources as part of the research because of the need to understand what information was being used by the industry itself. Concerns over the authenticity and subjectivity of this data became part of the discussion as the

industry interviews and public survey data began to build a picture of how the industry as a whole viewed itself across the sectors involved.

This procedural process developed as the research of the subject grew to explore different aspects of the industry, the relevance of which often became apparent only at later stages. What began as a linear course of action therefore evolved into a far more iterative process, revisiting existing literature and later, a broader range of academic papers when it became clear which areas were likely to provide answers to the issues being uncovered. To that end, much of the academic research focused on motivation and risk, often within fields far removed from the construction industry. Later research into appropriate methodologies focused on complex problem solving, the beneficial use of mixed methods and the dangers of misinterpretation of data due to social confounders. None of these areas of research represented obvious directions of travel at the outset, with their relevance only being discovered due to the decision to rule nothing out until it had been at least considered, if not studied in depth. That approach was adopted in terms of disciplines, historical time frames and geographical significance, resulting in a comprehensive initial scan across a broad range of topics that has given this research much of its originality.

A notable outcome of this approach has been the inclusion of much evidence that would not stand up to the same scrutiny as peer reviewed academic work, which has also benefitted the research by increasing the scope of the knowledge base being assessed. It has been explained why this industry level information has been studied (Section 1.2.2), but there is also a need to define how that evidence has been used, the degree to which its reliability has been tested, and how it has shed new light on the issues being investigated. It is certainly true that the housing industry uses many information sources that are recognized to be of variable worth, and to some extent allowances are made by the industry for that (M.01.1, p5), but there is also a hidden hierarchy of information transfer that confuses the picture further. Decisions made at governmental level and the trusted white papers produced to relay these decisions back to industry are often based on the same industry data sources seen by practitioners as subjective at best, if not fundamentally flawed in the conclusions they draw. Research practices at this governmental level have in fact been exposed as being some of the least rigorous of any research bodies (UK Parliament et al, 2018, p. 3). The arguments in favour of timber as a sustainable building material and the policies now founded on those arguments are a case in point, which the concrete industry, it has been suggested here, needs to challenge. It cannot be assumed that all government research has taken account of the potential bias in the evidence it has gathered from what is often only the more vocal or better funded sectors of the industry. The issue of inaccurate peer reviewed papers funded by some material suppliers has even been raised as a concern by some in the industry (M.02.6, p.14), showing how important it is to know the source of all data and statistics before using that as the foundation for any further work. The line taken throughout this research has therefore been one of caution regardless of the source, an emphasis on first principles, and a policy of safety through multiple sources to corroborate all data used. It is through taking these steps and broadening the scope of the enquiry that a more enlightened understanding of the issue at hand has been achieved.

7.2 Methodological problems faced

The methodological approach used throughout the research has been based on a qualitative interpretive framework. It is procedural and inductive and has been used to build a context based description of the industry in a bid to explain its apparent inability to accept change. To do this it has posited that the industry consists of different sectors, each of which holds to its own version of reality, and that it is possibly the difference between these ontological viewpoints that is responsible for the disconnect that prevents them from functioning as a unified whole. The questions asked in the industry interviews elicited many opinions around the key issues that have led to the inertia now associated with our housing industry, all of which were then investigated and tested for their validity. The process therefore became one of creating a tapestry of facts and perceptions, testing for how broadly each was held, and then looking for empirical or at least analytic evidence to back them up. As a route in to a more academic analysis of the problems highlighted at the outset, this ensured that the area of study was always closely related to reality as defined by those who will ultimately be responsible for adopting the changes being prescribed. Key to this approach is the understanding that a perception, even one that can be proven to be unfounded, cannot be dismissed. It has as much validity as the facts it has displaced in terms of it representing a barrier to progress, and must therefore be given equal emphasis. The very real difference comes in how misplaced perceptions need to be dealt with, as they can potentially be harder to displace than incorrect facts.

From an academic perspective, this represents a difficult balance to achieve, whereby academic rigour must be applied to an approach that accepts the role of unfounded perceptions. There is for instance, evidence that unfounded perceptions in the form of 'consumer confidence' can provide a more powerful influence over property prices than proven statistical evidence to the contrary (Countrywide PLC, 2014). It is one thing to attempt to correct that misconception, but it is quite another to ignore it on the basis that it is unfounded. In many instances, as quoted earlier, perception is reality.

The decision making tool that this research has developed has therefore tried to balance academic credibility and business reality, based on verifiable research but delivered in a practical form that can be accepted by those who will need to use it. This approach is as true for the way in which the data has been gathered as it is for the way in which it has been interpreted to help practitioners work out their own most appropriate solutions.

Data gathering.

Gathering data from a variety of sectors, all of which were structured differently led to the use of a variety of methods. A degree of data comparability had to be maintained, however, something that was considered early on when the industry interviews were recognized to be inappropriate for some sectors. The principles that needed to be maintained were the semi structured nature of the questioning, the broad range of informed participants from each sector, and of course, the key questions being asked, or at least the purpose behind them. In this respect it was the insight into what was known and what was perceived in relation to the roles played by the others' sectors that was deemed to be important.

The main problems encountered were in reaching the full range of actors within each sector, and in guaranteeing that the answers given were a genuine reflection of that sector's thinking or merely a representation of the story they wanted to be heard. On the whole it was felt that the interviewees were remarkably candid once they had been convinced to participate, with those unwilling to disclose information removing themselves from the process at the outset. This was particularly true of governmental bodies and competing material industries (Steel, timber, CLT) who could not be persuaded to participate. Within the public survey however, it was the on-line medium's inability to reach certain sectors (specifically the over 65s and those of lower educational status) that proved to be the barrier to achieving full representation.

Interpretation.

The extent to which this data could be interpreted as representative was limited by its qualitative nature, but this was not the main intention of the research. Where there was strong evidence of unified, consensus opinions through corroboration across the different methods used, this was reported as normative and used to inform further lines of enquiry, but the fundamental purpose of the research was to uncover those factors that were influencing the decision making process in ways that had not previously been recognized. The degree to which any of these factors impact on those decisions is what changes over time and must be constantly re-evaluated.

Lessons learnt.

The scope of this research was necessarily broad with the intention of its boundaries being 'self-determined' rather than arbitrarily imposed at the outset. Although this has proven to be a substantial undertaking, it has also proven to be beneficial in that it has resulted in some issues being included that have not previously been seen as relevant to the argument. It is true that the areas of relevance uncovered were too many to pursue all in detail, and ordinarily that might have been seen as a failing for research at this level, but as has been stated throughout, the purpose of this research was not to provide definitive answers but to highlight the dangers of limiting the scope of the questions being asked.

The research has also touched on a number of methodologies from other disciplines, notably from social sciences, which have been applied to the housing industry's issues. This was a natural consequence of the breadth of the initial research, and the realization that the problems being faced were not ones that could be approached in the conventional linear fashion. This interdisciplinary approach has proven to be central to both the originality and the success of this research, and why the decision making tool, developed as the main output, may prove to be valuable in moving the process forwards.

In hindsight, therefore, this research became a process that sought reasons for an industry's inability to innovate through asking questions that extended beyond the boundaries normally applied. And partly as a consequence of this, solutions were found through extending that research into other disciplines, which have then been adapted and applied to the issues uncovered by the questions asked. "Problems cannot be solved from within the same level of thinking that created them" was a mantra of Albert Einstein, and would appear to be equally true of those being considered here.

7.3 Aims & objectives with respect to existing research

It was not clear at the outset what the gap in the knowledge was that needed to be addressed, as can be seen in how the question originally being asked evolved during the initial research period. The industry question of 'how can the concrete industry be more effective in promoting its products to the house building industry?' quickly focused in on the barriers to adoption of innovative solutions being the fundamental concern. At this point a number of decisions were made that resulted in the aims of the research solidifying and forming the basis for the research question asked.

At this early stage, a decision could have been made to focus in on one of the many known barriers that confront the concrete industry, such as the acceptance of timber as a more sustainable building material, or the inability of SAP to fully recognize the benefits of thermal mass, either of which could be developed as thesis topics. The decision not to pursue any one specific issue was taken partly because of the very broad brief presented by the funding partner, and partly because of the limited impact that such a study would be likely to have. One of the universally recognized issues that the UK housing industry has to contend with is its fragmentation. The endless complexities that have grown up around our housing delivery system mean that no one successful resolution to an isolated argument can be expected to result in progress being made. The interconnectivity of interests throughout the industry is in itself a barrier to change, and it was decided that addressing this broader issue was far more likely to provide the concrete industry with the solutions being sought.

The next decision, to broaden the question beyond that of concrete to innovation in general was also taken with the concrete industry in mind. If the question now being asked was to focus on the barriers to the adoption of alternative solutions, that would also need the research to encompass those other alternatives in order to fully understand the decision making processes being applied. More importantly, it would also need to look beyond the materials themselves to capture the full extent of the influencing factors. At that point it became clear that this research, to be of any relevance had to either focus on one specific aspect, or encapsulate the entire remit of possible factors in the decision making process. Anything in between would lead to potentially misleading conclusions.

Having accepted the breadth of the research in terms of the factors to consider, the next step was to question the worth of such a far-reaching analysis without also attempting to provide a method by which these findings could be applied to changing circumstances over time. This was ultimately providing the answer to the question being asked at the outset of how to be more effective at promoting concrete products into the housing industry, the answer being 'to become more informed about that industry, what its needs are and how it approaches decision making. As this represents a set of constantly changing variables, answering those questions would be of far less value than providing a framework by which to ask them.

Finally, it was decided to make concrete a case study within the context of innovation, specifically focusing on sustainability as the main driver. This was in recognition of the fact that the concrete industry had itself focused on sustainability as a key factor in its marketing campaign, and an acceptance that most innovation within the housebuilding industry is driven to some extent by the need to become sustainable, both in the products we use and the way in which we live. Rather than this diluting the relevance of this research for the concrete industry this was seen as a way of drawing

on more evidence that might not have been apparent from one isolated industry's perspective. It also became increasingly difficult to create a division between any one factor and another once the discussion had been taken to be bounded only by relevance to the decision making process.

Despite this, the focus throughout has remained on concrete as an example of a product trying to influence a market that is very conservative in what materials it uses and where. The three main areas within this definition were therefore the concrete industry, the housing industry and the sustainability industry with the interface between all three being used to define the focus of the research. Out of this research the aim was to gain a better understanding of the decision making process that is ultimately behind the success or not of any innovation.

In essence, it is the combination of that focus together with the breadth of the factors considered that gives this research its originality. There is a wealth of research relating to the housing industry, to the many uses of concrete and to the world of sustainability, but surprisingly little combining any two of these, let alone all three. There is also a wealth of research relating to the decision making process, to risk and to complex problem solving, but it is the application of these areas of research to the field of innovation in housing that the author recognized as the gap in the knowledge base that needed addressing.

7.3.1 Parallels with other research

The Institute for Government:

Much of this research has called upon the findings from research in other fields to apply within the house building industry. One such example is a recent work programme carried out by the Institute for Government entitled 'What's wrong with infrastructure decision making?' (Atkins *et al.*, 2017). The report's remit was to explore why UK economic infrastructure policymaking is so weak and how it could be improved. There are potential parallels here with this research and the proposition that improving the decision making processes taking place within the house building industry might reduce the barriers to innovation, and also parallels with the need to understand the government's own decision making processes if any meaningful change is to take place. Their report highlights six shortcomings in that process that are therefore worth comparing with this research's own findings:

1. There is no national strategy for infrastructure investment.

"Without a clear strategy for why change is needed, with HS2 used as an example of this, investor uncertainty becomes a major barrier to progress. Direct comparison with alternative solutions becomes clouded by confused and changing objectives, resulting in complex unresolvable decisions."

To relate this to the UK housing industry, and specifically to off-site manufacturing as a solution to our problems, any new innovation must establish a clear need, the market for that need, and its own ability to satisfy that need more appropriately than any other solution. But for an innovation to take root, it also helps to have a consistent national strategy in place for a period of time and an assurance at the outset that this will be the case. Otherwise the investment needed will not there.

2. Government does not devote enough attention to assessing early options.

"Failure to devote sufficient attention to examining early options can result in better solutions being overlooked."

The potential to base all research on an initial gut reaction which then only serves to reinforce that initial decision has been recognized as one of the concrete industries greatest threats, with the battle against timber often being lost at the outset to sustainability. Putting the decision making process on a more structured footing is therefore a necessary step to ensuring those early decisions are fully addressed.

3. The more ambitious the forecast, the more questionable the model.

"The inherent difficulties of modelling large projects with long-term payoffs" is regularly under-estimated by governments resulting in projects that struggle to attract private investment due to the risks associated with this level of uncertainty.

Any private construction company faced with an innovative solution that requires a long term perspective on the benefit to themselves will consider that a barrier to adoption. Future predictability has been highlighted in this research as an essential component for minimizing perceived risk, but government policies cannot not be relied upon for delivering this.

4. Ministers and senior civil servants can fail to understand project risk.

This concurs with the position taken in this research on the many years of government white papers that have continuously failed to recognize the role that risk has taken in preventing the housing industry from implementing the many changes that have been put forward as solutions to the industry's poor performance. The call for businesses to take individual risks for a possible collective gain underlies all these initiatives, the consequences of which are felt less by governments than by the businesses they are appealing to.

5. Government finds it difficult to make decisions which create 'concentrated losers'.

There is no obvious parallel with this finding, although the government's inability to unequally promote any one business solution over another does reduce their ability to drive innovation. That much has been recognized in the comparatively low influence that the legislative sector has over the housing delivery system, and the danger of relying on any one policy to be in place for any length of time before it is contested by the negatively affected sector.

6. Inadequate evaluation misses the opportunity to improve future projects.

"Decision makers are not routinely learning from past mistakes."

The fast turnaround of personnel within our political system (Gash, T., Magee, I., Rutter, J., & Smith, 2010, p. 63) makes the process of influencing government even more time consuming than it ought to be. The cyclical failure of off-site manufacturing is often put down to a lack of historical oversight on behalf of government and the housing industry, and again suggests that a more thorough questioning of the facts at the outset of any decision-making process should lead to more reliably

positive outcomes. The call for greater collaboration across the build process is a response to this so that incremental improvements can be incorporated into the design process more efficiently.

The Resolution Foundation:

Of equal interest is the recently published report from the Resolution Foundation's Intergenerational Commission, which has put our housing crisis at the center of the issues being faced by the Millennial Generation, recommending the piloting of *"community land auctions so local authorities can ensure more land is brought forward for house building, underpinned by stronger compulsory purchase powers"*. But they also recognize the enormity of the task: *"We do not underestimate the task at hand, especially for democratically elected politicians in an era of unstable politics".* This research has regularly stated the need to recognize when issues are too complex or entrenched for there to be any realistic chance of change. These are the barriers to be accepted and factored in if that is the informed decision that is reached.

What Works Network:

This move towards more accountability in Government, reflected by the work of these think tanks is driving a demand for more robust evaluation methods to back up government policy making. The What Works Network (Cabinet Office, 2018), established in 2013, tries to establish a culture of question based reasoning that aims to grow a more holistic understanding amongst ministers and the civil service of the problems they are dealing with, rather than depending on a superficial understanding of existing research that might be brought to their attention. The language used in their reports – of cross governmental advice panels, academic input into evidence based evaluations, interest in behavioural insights – reflects the approach taken in this research and provides a route in for industry partners wanting to influence decisions at this level.

7.4 Limitations of the research

How successful this research has been cannot be fully answered at this stage as the main output has been the decision making tool for the concrete industry and others to use going forwards. Close consultation throughout the process however has meant that the design of the tool has been influenced by trials carried out during its development. Two outcomes from that process are worth mentioning.

The first is that there is a tendency to want to short circuit the process the higher that process gets up the decision making tree. This is perhaps an inevitable consequence of those in positions of greater authority having less time to allocate to any one objective, especially longer term objectives, no matter how fundamental they might turn out to be. To that end, the aim of this research has always been to provide a tool that recognizes that need to make fast decisions but at the same time to ensure that those decisions are based on a full awareness of the factors that need to be considered. The

solution sought to counter this tendency was to develop the tool in such a way that its outputs reflected the need for increasingly concise synopses as the findings were presented to higher levels of authority within a business. The benefit of this system over less structured methods is the ease with which the reasoning behind a condensed report can be accessed by interrogating lower levels of information held within the database structure.

There is also a tendency to want to shoehorn the process into previously used models or methods of working. The lessons learnt from this were that the model being presented had to be both straight forward and relevant, whilst retaining detail and balance. Maintaining relevance was relatively easy to achieve by providing concrete-centric examples at each stage of the process. Maintaining the simplicity needed to ensure its use over and above other simple but less effective models was harder to satisfy, as the fundamental principle behind this approach is one of needing to understand the detail before arriving at the solution. In a more commonplace top down approach, there is a tendency for only the detail to be sought that backs up and justifies the initial proposition.

In part, the solution to these issues was to build flexibility into the tool so that lower, more detailed levels of guidance were available without becoming too obtrusive or a compulsory part of the process. The ability to switch between different modes of working was also seen as a necessary dimension to the tool, so that different mindsets – database .v. mindmaps - could feel equally comfortable following the process, although this 'direct translation' was not fully incorporated into the prototype version resulting from this research.

Beyond the limitations of the decision making tool itself, there were some areas of research that were clearly left incomplete. The argument used here has been throughout that the purpose of this research has been more focused on proving the benefit of this research extending beyond the commonly accepted boundaries of relevance than on providing the full empirical evidence that this research would bring. To that effect, many of the case studies have been highlighted as areas requiring further research going forwards.

The data gathering exercise also exposed limitations which have been dealt with in those chapters by way of explaining the progression on to other methods (2.4.1). Those sectors where it proved impossible to get access to the right people, due to the sensitivity of the information being asked for either from a competition perspective or a political transparency perspective, were dealt with using different methods. Those methods were chosen based on the realities of what was available in the sectors being addressed and the need for all the methods used to sit within the same methodological framework. In all cases the aim was to understand the different viewpoints held about the industry as a whole and the other sectors with which they (should) collaborate. The difficulty comes when trying to get to the truth that lies behind the promotional message to show how that differs from the perceptions held by others.

The methods chosen often allowed for a cumulative picture to grow based on corroboration across different sectors, but care had to be taken to differentiate this from evidence, as there was also evidence on occasion of all sectors subscribing to the same misconceptions. Because of this there are some conclusions drawn that are still unsubstantiated and put forward as theories requiring further investigation. These are still seen as valid to the research however, as they draw attention to the many

ways in which decisions can and are being made based on perceptions rather than evidenced facts, and only goes to prove the need for a more robust decision making process.

7.5 Conclusions

There have been some important milestones reached during the evolution of this research that are worth noting as precursors to the final conclusions reached. The first of these was an almost immediate realization of how the author's own historical research into the pros and cons of alternative sustainable building solutions had become little more than a process of post justification for preferences already held. This almost subliminal drift into the consolidation of one option's benefits over those of another, whilst no doubt a very natural tendency when both the answers and the evidence to justify those answers are needed as quickly as possible, cannot be seen as a sound basis for decision making.

The next milestone, during the undertaking of the industry interviews, was the realization of how endemic this problem actually is. The simple statement from one such interview, 'perception is reality', became a key mantra that has underpinned much of the thinking behind how this research has been approached, and emphasized how important it was to maintain the link between academic purpose and an understanding of the industry's needs and motivations.

As the scope of the research grew to encompass the full range of possible influencers behind the decisions being taken by the housing industry, regarding whether or not to innovate, it also became clear how interconnected all those apparently unrelated and incomparable factors were. It was at this juncture that the research broadened further still and entered other disciplines in search of methodologies more appropriate for dealing with motivation, risk and complex problem solving.

Further milestones were reached during the deconstruction phase, when the process of managing the wealth of information uncovered began to rationalize the thinking behind the question originally asked - that of how to improve the success rate of innovations - into specific operations. The matching of motivations across sectors and the realization that barriers consisted of the need for knowledge, motivation and ability, led to the categorization of those barriers in the reconstruction phase as those that must be removed, avoided or merely accepted, when defining the path of least resistance for an innovation to stand the best chance of being adopted. Together, all these developments began to coalesce into a logical structure for how to approach such complex problems.

The final conclusion, however, that the root causes that lie behind all barriers to the adoption of innovation must be found and must be dealt with before any progress can be made at any level, was the 'inconvenient truth' that effectively frames the entire research in a negative light: Root causes are by definition difficult to displace, and for that reason their existence tends to be denied, allowing their hold on a problem to grow.

There are a number of root causes that this research has identified as lying behind the housing industry's ills that are not currently being addressed, and they all require some degree of political intervention. The decision therefore becomes one of recognizing what these root causes are and being

honest about the likelihood of them being addressed, or even of them being addressable, and if necessary, reframing the argument for any proposed strategy in this light. If the strategy arrived at is one of bringing about a change in policy, that begins with providing the evidence needed to make the case.

Ultimately, however, this research needs to be seen in a positive light, which means seeing beyond the endless barriers that could be portrayed as the inescapable reasons behind our inability to innovate. The barriers are indeed many and on occasion may be insurmountable, but a knowledge of their existence is also how we define the path of least resistance, and by doing that find the route through to the most appropriate markets for the most appropriate solutions.

By adopting this approach, and fully understanding the scope of the issues to be addressed at the outset, fewer strategies will be taken forwards, but those that are will stand a better chance of success. That is the benefit that should ensure this tool is adopted and in turn help ensure that the innovations being promoted are adopted too.

7.6 Future research

As a research project, this work has certainly raised as many questions as it has answered, and to some extent that was the intention, as the case studies in particular focused on known issues that demanded a far broader approach than they had previously been afforded. The main aim here was to draw attention to that fact and show how that wider scope could radically change the conclusions drawn and therefore the strategies chosen. The questions themselves were often left as areas requiring further research. How many of those were questions to be answered by industry and how many would require further academic research was less easy to define.

The fact still remains however that the main outcome of this research was that the industry as a whole would benefit from adopting a more sophisticated decision making process to deal with the complex problems they are trying to resolve with respect to innovation - and the main output was the decision making tool designed to help achieve this aim. By trialing the tool through a series of case studies relevant to the concrete industry, a number of strategies emerged that differed from those previously pursued. The main purpose of this case study validation exercise was to show by way of example how this approach could help differentiate between those strategies that had a reasonable chance of success and those that would eventually run into immovable barriers, resulting in their predictable failure. The main purpose of the research as a whole, however, was to show the greater importance of the process over the outcome, and that whilst the outcomes arrived at might be of interest now, their relevance would be short lived, and it is therefore the process that needs to be adopted to ensure future outcomes can be arrived at with equal confidence.

In that light, these are the outcomes that have emerged from the process, as areas requiring further development, but discussed within the framework of the process to emphasize their time limited relevance.

These emerging strategies have be categorised under the four options of Change the Message, the Product, the Market or the Policy. Within each of these there will be a process that often begins with further research or data gathering before being able to progress in a specific direction, which may then also result in further options. As a starting point, there are four key areas of further research that have been identified that are necessary to underpin many of the strategies discussed below. The author intends to write papers covering each of these areas for publication and abstracts for these are included in the following section. Whether this research is carried out internally, by the Concrete Centre or by an academic institution will depend on the scope and purpose decided upon.

7.6.1 Proposed strategies

1 Change Message

Customise message for different markets

1.1 Extend public survey to understand customer base better – triangulate information gathered on the public in terms of their knowledge and perceptions, their needs and desires and their demographic and sociographic profiling. (Case Study 6.1.2)

Perceptions of 'what the public wants' are often used by the industry, specifically the volume house builders, to justify their business model and the solutions offered. This has proven to be detrimental to the concrete industry's cause and needs to be rectified with some first-hand information. Clearly this is not a one off requirement, but like the national census needs to be carried out on a regular basis. How broadly this is written will dictate what levels of collaboration are open to the concrete industry in funding this exercise, but there are many routes to consider that would be of interest to other parties, such as opinions towards resilience.

Variables: influence of the volume house builders; levels of public knowledge; power of public's collective voice – social media; shortage of housing; changing demographics – home ownership.

1.2 Focus on Resilience as a main promotional tool – using the results from the pilot survey, this would be a far easier message to portray, not only with the public but the government legislators, warranty bodies and the housing providers. (Case Study 6.1.5)

Even if we were to halt global temperature rises at their current levels, it has been suggested that we would still need to be dealing with that impact for the next 500 years, so we are not deciding between sustainability and resilience, we need to focus on both. If concrete solutions are equally effective in both scenarios, it makes sense to focus on the easier message: Immediate and direct benefit will always trump future collective benefit, especially when there is the possibility of a financial offset through reduced insurance premiums.

Variables: Impact of climate change; Brexit – proximity of supply, impact on CLT industry; Government attitudes towards the sustainability of timber; public attitudes towards concrete; insurance industry's reaction; availability of land, floodplains.

1.3 Start a student architecture training programme – recognise the importance of maintaining the knowledge of concrete construction, passive solar design, sustainability and resilience at a student level. Provide construction details and fact sheets in easy to digest formats. Run competitions. (Case Study 6.4.4)

There are possibly further reaching consequences to this strategy if the architectural profession takes on the role of 'master co-ordinator' that is being asked of it. BIM has effectively stalled and the industry and government both need it to be adopted more broadly to provide the vehicle for the collaborative work practices that are needed for OSM to succeed. The benefits concrete can offer are broad, not necessarily immediate and often counter-intuitive, requiring a level of oversight that has been lost alongside the demotion of the architect in the housing delivery process. Ensuring that architectural students understand these benefits at the outset is the easiest way of promoting its use throughout the entire industry.

Variables: the role of the architect; the comparative influence of competing industries; timber first policies; the success of CLT; government support for BIM & EPDs

2 Change Market

Focus on markets where the benefits of concrete are more recognised

2.1 Collaborate with social housing and build for rent markets – look for market sectors that are either large enough or growing, where the benefits of cost in use alongside durability, longevity and low maintenance costs are considered important. (Case Study 6.3.3)

Balance the benefits of market size against growth potential, the appropriateness of your products for their needs, government incentive schemes and public awareness. This will still require evidence to back up the argument for concrete but at least the message can be couched in a language that will resonate.

Variables: financial model for HAs, local councils; government tax incentives for build to rent; government policy for supporting OSM through recessionary periods; economic cycle; volume house builder output; change in political motivation.

2.2 Define the housetypes where the use of concrete is most appropriate – look for multiple benefits where the many credentials of concrete combine to strengthen the case for its use – eg: apartment style housing where soundproofing combines with compartmentation requirements. (Case Study 6.2.5)

This is a process that will create a matrix of benefits and show where the most of these come together to define one market. This goes beyond material benefits and encompasses all the variables listed

below, and defines the third phase of the DMT process where all relevant factors are considered and assessed alongside each other.

Variables: geographic proximity, ease of access, strength of competition – like CLT in London, height of build, comparative impact of land value over material costs, developer knowledge, client preference, planning requirements – timber first policies.

2.3 Consider co-housing as a model for developing a new housing alternative – look for markets where a new model can be developed that benefits from the use of concrete and allows concrete to be seen in a new light. (Case Study 6.4.5)

If the real barrier to providing more housing is the shortage of people who can afford to buy the housing that we can afford to build, there will need to be a radical rethink in what housing means. If, also, we accept our preference for ownership, or at least the government's preference for us to own, we will need to start providing smaller owned 'parts' within a greater shared 'whole' – the co-housing model. The smaller that part becomes, the greater the emphasis will become on its solidity, durability and longevity.

Variables: public attitudes towards ownership; financial realities; government support for alternative housing solutions – the perpetuation of a homeowning society; growth of the co-housing movement.

3 Change Product

Adapt products for specific markets and be more client led

3.1 Develop standardised components for OSM – think how the move to OSM can benefit concrete solutions. This is unlikely to be a panelised or volumetric product, but could be a range of mass produced standardised components that can be stockpiled and purchased from builder's merchant on demand. This would increase pre manufactured value and standardisation whilst maintaining flexibility and existing supply chains. (Case Study 6.3.4)

The concrete industry cannot afford to ignore the OSM movement, but needs to be realistic about its chances of competing against lightweight solutions. By understanding the real purpose and drivers behind OSM it is possible to develop a solution that better reflects its own position as an industry with a foot in both camps.

Variables: the demise of OSM during next recession; UK labour force – immigration laws; warranty industry drive for standardisation; government position on timber sustainability, resilience; demand for UK products

3.2 Develop Group Custom Build crosswall solution – Collaborate with GCB bodies to develop a concrete shell system for irregular brownfield sites with difficult ground conditions that involves a contained upfront involvement for the concrete industry that maximises the use of concrete; infrastructure, pile foundations, ringbeams, beam and block flooring, crosswall partitioning, staircases and flat roofs. (Case Study 6.3.3)

Taken to its logical conclusion, the 'most appropriate market' approach will focus in on some very specific markets where concrete offers a solution that no other alternative can match. Whilst this may not be a financially viable market in its own right, it provides the definition of the type of market that needs to be grown by promoting it to a wider audience.

Variables: government support for Group Custom Build; growth of GCB market; incentives for use of brownfield sites; housing shortage

3.3 Develop a packaged solution concrete house – develop a solution for a concrete house that has no visible concrete and no external envelope thermal mass so that it can be made to maximise any site layout and work under any planning conditions. Combine with other benefits and market under its performance and flexibility rather than under its concreteness. (Case Study 6.3.5)

To appeal to the greatest possible market, any restrictions or complications associated with a change to concrete need to be minimised. This is effectively the opposite approach to finding the most appropriate market through accumulated advantages and involves appealing to the largest possible market by ruling out all possible disadvantages, even if this means concealing all use of concrete.

Variables: acceptance of thermal mass as a measurable benefit; need for resilience; need for UK based material products; shortage of alternative materials, skills.

4 Change Policy

Lobby for change where existing policies are limiting your market

4.1 Fight Timber First policy – challenge the belief that timber is the most sustainable solution to construction by exposing the flaws in the timber industry's science. Concrete's calculation is straight forward, so it is the timber industry that needs to provide their proof – which they know they cannot. (Case Study 6.1.3)

This emerges as possibly the most important task that needs to be undertaken, as all other strategies are compromised by this belief, now embedded in government policy making. The outcome needs to be both some sound empirical evidence to lobby for change at a governmental level plus an easily conveyed message that can be used as a 'counter perception' to change the public's opinion of concrete as detrimental to the environment.

Variables: availability and price of timber in the UK; a catastrophic residential fire; a change to Part B of the Building Regulations

4.2 Lobby for change of SAP / definition of housing - Evidence the thermal mass argument for reducing carbon emissions and show how SAP is failing to capture this. Alternatively lobby for a change in the definition of housing to put apartment blocks and high rise under BREEAM's dynamic modelling camp. (Case Study 6.1.4)

Which of these strategies proves to be the most appropriate will depend on the success of the previous issue and exemplifies their interrelatedness. If neither can be achieved, pursuing resilience as a key promotional message becomes more important, as does the choice of markets to focus on.

Variables: success of other strategies; impact of climate change; move to more apartment style living; strength of counter-lobbying

4.3 EPDs based on Cradle to Gate – Make the case for how Cradle to Gate produces flawed figures for the comparative sustainability of timber and concrete which needs to be either compensated for or replaced by Cradle to Grave as the required methodology. (Case Study 6.4.3)

Winning the argument for why Cradle to Gate is a flawed process is relatively easy compared to the task of securing the implementation of Cradle to Grave, which would require the industry wide adoption of BIM to allow for the necessary data to be recorded accurately. The introduction of factors that reduce the imbalance might therefore be a more realistic goal.

Variables: Industry adoption of BIM; the role of architects in promoting this; government attitude towards concrete, resilience, the sustainability of timber

There are twelve strategies here to be considered, some of which are dependent on others being carried out beforehand. Others can be done independently, but all are interrelated to some extent and if viewed holistically, there are some patterns that emerge:

Strategies involving changes to government policy tend to be dependent on each other;

Any fact finding or data gathering exercises need to be carried out prior to any further decisions being taken, and will be required to provide empirical evidence for any lobbying;

Product changes can be developed independently but not necessarily marketed until the markets themselves have been identified.

Problems arise when some necessary stages in a strategy might take years to complete, but are needed to inform the next stage. There is no reason why alternative strategies should not be run simultaneously in these circumstances, with for instance ‘changing the market’ being adopted in the short term, whilst policy changes are sought so that the existing market can be influenced more readily at a later date.

7.6.2 Map of strategies

The following model (Figure 7-1) shows which strategies could be started immediately and which others would feed in at a later date or potentially take over from them if successful. These policies begin with an evidence gathering exercise reflecting the four papers referred to earlier. All other strategies stem from these except for the ‘development of standardised components’ which could be carried out independently prior to the necessary legislation and markets being in place. Bold arrows

represent pathways from ‘essential prerequisites’ as opposed to the less critical causal links between strategies.

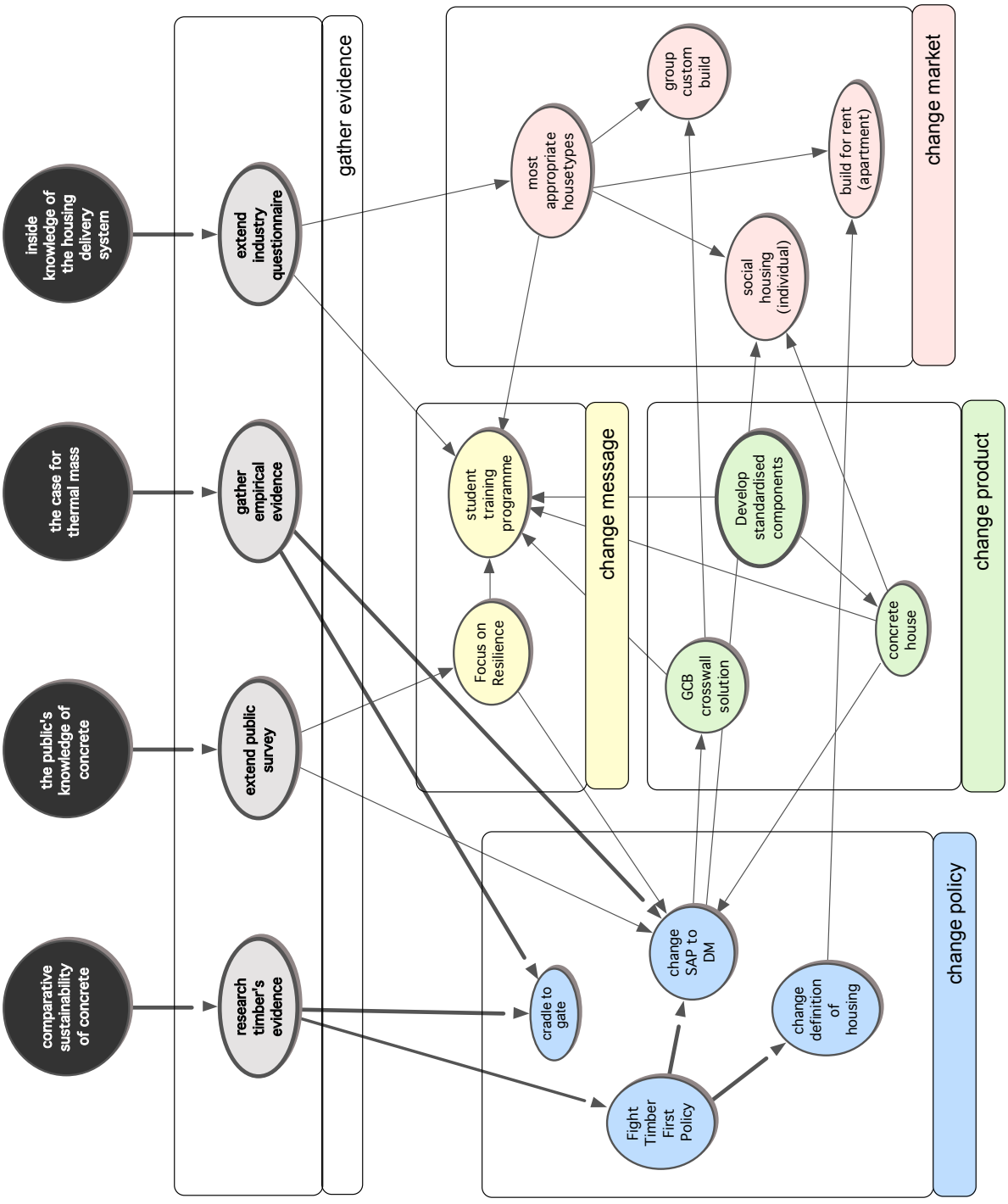


Figure 7-1 Map of proposed strategies to be pursued.

7.7 Additional Activities and Ongoing Research

In addition to the further research areas and strategies outlined for the concrete industry to pursue, the author has also listed areas of related research that are being followed up independently.

7.7.1 Publications

Siebert, M (2019). The need for a Systems Thinking approach in the Housing Industry. Conference Proceedings, 20th UKSS International Conference

Siebert, M. et al. , (2018). Identifying the Barriers to Change in the UK Housebuilding Industry . Future Cities and Environment . 4 (1) , p . 13 . DOI: http://doi.org/10.5334/fce.43

Paper delivered at SET 2017 **The 16th International Conference on Sustainable Energy Technologies** Bologna, Italy on the 17th –20th July 2017

7.7.2 Papers in progress

Reinstating the public's role in our housing delivery system

This paper looks at the results from a pilot online survey carried out to understand more about the public's knowledge and perceptions regarding the use of concrete in housing. The results highlight how much is not known about the reasons that lie behind the decisions being taken on behalf of the public, the suggestion being that until we find a way to involve the public - the client - in our housing delivery system, the quality and affordability of our housing will not improve.

There are many sectors within the housing industry and they all have a role to play in developing an end product that benefits society as a whole. One of the consequences of a chronic undersupply of housing in the UK for the past 40 years is the public's increasing insignificance in that decision making process, leading to a suboptimal uniformity in the housing market dictated by the volume house builders' business model. Rebalancing our housing delivery system involves us bringing the public end user back into the equation – something that has already begun as the public begin to find the power of their collective voice on social media.

The reliance on perceptions about the public's perception of housing need to be replaced with evidenced information that triangulates demographic and sociographic profiling with their knowledge and perceptions and their needs and desires. With that level of knowledge the industry will be able to focus innovations in housing at the most receptive markets and in the right language to ensure the benefits are fully appreciated. Without it, we are in danger of never breaking away of the increasingly dysfunctional status quo that has come to define how we live.

The presumed superiority of timber's environmental credentials

This paper follows the research undertaken to compare the carbon footprint of a typical family house constructed as timber frame with that of an all concrete house. The key finding is how difficult it is to calculate this for a timber house due to the nature of sequestration, the huge variances between different species grown under different climatic and soil conditions and harvested at different maturities. In addition to these variables, changes in tax incentives, consequential restocking rates and the policing of responsible sourcing certification in the UK, let alone elsewhere, leads to a very confused picture regarding how the figures used to influence government legislation have been arrived at.

There is a danger of industry level research becoming little more than a subliminal justification of our initial perceived points of view due to the limited time available and the need to quickly explain our decisions to others. An example of this would be the growing acceptance throughout the construction industry of the environmental superiority of timber over any other building material. At a very superficial level most people would assume this to be true, because trees are good for the environment and trees are a replenishable resource, but whilst both these claims are patently true, the reality is that timber's carbon footprint is almost impossible to calculate due to the sheer complexity of the factors involved. The growing presumption that timber is the material of choice has now reached governmental levels without any meaningful attempt being made to evidence this claim. The concrete industry, first in line to suffer from the adoption of 'timber first' policies needs to challenge the calculations being used and show how the relatively simple case for concrete's carbon footprint can be used to at least put the two materials on an equal footing if not surpass timber over the full lifecycle of a typical building.

The challenges of using Thermal Mass as a promotional tool for concrete

This paper follows the research undertaken to discover what steps would be necessary to overcome all the barriers that stand in the way of this approach to building being accepted as a mainstream solution. By studying these barriers from the perspectives of all those involved in that decision making process, the research reaches an unexpected conclusion for how these benefits could be realised without having to confront many of the more immovable political barriers that can be shown to be preventing passive solar design from playing its important role in reducing carbon emissions.

The use of thermal mass as part of a passive solar gain approach to controlling the thermal environment of our housing has been a long standing if never a mainstream solution in the UK. The arguments in favour of thermal mass are well known – or are they? The concrete industry makes much of this benefit in its promotional campaign without fully appreciating the barriers that might need to be overcome – including a lack of understanding - before it can be accepted by those who hold the key to that mainstream market. One of those barriers is a regulatory system that does not recognise these apparent benefits, and ahead of that the government's failure to recognise the dangers of overheating that would in tun lead to those regulations being adapted in concrete's favour. Bringing about those changes requires the concrete industry to lobby government, and that requires empirical evidence for the benefits thermal mass can deliver, something that after all these years is still in short

supply. That evidence is there to be collected but any campaign wanting to bring about change at this level will need to evoke a more comprehensive argument that goes beyond the physical proof and also provides evidence of a market willing and able to adopt the changes being sought.

How to defragment our housing industry

This paper looks at the level of knowledge held within each sector of the housing industry about each other sector's methodologies and motivations for behaving the way they do. Through a series of industry interviews and questionnaires a picture begins to emerge of an industry that has collectively reached similar conclusions about its internal operations without any real evidence to back up its claims. Where these conclusions can be shown to be wrong, an opportunity arises for moving the conversation forwards by improving levels of understanding and opening up areas of undiscovered mutual benefit.

The UK housing industry is both fragmented and adversarial, and seemingly incapable of bringing about the changes that are now widely recognised as essential for its very survival. Even government has effectively 'washed its hands' of the industry, seeing our housing crisis as a problem beyond its capabilities to influence, certainly within a five year term that might bring political dividends. The resulting impasse has seen successive governments - and eight housing ministers within as many years - partially adopting high profile solutions that play to the electorate as concerted attempts to intervene, whilst failing to deal with the underlying issues that perpetuate the status quo. If the industry is to dig itself out of this state of inertia it must first understand its own internal machinations – how it operates or needs to operate to allow innovative solutions a chance to move the industry forwards. This begins with gaining a better knowledge of those fragmented sectors and what motivates them to behave the way they do. Only then can a meaningful dialogue begin that matches new solutions with existing needs and delivers a more productive, less adversarial industry.

'Professions and Proficiency: The Rise and Demise of Knowledge'

I have been invited to work on a paper for this symposium to be held at Heidelberg University, Germany in June 2019. This stems from the case study looking at the role of the architect as 'master co-ordinator' as a necessary step in the process of defragmenting the housing industry. (now submitted)

More collaboration is the overriding message to be taken from the government's latest drive to improve productivity within the housing industry. This follows calls from numerous white papers for the adversarial nature of procurement practices to be reassessed. When asked, 80% of the construction industry agreed that "*architects should be responsible for BIM co-ordination on construction projects"*. Whether this is a vote of confidence or more a passing of the BIM buck, this would seem to suggest that the now widely recognised need for collaboration might result in the architect becoming reinstated, not so much as Master Builder, but as Master BIM co-ordinator.

Planning Reform and Housing Needs

I have been invited to submit an article by the editor of the LGC (Local Government Chronicle) based on a paper sent to Nottingham City Council discussing the issue of land value being the fundamental barrier to housing innovation. (now submitted)

Much like our tax system, planning law has evolved to cope with the many attempts made to circumvent it, both at a personal and a political level. Wholesale reform of the planning system is a popular refrain, but with no clear consensus for what this should aim to deliver beyond a simplification of the process, this is an unachievable goal. Wholesale reform requires consensus. But why that reform would not in any case provide the answers being sought to our housing crisis, even given that consensus, takes the debate to another level of understanding that sits beneath how we decide to allocate our land for development – and that is how we choose to value it.

7.7.3 Boards

During the course of this research, the author has volunteered or has been invited to sit on a number of boards:

Construction Leadership Council (CLC) : Metrics and Demonstrator Site Workgroup.

Over a three period, the author has been part of a group of industry professionals meeting to develop a range of metrics to measure the benefits of Smart Construction techniques, and test these on a number of Demonstrator Sites, chosen for their use of modern methods of construction. Those sites will form the basis of a promotional campaign showcasing live projects around the country (Figure 7-2, Figure 7-3).

Delivering MMC Collaboratively

A committee of East Midlands Housing Associations and city councils combining their resources to both research and commission MMC solutions. The author was invited to join this group and also present at their meeting to advise on how to proceed and what factors they needed to be considering.

Nottingham Co-Housing Group

As a member of this group the author advised on how to approach the three key requirements of finding a housing provider, enough participants and the appropriate funding, all within the timeframe necessary to allow them to bid successfully for sites.

Pint of Science

Signing up to help deliver presentations for Pint of Science in Nottingham 2019 has resulted in the author delivering a talk on this research, based on ‘how we live’ and the importance of the public being involved in the decision making process if any change is to take place.

SMART CONSTRUCTION

Measuring the benefits

The aim of this project is to embed innovative construction techniques within the housing industry to improve productivity and capacity, as well as the quality and whole-life performance of our homes. Achieving this requires there to be market confidence in the technologies being promoted, which means going beyond a list of benefits and focusing on the quantifiable gains that can be realized by their adoption.

That comparative information needs to be gathered from across the industry to generate an evidence base that can be trusted by those needing to know the time is right to change their working practices. That task begins here with your agreement to participate, by providing the data we need to ease that process. Not all the information asked for will be relevant to your way of working, but these are the 'metrics' that will be used to calculate the benefits of Smart Construction over our traditional methods. Neither will all the metrics be asked for in a format you will be used to, but we need to work towards some standard definitions that the industry can come to rely upon.

The following table sets out the 13 metrics chosen for this task, together with a brief definition of their purpose. We would rather collect information in different formats than not at all, so the table below is set out with a description field, a numerical score field and a further comments field to allow for any alternative calculations or unconsidered circumstances to be included. Further definitions and sources used can be found by clicking on any underlined term.

This has been, and will continue to be a collaborative effort for the benefit of the industry as a whole, but also for all of those who have already converted and need to ensure that these new technologies continue to be adopted and gain widespread acceptance. We therefore thank you in anticipation for your involvement and hope you find this as enlightening as those who will learn from your example.

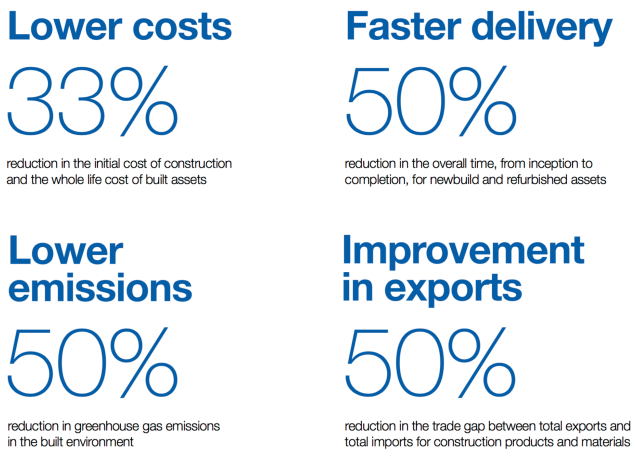


Figure 7-2 CLC synopsis written for website

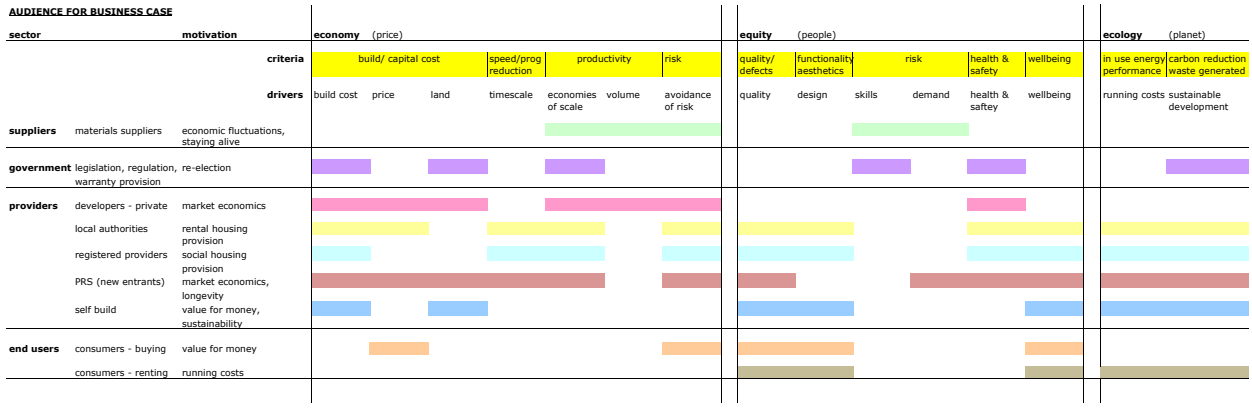


Figure 7-3 Industry divisions adopted by CLC workstream

7.7.4 Workshops

Based on the Decision Making Tool developed as part of the research, the author has run a number of workshops to help businesses understand the complexity of the problems they are dealing with and how that needs to be approached to optimise the time available for strategizing.

Tarmac PLC

The first of these was carried out in house with Tarmac, using the evidence gathered as part of the research to compare existing strategies with those suggested by following the DMT process.

Blueprint

Another trial workshop was then carried out with Blueprint, a development company committed to pushing the boundaries of MMC and sustainable solutions at a commercial level.

Nottingham City Homes

One further trial has now been proposed with Nottingham City Homes, a large Housing Association orchestrating the 'Delivering MMC Collaboratively' committee meetings.

Ilke Homes

Working closely with Ilke Homes has provided an insight into how drawn out a promotional campaign for a MMC can be, and also gave the author an early opportunity to influence the process they were adopting based on the broader perspectives central to this research through a paid workshop.

REFERENCES

Acosta-Michlik, L. *et al.* (2011) 'Integrated assessment of sustainability trade-offs and pathways for global bioenergy production: Framing a novel hybrid approach', *Renewable and Sustainable Energy Reviews*. Elsevier Ltd, 15(6), pp. 2791–2809. doi: 10.1016/j.rser.2011.02.011.

Archer, T. and Cole, I. (2014) 'Over-reliance on private housebuilders is fuelling UK's housing crisis', *The Guardian*, (September 12, 2014).

Architectural Review (1943) 'Swedish peace in war', *Architectural Review*, (September).

Atkins, G. *et al.* (2017) *What's wrong with infrastructure decision making? Conclusions from six UK case studies*. Available at: https://www.instituteforgovernment.org.uk/sites/default/files/publications/Infrastructure report %28final%29r.pdf.

Aubrey, T. (2015) *The challenge of accelerating UK housebuilding A predistribution approach*.

Ball, M., Cowley, J. and Slaughter, J. (2005) *THE LABOUR NEEDS OF EXTRA HOUSING OUTPUT : CAN THE HOUSEBUILDING INDUSTRY COPE*.

Ball, M. and Dosanjh, L. (2012) 'Prospects for the UK house building industry'. Available at: http://www.nhbcfoundation.org/Researchpublications/ProspectsfortheUKhousebuildingindustryNF39/tabid/495/Default.aspx.

Barker, K. (2004) *Review of Housing Supply*, *HMSO Her Majesty´s Stationery Office*. doi: 10.1037/015276.

Barker, N. (2018) 'Borrowing cap to be removed at end of the month', *Inside Housing*, (18/10/18).

Barlow, J. *et al.* (2003) 'Choice and delivery in housebuilding: Lessons from Japan for UK housebuilders', *Building Research and Information*, 31(2), pp. 134–145. doi: 10.1080/09613210302003.

Barquin, L. *et al.* (2014) 'The knowledge and skills needed to engage in REDD+: A competencies framework', pp. 1–171.

barratt Homes (2019) *Barratt Homes*. Available at: https://www.barratthomes.co.uk (Accessed: 22 February 2019).

BD and Morrell, P. (2014) 'White papers 01 BIM', *Building Design*. Available at: http://www.bdonline.co.uk/journals/2014/06/06/b/c/k/BD_WhitePaper_BIM.pdf.

Bennett, A. (2014) 'Britain's Housing Crisis Explained', *The Huffington Post*.

Bentley, D. (2017) *The Land Question*.

Biais, B., Rochet, J. C. and Woolley, P. (2015) 'Dynamics of innovation and risk', *Review of Financial*

Studies, 28(5), pp. 1353–1380. doi: 10.1093/rfs/hhv003.

Braidwood, E. (2016) 'Comply or cough up : Unpicking London ' s radical zero carbon rules'.

Brannen, J. and Brannen, J. (2005) 'Mixing Methods : The Entry of Qualitative and Quantitative Approaches into the Research Process Mixing Methods : The Entry of Qualitative and Quantitative Approaches into the Research Process', *International Journal of Social Research Methodology*, 8(July 2005), pp. 173–184. doi: 10.1080/13645570500154642.

Bridger, J. (2010) 'Don't Call it a Commune', *Metropolis*, pp. 1–7.

Bridges, T. S. (2009) 'making', 1(2).

Broadhead, P. (2016) *Interview 02.07.1 BSA*.

Brown, M. (2012) 'Why the construction sector should engage with social media', *Guardian Professional Network*.

Brown, S. *et al.* (2013) *Motivating Collective Custom Build*. Available at: http://www.collectivecustombuild.org/site/media/PDF_Downloads/Motivating_Collective_Custom_Build_(2013)_-_Full_Report.pdf.

BSA (2012) *Laying the Foundations for MMC*. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=aph&AN=78367140&lang=zh-tw&site=ehost-live.

Buday, B. R. (2017) 'The Confused and Impoverished State of Architectural Research', pp. 1–9. Available at: http://commonedge.org/the-confused-and-impoverished-state-of-architectural-research/.

Van Bueren, E. and De Jong, J. (2007) *Establishing sustainability: policy successes and failures*, *Building Research & Information*. doi: 10.1080/09613210701203874.

Burridge, J. (2016) *The Concrete Centre 02.03*.

Butterworth, M. (2017) *Top 20 features that will sell your home : The ' must-have ' property factors that buyers look for*, *MailOnLine*. Available at: https://www.dailymail.co.uk/home/index.html (Accessed: 22 March 2016).

Cabinet Office (2018) *The What Works Network - Five Years On*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/677478/6.4154_What_works_report_Final.pdf.

Callcutt, J. (2007) 'The Callcutt Review of housebuilding delivery', *Queen's Printer and Controller of Her Majesty's Stationery Office*, pp. 1–236.

Challenges, A. C. and Innovation, S. (2013) *The Reos Change Lab*.

Chan, S. P. (2017) *The economic lessons Japan can teach the West - BBC News*, *BBC*. Available at:

http://www.bbc.co.uk/news/business-42154516.

Chapman, J. (2004) 'System failure: Why governments must learn to think differently', *Demos*, p. 103. doi: 10.1016/j.technovation.2003.11.002.

Chartered Institute of Building (2012) 'Hackney clarifies: wood first equal', *Construction Manager*.

Chevin, D. (2017) 'We need to start linking tech to the bottom line', *CIOB, BIM+*, (February).

CIOB (2006) 'Corruption in the UK Construction Industry'. Available at: http://www.giaccentre.org/documents/CIOB.CORRUPTIONSURVEY.2006.pdf.

Clayman, S. E. (2017) 'The Micropolitics of Legitimacy: Political Positioning and Journalistic Scrutiny at the Boundary of the Mainstream', *Social Psychology Quarterly*, 80(1), pp. 41–64. doi: 10.1177/0190272516667705.

Collinson, P. (2018) 'Is custom build the future of housing?', *The Guardian*.

Colombo, J. (2012) 'Japan's Bubble Economy of the 1980s', *The Bubble Bubble*. Available at: http://www.thebubblebubble.com/japan-bubble/.

Communities and Local Government Committee (2016) *Capacity in the homebuilding industry*.

Confederation of Timber Industries (2015) 'SCOTTISH FIRM INVESTS £ 4M IN CLT FOLLOWING NAPIER UNIVERSITY WORK', p. 7291.

Construction Leadership Council (2017) *INNOVATION IN BUILDINGS WORKSTREAM DEMAND CREATION , INVESTMENT AND VOLUME SURETY*.

Council of Mortgage Lenders (2018) *Non-traditional construction*. Available at: https://www.cml.org.uk/consumers/issues-affecting-lending-decisions/properties-of-non-traditional-construction/ (Accessed: 10 October 2018).

Countrywide PLC (2014) *Latest housing survey reveals that over half of homeowners think the value of their home will increase in 12 months*, *Countrywide Integrated Solutions*.

Crosby, J. (2014) 'four ways next government solve housing crisis', *The Guardian*. Available at: http://www.theguardian.com/housing-network/2014/may/15/four-ways-next-government-solve-housing-crisis.

Crow, J. M. (2008) 'The concrete conundrum', *Chemistry World*, (March), pp. 62–66.

Cutland, N. (2012) *Lessons from Germany ' s Passivhaus experience*. Available at: www.nhbcfoundation.org.

Davidson, M. (2015) 'So the ' Waitrose effect ' adds 12 % to your home's value - but what else will ? Ten top factors that boost a property's price ...', *This is Money*.

Davies, A. (2018) *Modern Methods of Construction*, *RICS International Standards Team*. doi:

10.1108/02630800910941674.

DCLG (Department for Communities and Local Government) (2017) *Fixing our broken housing market*.

Department for Communities and Local Government (DCLG) (2015) *Right to Build : Supporting Custom and Self Build Government response to consultation*.

Dorling, D. (2014) *All That Is Solid: How the Great Housing Disaster Defines Our Times, and What We Can Do About It*.

Earnhart, D. (2002) 'Combining Revealed and Stated Data to Examine Housing Decisions Using Discrete Choice Analysis', *Journal of Urban Economics*, 51(1), pp. 143–169. doi: 10.1006/juec.2001.2241.

Egan, J. (1998) 'Rethinking Construction. The Report of the Construction Task Force', *Construction*, p. 38. doi: Construction Task Force. Uk Government.

Energy for London (2016) *Major London housing development to be zero carbon from October 2016*.

Evans, J. (2015) 'George Osborne has shown he is willing to put his neck on the line for policies he thinks will help to make the economy more productive', *Financial Times*.

Evans, J. (2017) 'Bovis Homes buyers hit out at quality of new houses.', *Financial Times*.

Farmer, M. (2016) *The Farmer Review of the UK Construction Labour Model*. Available at: http://www.constructionleadershipcouncil.co.uk/news/farmerreport/.

Farmer review recommends prefab push and CITB overhaul Those Farmer Recommendations In Full (2016) *This article was published on 17 Oct 2016 (last updated on 30 Nov 2016).*

Florida, R. (2014) 'What Makes Us the Happiest About the Places We Live', *CityLab*, (September).

Forestry Commission (2016) 'Woodland Area, Planting and Restocking - Statistics - Woodland', *Forestry.Gov.Uk*, (June), pp. 1–21. Available at: http://www.forestry.gov.uk/forestry/infd-7aqknx.

Gash, T., Magee, I., Rutter, J., & Smith, N. (2010) 'Read before burning', p. 74. Available at: www.instituteforgovernment.org.uk.

Giloni, A., Seshadri, S. and Tucci, C. L. (2008) 'Neo-Rawlsian fringes: A new approach to market segmentation and new product development', *JOURNAL OF PRODUCT INNOVATION MANAGEMENT*, 25(5), pp. 491–507. doi: 10.1111/j.1540-5885.2008.00316.x.

Gladwell, M. (2000) *THE TIPPING POINT*.

Glendinning, M. and Muthesius, S. (1993) *Tower Block*.

Glover, T. (2015) 'Code for Sustainable Homes scrapped', *Building*, (march).

gocompare.com (2016) *Revealed – the 20 things that will sell your home*. Available at:

https://mygocompare.gocompare.com (Accessed: 15 March 2016).

Goodier, C. and Pan, W. (2010) 'The Future of Offsite in Housebuilding', *Proceedings of the 3rd International World of Construction Project Management Conference, Coventry University*, pp. 310–319.

Gorringe, M. (2011) 'Industry insight - Property', *Agcas*, pp. 1–12. doi: 10.1109/ICEPES.2016.7915923.

Greenspec (2014) *Thermal Mass*, *Green Building Design*. Available at: http://www.concretecentre.com/technical%7B_%7Dinformation/performance%7B_%7Dand%7B_%7Dbenefits/thermal%7B_%7Dmass.aspx.

Greenspec (2018) *Decrement delay & Thermal Buffering*. Available at: http://www.greenspec.co.uk/building-design/decrement-delay/ (Accessed: 22 February 2019).

Griffith, E. (2014) 'Why startups fail, according to their founders', *Fortune.com*, p. 1. Available at: http://fortune.com/2014/09/25/why-startups-fail-according-to-their-founders/.

Grindrod, J. (2011) *Concretopia A Journey Around the Rebuilding of Postwar Britain'*.

Halman, J. I. M., Voordijk, J. T. and Reymen, I. M. M. J. (2008) 'Modular Approaches in Dutch House Building: An Exploratory Survey', *Housing Studies*, 23(5), pp. 781–799. doi: 10.1080/02673030802293208.

Hammond, G. P. and Jones, C. I. (2008) 'Embodied energy and carbon in construction materials', *Proceedings of the Institution of Civil Engineers - Energy*, 161(2), pp. 87–98. doi: 10.1680/ener.2008.161.2.87.

Hankinson, A. (2005) 'Three find glory in first of £ 60k house build awards', *Costruction News*, (November), p. 2005.

Hansmann, R., Mieg, H. A. and Frischknecht, P. (2012) 'Principal sustainability components: empirical analysis of synergies between the three pillars of sustainability', *International Journal of Sustainable Development & World Ecology*. Taylor & Francis, 19(5), pp. 451–459. doi: 10.1080/13504509.2012.696220.

Harding, R. (2016) 'Why Tokyo is the land of rising home construction but not prices', *The Financial Times*.

Harper, A. (2016) *Briefing Paper : Energy and Sustainability Standards in Planning in England*.

Hashi and Linda Lombardi (2013) 'Japanese Architecture: What Makes It Different?', *Tofugu*. Available at: https://www.tofugu.com/japan/japanese-architecture/.

Henderson, J. (2017) *Thermal Mass Discussion*, *BRE*.

Hertfordshire, U. of (2013) *Living sustainably - which way should we go?*

Hicks, M. (2016) ‘Tarmac Employee 01.07’, pp. 1–11.

HM Government (2013) ‘Construction 2025. Industrial Strategy: Government and industry in partnership’, *UK Government*, (July), p. 78. doi: HM Government.

HM Government (2015) *Register of All-Party Parliamentary Groups*.

HM Government (2017) *Industrial strategy. Construction Sector Deal*, *IEE Review*. doi: 10.1049/ir:19930092.

Holmans, A. E. (2014) *Housing need and effective demand in England A look at ‘the big picture’*. Available at: https://www.cchpr.landecon.cam.ac.uk/Projects/Start-Year/2014/Other-Publications/Housing-need-and-effective-demand-in-England/Report.

Holmes, G. *et al.* (2019) *UK housing : Fit for the future ?*

Horsky, D., Nelson, P. and Posavac, S. S. (2004) ‘Stating preference for the ethereal but choosing the concrete: How the tangibility of attributes affects attribute weighting in value elicitation and choice’, *JOURNAL OF CONSUMER PSYCHOLOGY*, 14(1–2), pp. 132–140. doi: 10.1207/s15327663jcp1401&2_15.

House_Builders_Federation (2013) *Homeowner satisfaction with new homes is at an all time high …*, *NHBC*.

House Builders Federation (no date) *customer satisfaction survey @ www.hbf.co.uk*. Available at: http://www.hbf.co.uk/policy-activities/customer-satisfaction-survey/.

House of Lords (2018) ‘Off-site manufacture for construction : Building for change Oral and Written evidence Contents’.

IISD (2019) *Emission Omissions: Carbon accounting gaps in the built environment*.

Information Policy Team (2014) *English Housing Survey - GOV.UK*. Available at: https://www.gov.uk/government/collections/english-housing-survey.

Institute for Government (2012) ‘Good Policy, Bad Politics’, in *Making Policy Better*.

Ipsos Mori (2013) *Housing standards and satisfaction : what the public wants*.

Jefferys, P. and Lloyd, T. (2017) *New Civic Housebuilding: Policy Briefing*, *shelter*. Available at: https://civichousebuilding.org/wp-content/uploads/2017/03/NCH_Policy_Report.pdf.

Keizer, J. A. and Halman, J. I. M. (2007) ‘Diagnosing risk in radical innovation projects’, *RESEARCH-TECHNOLOGY MANAGEMENT*, 50(5), pp. 30–36.

Kim, D. H. (2000) *Systems Thinking Tools: A User’s Guide*.

Kunze, J. (2005) *The revival of high-rise living in the UK and issues of cost and revenue in relation to height*, *The revival of high-rise living in the UK and issues of cost and revenue in relation to height*.

LABC (2018) *WHERE DO LAND DEVELOPERS GET THE BEST RETURN ON INVESTMENT IN ENGLAND ?*

Latham, M. (1994) 'Constucting the team: joint review of procurement and contractual arrangements in the United Kingdom construction industry', *Hmso*, 53(9), pp. 1689–1699. doi: 10.1017/CBO9781107415324.004.

Lazonick, W. and Mazzucato, M. (2013a) 'The risk-reward nexus in the innovation-inequality relationship: who takes the risks? Who gets the rewards?', *INDUSTRIAL AND CORPORATE CHANGE*, 22(4, SI), pp. 1093–1128. doi: 10.1093/icc/dtt019.

Lazonick, W. and Mazzucato, M. (2013b) 'The risk-reward nexus in the innovation-inequality relationship: Who takes the risks? Who gets the rewards?', *Industrial and Corporate Change*, 22(4), pp. 1093–1128. doi: 10.1093/icc/dtt019.

Lee, S. H. and Lee, E. (2016) 'Understanding Residential Needs of Single or 2-Resident Households with a Focus on Communal Amenities of Multi-Family Housing Complexes', (May), pp. 263–270.

Light, S. (2011) *One Hyde Park – review*. Available at: https://www.rsh-p.com/projects/one-hyde-park/ (Accessed: 17 March 2019).

Linowes, J. S. (1991) 'A Summary of "Crossing the Chasm"', *Selling*, pp. 1–11.

Lloyd, T. (2015) *Britain's broken land market*.

Local Homes (2018) *LoCal Homes*. Available at: http://www.localhomes.co.uk (Accessed: 22 February 2019).

London Assembly Planning Committee (2017) *Designed, sealed, delivered*.

Lucas, L. (2014) 'Japan blighted by zombie housing', *The Financial Times*.

Lutzenhiser, L. (1994) 'Innovation and organizational networks Barriers to energy efficiency in the US housing industry', *Energy Policy*, 22(10), pp. 867–876. doi: 10.1016/0301-4215(94)90146-5.

Lyons, M. (2014) *Mobilising across the nation to build the homes our children need*.

Mak, S. *et al.* (2008) 'Sustainable Housing using lightweight cellular concrete.', pp. 314–321.

Mann, B. W. (2017) 'Precast prepared for offsite's second coming', *Construction News*, pp. 19–21.

Mann, W. (2017) 'Has offsite's time finally arrived?', *CIOB*, (October).

Maréchal, K. and Hecq, W. (2006) 'Temporary credits: A solution to the potential non-permanence of carbon sequestration in forests?', *Ecological Economics*, 58(4), pp. 699–716. doi: 10.1016/j.ecolecon.2005.08.017.

Mathews, L. D. (2016) *HACKNEY TIMBER BUILDS*.

Matthews, C. (2015) *Homes and Places. A History of Nottingham's Council Houses*.

McAllister, I. and Yates, A. (2013) *The use of modular building techniques for social housing in the UK*.

Miles, J. and Whitehouse, N. (2013) 'Offsite Housing Review', *Department of Business, Innovation & Skills and the …*, (February), pp. 1–43. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Offsite+Housing+Review#0.

Minister of the Brussels-Capital Region for the Environment Energy Urban Renewal and Welfare. (2016) *Brussels. From eco-building to sustainable city*.

Minson, A. (2016) *The Concrete Centre 02.01*.

Monk, S. *et al.* (2013) 'International Review of Land Supply and Planning Systems', (March 2013), pp. 1–4.

Morby, A. (2015) 'O' Rourke off-site housing factory gets £22m grant', *Construction Enquirer*.

Morgan, M. and Cruickshank, H. (2014) 'Quantifying the extent of space shortages: English dwellings', *Building Research and Information*. Taylor & Francis, 42(6), pp. 710–724. doi: 10.1080/09613218.2014.922271.

Morison, J. *et al.* (2012) *Understanding the carbon and greenhouse gas balance of forests in Britain.*, *Forestry Commission Research Report.*

Morrell, P. (2010) *Low Carbon Construction, Final Report*.

Morris, N. (2017) 'Practice based research , no longer the poor relation to academia', *RIBA*.

Neelamegham, R. (1999) 'A Bayesian Model to Forecast New Product Performance in Domestic and International Markets', 18(2), pp. 115–136.

NHBC_Foundation (2016) *Modern Methods of Construction: views from the industry*. Available at: http://www.nhbcfoundation.org/Publications/Primary-Research/Modern-methods-of-construction-NF70.

NHBC (2018) *NHBC NEW HOME STATISTICS REVIEW Q3 2018*, *NHBC*.

Nidumolu, R., Prahalad, C. K. and Rangaswami, M. R. (2009) 'Why sustainability is now the key of innovation', *Harvard Business Review*, 87(9), pp. 57–64. Available at: https://hbr.org/2009/09/why-sustainability-is-now-the-key-driver-of-innovation.

Nottingham City Homes (2012) *Creating homes and places where people want to live. Corporate Plan 2015-18*.

Oldfield, P. (2015) 'UK scraps zero carbon homes target', *The Guardian*, (July 2015), pp. 2015–2016. Available at: http://www.theguardian.com/environment/2015/jul/10/uk-scraps-zero-carbon-home-target.

ONS (2014) 'Chapter 2 : Housing Expenditure', *Family Spending 2013*, (December), pp. 9–19.

Pan, W., Gibb, A. and Dainty, A. (2005) 'Offsite Modern Methods of Construction in Housebuilding Perspectives and Practices of Leading UK Housebuilders', *Strategies*.

Payne, S. and Homes, M. (2012) 'can the volume housebuilding model survive ?', 3(December), pp. 548–551.

Pushkareva, E. (2011) *United Nations Environment Programme (UNEP)*, *Max Planck Encyclopedia of Public International Law*.

Rahman, M. M. (2014) 'Barriers of Implementing Modern Methods of Construction', *JOURNAL OF MANAGEMENT IN ENGINEERING*, 30(1), pp. 69–77. doi: 10.1061/(ASCE)ME.1943-5479.0000173.

Ray O'Rourke et.al (2013) 'The future of DfMA is the future of construction', *Engineering Excellence Journal*, 2013 Editi. Available at: www.laingorourke.com.

Redfern Review (2016) 'The Redfern Review into the decline of home ownership'. Available at: http://www.redfernreview.org/.

RIBA (2013) *Government consultation on housing standards for England*.

Rittel, H. W. J. and Webber, M. M. (1973) *Dilemmas in a General Theory of Planning*, *Policy Sci*. doi: 10.1007/BF01405730.

Roberts, G. (2016) *2016 THE YEAR OF THE ZERO CARBON HOME ?*, *BRE BUZZ*. Available at: http://brebuzz.net (Accessed: 15 December 2016).

Robin Hatin (2016) 'Why Tokyo is the land of rising home construction but not prices', *Financial Times*. Available at: http://www.ftchinese.com/story/001069468/ce.

Roper, S. and Tapinos, E. (2016a) 'Taking risks in the face of uncertainty: An exploratory analysis of green innovation', *Technological Forecasting and Social Change*. The Authors, 112, pp. 357–363. doi: 10.1016/j.techfore.2016.07.037.

Roper, S. and Tapinos, E. (2016b) 'Taking risks in the face of uncertainty: An exploratory analysis of green innovation', *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE*, 112, pp. 357–363. doi: 10.1016/j.techfore.2016.07.037.

Ross, K. (2002a) *Non-traditional housing in the UK – A brief review*, *Building Research Establishment*. Available at: http://www.cml.org.uk/documents/non-traditional-housing-in-the-uk-a-brief-overview-report/pdf_pub_misc_NontradhousingBR.pdf.pdf.

Ross, K. (2002b) *Non-traditional housing in the UK – A brief review*, *Building Research Establishment*. Available at: http://www.cml.org.uk/documents/non-traditional-housing-in-the-uk-a-brief-overview-report/pdf_pub_misc_NontradhousingBR.pdf.pdf.

Ryan, L. (2015) 'What now for Localism ?', *Open Democracy UK*, (May).

Saaty, T. L. (1990) 'How to make a decision: The analytic hierarchy process', *European Journal of Operational Research*, 48(1), pp. 9–26. doi: 10.1016/0377-2217(90)90057-I.

Salmon, F. (2016) ‘Concrete jungle : why brutalist architecture is back in style’, *The Guardian*.

Samuels, I. (2005) ‘What home buyers want: Attitudes and decision making among consumers’, *London, CABE*. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:What+home+buyers+want+:+Attitudes+and+decision+making+among+consumers#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:What+home+buyers+want:+Attitudes+and+decision+making+amo.

Saviotti, P. P. and Metcalfe, J. S. (1984) ‘A theoretical approach to the construction of technological output indicators’, *Research Policy*, 13(3), pp. 141–151. doi: 10.1016/0048-7333(84)90022-2.

Schoenwitz, M. *et al.* (2017) ‘Product, process and customer preference alignment in prefabricated house building’, *International Journal of Production Economics*. Elsevier, 183(October 2016), pp. 79–90. doi: 10.1016/j.ijpe.2016.10.015.

Scimago (2018a) *SCImago Journal & Country Rank*, *SCImago*. Available at: http://www.scimagojr.com/journalsearch.php?q=12560&tip=sid&clean=0%29# (Accessed: 22 February 2019).

Scimago (2018b) *Subject Bubble Chart*. Available at: https://www.scimagojr.com/mapgen.php?maptype=bc&country=GB&z=item (Accessed: 22 February 2019).

Scimago (2018c) *WHAT IS SCIMAGOJR FOR?* Available at: https://www.scimagojr.com/index.php (Accessed: 26 October 2018).

Select Committee on Economic Affairs (2016) *Building more homes - Inquiry into the economics of the UK housing market*. Available at: http://www.publications.parliament.uk/pa/ld201617/ldselect/ldeconaf/20/20.pdf.

Seth, S. (2017) *The Most Important Factors For Investing In Real Estate*, *Investopedia*. Available at: http://www.investopedia.com/articles/investing/110614/most-important-factors-investing-real-estate.asp (Accessed: 30 January 2017).

Siebert, M. and Robinson, A. (2018) ‘FoI, Mayor of London’, (February), pp. 1–2.

Smulian, M. (2016) ‘Builders hit back at Javid landbank threat’, *Inside Housing*, (December).

Spicker, P. (1987) ‘Poverty and depressed estates: A critique of utopia on trial’, *Housing Studies*, 2(4), pp. 283–292. doi: 10.1080/02673038708720608.

Stephens, G. (2017) ‘“ Stagflation ” is coming to the UK , and how to invest in it.’, *What Investment*, (May).

Stephens, P. (2014) ‘“The Too Difficult Box’””, *Financial Times*, (July 18th).

Stern, N. (2006) ‘STERN REVIEW: The Economics of Climate Change Executive Summary’, *October*, 30(3), p. 27. doi: 10.1378/chest.128.5.

Tatchell-Evans, M. (2016) 'Scottish Forestry', (November 2016).

Taylor, S. P. and Taylor, S. P. (2018) 'Critical Realism vs Social Constructionism & Social Constructivism: Application to a Social Housing Research Study', *International Journal of Sciences: Basic and Applied Research*, 37(2), pp. 216–222. Available at: http://gssrr.org/index.php?journal=JournalOfBasicAndApplied.

The_Concrete_Centre (2015) 'Specifying Sustainable Concrete', *MPA The Concrete Centre*.

The Concrete Centre (2016) *9th Concrete Industry Sustainability Performance Report. 2015 Performance data*. Available at: http://www.sustainableconcrete.org.uk/PDF/MB_7thPerformance Report_SCF_2013data.pdf.

The Edge (2015) *Collaboration for Change, The Edge Commission Report on the Future of Professionalism*, *Designing Buildings Wiki*.

The Resolution Foundation (2018) *A NEW GENERATIONAL CONTRACT*.

Theresa, U. (2017) 'Building places that work for everyone', (February).

Thompson, G. (2016) 'The Concrete Centre 02.06'.

Todd, S. and Fitton, R. (2016) 'Modelling Dwelling Energy use in a BIM based CAD system Stephen Todd Applied Buildings and Energy Research Group , University of Salford UK Richard Fitton Applied Buildings and Energy Research Group , University of Salford UK', *Intersymp*, pp. 1–7. Available at: http://www.iias.edu/frameset_start_inters_ann.html.

Toma, Luigi and Gheorghe, E. (1992) 'Equilibrium and disorder in human decision-making processes:. Some methodological aspects within the new paradigm', *Technological Forecasting and Social Change*, 41(4), pp. 401–422. doi: 10.1016/0040-1625(92)90046-V.

Toma, L and Gheorghe, E. (1992) 'EQUILIBRIUM AND DISORDER IN HUMAN DECISION-MAKING PROCESSES - SOME METHODOLOGICAL ASPECTS WITHIN THE NEW PARADIGM', *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE*, 41(4), pp. 401–422. doi: 10.1016/0040-1625(92)90046-V.

Toogood, E. (2016) *The Concrete Centre 02.05*.

Tsubuku, M. and Brasor, P. (2014) 'Inheritance tax in Japan may not be the burden you imagined', *The Japan Times*.

Tummers, L. (2016) 'The re-emergence of co-housing in Europe'.

U K Green Building Council (2017) *THE ROLE OF LOCAL LEADERSHIP IN CREATING SUSTAINABLE HOMES*.

UK Construction (2010) *Willmott Dixon complete landmark Nottingham One development*, *UK Construction*.

UK Green Building Council (2015) *Tackling embodied carbon in buildings*. Available at:

www.ukgbc.org.

UK Parliament et al (2018) ‘Research Impact and Legislatures’, (September). Available at: https://www.parliament.uk/documents/Research Impact in Legislatures_FINAL 2.pdf.

UK Timber Frame Association (no date) *Public Attitudes And Timber*. Available at: http://www.uktfa.com/public-attitudes-and-timber/ (Accessed: 22 May 2018).

Urban Splash (2018) *Welcome to HOUSE*.

Venables, T. and Courtney, R. (2004) ‘Modern methods of construction in Germany – playing the off-site rule’, *Global Watch Mission Reports dti*, (March).

Visit Nottinghamshire (2018) *Hockerton Housing Project*. Available at: http://www.hockertonhousingproject.org.uk/ (Accessed: 26 October 2018).

Wainwright, O. (2017) ‘Britain has enough land to solve the housing crisis – it’s just being hoarded | Cities | The Guardian’, *The Guardian*. Available at: https://www.theguardian.com/cities/2017/jan/31/britain-land-housing-crisis-developers-not-building-land-banking.

Whitaker, R. (2016) *Interview 03.08.1 NCH*.

White, R. (2017) ‘Compulsory purchase and council homes – a new direction for housing policy ?’, *Shelter*, (May).

Wilmore, B. J. (2017) ‘Housebuilding giants ’ dominance must end , MPs urge’, d.

De Wolf, C., Pomponi, F. and Moncaster, A. (2017) ‘Measuring embodied carbon dioxide equivalent of buildings: A review and critique of current industry practice’, *Energy and Buildings*. Elsevier B.V., 140, pp. 68–80. doi: 10.1016/j.enbuild.2017.01.075.

Wu, W. and Hyatt, B. (2016) ‘Experiential and Project-based Learning in BIM for Sustainable Living with Tiny Solar Houses’, *Procedia Engineering*. Elsevier B.V., 145, pp. 579–586. doi: 10.1016/j.proeng.2016.04.047.

Yates, J. and Mackay, D. F. (2006) ‘Discrete choice modelling of urban housing markets: A critical review and an application’, *URBAN STUDIES*, 43(3), pp. 559–581. doi: 10.1080/00420980500533695.

Zed Factory (2017) *zerobillshome.pdf*.

Zero Carbon Hub (2015) *The Future of Low Energy Cities and Communities*.

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Appendix A Advisory Bodies

(Section 1.2.3)

name	acronym	relationship ~ above	purpose	web site	funding status	source	business status	info type	board info	est.	advisory sector	advisory role
Association of British Insurers	**ABI**											
Approved Inspectors	**ACAI**		The Association of Consultant Approved Inspectors (ACAI) was formed in 1996 to increase awareness and understanding of private sector building control as a commercial, professional and cost-effective alternative to local authority inspectors. Today it has about 50 members who collectively represent 95% of all independent building control work.	https://approvedinspectors.org.uk	membership	lobby group	business	guidance	https://approvedinspectors.org.uk/contact-us/		business	forlobby
Association for Decentralised Energy	**ADE**			http://www.theade.co.uk								
Association for Environment Conscious Building	**AECB**		Membership of the AECB includes local authorities, housing associations, builders, architects, designers, consultants and manufacturers. The Association was Founded in 1989 to increase awareness within the construction industry of the need to respect, protect, preserve and enhance the environment and to develop, share and promote best practice in environmentally sustainable building.	http://www.aecb.net	membership	independent research	business	guidance	http://www.aecb.net/about/about-the-aecb/aecb-staff-and-board/		business	lobby
British property Federation	**BPF**		The British Property Federation is the membership organisation for, and the voice of, the UK real estate industry.We represent and promote the interests of all those with a stake in real estate in the UK – owners, developers, funders (equity and debt), agents and advisers.We work with government and regulatory bodies to help the real estate industry grow and thrive, to the benefit of our members and the economy as a whole. Because our membership is industry wide, we can provide government and regulators with the knowledge they need to make decisions.	http://www.bpf.org.uk	membership	lobby group	business	factual	http://www.bpf.org.uk/about-us/board			
Building Regulations Advisory Committee	**BRAC**	DCLG	advise the relevant secretaries of state in England and Wales on making building regulations and setting standards for the design and construction of buildings	https://www.gov.uk/government/organisations/building-regulations-advisory-committee	government	government information	government body	guidance			state	advisory
British Research Establishment	**BRE**		BRE is an independent and impartial, research-based advisory, testing and training organisation, offering expertise in every aspect of the built environment and associated industries. We help clients create better, safer and more sustainable products, buildings, communities and businesses - and we support the innovation needed to achieve this.	www.bre.co.uk	industry body	independent research	trust - not for profit	guidance	http://www.bre.co.uk/pod page.jsp?id=2044		business	research
	BREEAM	BRE	The BREEAM assessment process evaluates the procurement, design, construction and operation of a development against targets that are based on performance benchmarks. Assessments are carried out by independent, licensed assessors, and developments rated and certified on a scale of Pass, Good, Very Good, Excellent and Outstanding.	http://www.breeam.com	industry body	independent research	business	assessment			business	assessment
Building Societies Association	**BSA**		We provide our members with information to help them run their businesses, and we represent their interests to a wide range of audiences including regulators, the government, parliament (EU and UK), the media, other opinion formers and the general public.	https://www.bsa.org.uk								
Building Services Research and Information Association	**BSRIA**		BSRIA is a test, instruments, research and consultancy organisation, providing specialist services in construction and building services.As a non-profit distributing, member-based association, clients can be assured of our independent approach and authoritative reputation. Any profits made are invested in our on-going research programme, producing industry recognised best practice guidance.BSRIA (owned by The Building Services Research and Information Association) was founded in 1955 and had a turnover of £14.5 million in 2015-16. We employ over 200 people at our head office in Bracknell (UK), at regionally based construction compliance offices throughout the UK; at offices in France, Spain, China, USA; and Associates in Northern Ireland, Japan, Brazil and Australia.	https://www.bsria.co.uk	membership	independent research	trust - not for profit	guidance	https://www.bsria.co.uk/about/council/		business	discussionr esearch
Build UK (ex UKCG & NSCC)	**BUK**	SFC	Build UK provides a strong collective voice for the construction supply chain by bringing together construction Clients, Main Contractors and the leading Trade Associations representing over 11,500 Specialist Contractors.Build UK focuses on key industry issues that can deliver change and enable the construction supply chain to improve the efficiency and delivery of construction projects for the benefit of the UK economy.Providing influential and dynamic leadership, Build UK ensures a joined up approach from the supply chain, making us the 'go to' representative organisation for industry stakeholders.	http://builduk.org	membership	lobby group	business	guidance	http://builduk.org/the-build-uk-team/	2015		
Centre for resilience	**C4R**	BRE	The Centre for Resilience was created in 2014 to identify critical issues which affect the UK's homes, commercial buildings and infrastructure.	http://www.centre4resilience.org	government	government information					business	foradvisory
The Construction Alliance	**CA**	SFC	The Construction Alliance is the grouping of major construction trade organisations working together within the remit of the Strategic Forum for Construction. The Alliance represents over 13,500 individual companies and organisations involved in the construction industry. Alliance membership comes from across the UK and represents constructors throughout the supply chain.dividerThe founding trade bodies are The Civil Engineering Contractors Association (CECA), The Scottish Building Federation (SBF) and The National Federation of Builders (NFB) . They have come together to work on the significant common issues that affect our industry and to devolve best practice throughout their memberships.	http://theconstructionalliance.org								
The Concrete Centre	**CC**	MPA	In an age when legislation is constantly changing, it is increasingly difficult for operators to stay in touch with what is often essential information. The opportunity to influence outcomes is equally precious and is not usually available if you do not have the combined strength of a good trade association and its lobbying capacity.	http://www.mineralproducts.org	membership	lobby group	business	campaign	http://www.mineralproducts.org/cont_mpa02.htm		business	forlobby
Constructing Excellence	**CE (G4C)**	BRE (merger)	Constructing Excellence is a platform for industry improvement to deliver better value for clients, industry and users through collaborative working.We bring together informed intelligent clients with leading industry players, universities and other stakeholders to collaborate on:Innovation and researchBenchmarking and demonstrationsKnowledge transfer and learningNetworking and thought leadership.	http://constructingexcellence.org.uk	membership	lobby group	business	guidance				
Construction Industry Council	**CIC**	SFC	To improve the UK construction industry by collectively representing and supporting the built environment professions.CIC now occupies a key role within the UK construction industry providing a single voice for professionals in all sectors of the built environment through its collective membership of 500,000 individual professionals and more than 25,000 firms of construction consultants.	http://cic.org.uk	membership	independent research	business	guidance	http://cic.org.uk/about-us/council-members.php		business	lobby
Chartered Institute of Housing	**CIH**		Formed in 1916, for 100 years CIH has devoted its work to one simple purpose: to ensure everyone has a decent, affordable home in a thriving, safe community.As the professional body for housing, our work is rooted in three main objectives - to support the housing sector to learn, improve and influence. The activities we carry out centre around providing individuals and organisations with opportunities to develop their knowledge, driving up standards and skills within the housing sector, and championing housing with decision-makers and the media to shape the future of our industry.	http://www.cih.org	membership	lobby group	trust - not for profit	guidance		1916		
BuildOffSite / CIRIA	**CIRIA**		The Buildoffsite Housing Hub was set up at the start of 2015 to support a substantial increase in the use of offsite construction methods to increase the overall supply of new homes in the UK.	www.buildoffsite.com/sectors/housing/	membership	lobby group	business	campaign	http://www.buildoffsite.com/content/uploads/2015/04/Exec-group-chart-April-2015_pdf.pdf		business	lobby
Construction Information Service	**CIS**	IHS Markit and NBS	an online tool to quickly access current regulations, construction standards, technical advice and industry news on building, engineering, design and construction processes	https://www.ihs.com/products/uk-construction-information-service.html	membership	independent research	business	guidance				

Construction Industry Training Board	**CITB**		For British construction to have a recognised, world-class, innovative approach to developing its workforce to deliver quality in the built environment. A social enterprise, devoted to building competitive advantage for the construction industry and the people who work in it.	http://www.citb.co.uk						1964		
Construction Leadership Council	**CLC**	CIC	The CLC's objective is to drive industry improvement. It draws together business leaders from across the sector to identify how to promote solutions to meet Construction 2025's ambition of: 33% reduction in cost 50% reduction in project time 50% reduction in carbon emissions 50% reduction in the trade gap.	http://www.construction leadershipcouncil.co.uk	industry body	lobby group	business	guidance			business	for
Innovation in construction workstream	**CLC I**	CLC	The Innovation in Buildings work stream is focussed on embedding innovative construction techniques to improve productivity and capacity in the construction industry, and the quality and whole-life performance of buildings.	http://www.construction leadershipcouncil.co.uk/ workstream/innovation/	industry body	independent research	funded	campaign			business	research
Council of Mortgage lenders	**CML**		The CML is the main trade body representing UK mortgage lenders. Our members are banks, building societies, and other lenders who together account for around 97% of the nation's residential lending.	www.cml.org.uk	membership	company literature	business	factual	https://www.cml.org.uk/about-us/cml-team/		business	lobby
Campaign for the protection of rural england	**CPRE**		We campaign for a beautiful and living countryside. We work to protect, promote and enhance our towns and countryside to make them better places to live, work and enjoy, and to ensure the countryside is protected for now and future generations.	http://www.cpre.org.uk	membership	lobby group	trust - not for profit	campaign			public	lobby
centre for sustainable development	**CSD**		cambridge uni	http://www-csd.eng.cam.ac.uk	academic	independent research	funded			2000	business	research
Dept of Communities and local governemnt	**DCLG**	1 of 25 ministerial depts	Works with 11 agencies and public bodies, inc. ARB, HCA, BRAC	https://www.gov.uk/government/organisations/department-for-communities-and-local-government	government	independent research	government body	guidance			state	advisory
Design Quality Indicator	**DQI**	CIC	In 1999 the Construction Industry Council gathered the finest individual minds in the industry, to address the issue of poor quality design in buildings. This action was supported by the Commission for Architecture and the Built Environment, the Department of Trade and Industry, the Office of Government Commerce, Constructing Excellence and the Strategic Forum of Construction. After four years of development, DQI was the solution.	http://www.dqi.org.uk	industry body						business	assessment
Federation of Master Builders	**FMB**		THE UK'S LARGEST TRADE ASSOCIATION IN THE CONSTRUCTION INDUSTRY, CHAMPIONING CONTINUOUS IMPROVEMENT IN BUILDING STANDARDS FOR OVER 75 YEARS.	http://fmb.org.uk	membership	lobby group	trust - not for profit	guidance	http://www.fmb.org.uk/about-the-fmb/who-s-who/	1941	business	lobby
Green Alliance	**GA**		Green Alliance is a charity and independent think tank focused on ambitious leadership for the environment.Since 1979, we have been working with a growing network of influential leaders in business, NGOs and politics to stimulate new thinking and dialogue on environmental policy, and increase political action and support for environmental solutions in the UK.	http://green-alliance.org.uk	membership	lobby group			http://green-alliance.org.uk/staff.php		business	research
green construction board	**GCB**	CLC	The Green Construction Board was established in October 2011 as a consultative forum for government and the UK design, construction, property and infrastructure industry. The Board is the sustainability work stream of the Construction Leadership Council.	http://www.greenconstructionboard.org	industry body	independent research	funded	guidance	http://www.greenconstructionboard.org/index.php/board		business	research
Good Home Alliance	**GHA**		The Good Homes Alliance is a group of housing developers, building professionals and sustainability experts whose aim is to build and promote sustainable homes and communities, and to transform the whole of mainstream UK house building into a sustainable endeavour.	www.goodhomes.org.uk	membership	lobby group	trust - not for profit	campaign	http://www.goodhomes.org.uk/who/board		business	lobby
House Building Federation	**HBF**		HBF works with Government and stakeholders to develop housing policy in the UK. Membership gives companies a voice on current issues through inclusive and specialist representation and access to up to date information on policy development.By co-ordinating an industry wide response in its dealings with Ministers and Government personnel, HBF ensures a two way flow of information that ensures the industry's views are heard – and that the industry is aware of issues that affect them.	http://hbf.co.uk	membership	lobby group	business	campaign	http://www.hbf.co.uk/about-us/staff/		business	lobby
Homes and Communities Agency	**HCA**	DCLG	The Homes and Communities Agency (HCA) helps create successful communities by making more homes and business premises available to the residents and businesses who need them. We also regulate social housing providers in England	https://www.gov.uk/government/organisations/homes-and-communities-agency	government	government information	government body	guidance			state	advisory
Housing Forum	**HF**	NHBC	Our approach is to:deliver benefits to member organisations through access to innovation and break-through practiceprofile member organisations' own achievements and strengths to both membership and a wider audiencevoice solutions from our membership to policy makers Our audience is:Membership and potential membership organisationsGovernment and local governmentCEOs and significant individuals in housing businessesMedia and social media networks	http://www.housingforum.org.uk	membership	lobby group	business	guidance	http://www.housingforum.org.uk/about_us/Our-Board/board-members		business	lobby
Housing & Finance Institute	**HFI**	GOVT?	We work with industry and public sector partners to deliver a step change in housebuilding, housing delivery and finance.	http://thehfi.com								
HQM	**HQM**	BRE	The UK construction industry providing a single voice for professionals in all sectors of the built environment through its collective membership of 500,000 individual professionals and more than 25,000 firms of construction consultants.iteria against which homes will be assessed for the Home Quality Mark (HQM) are based on the latest scientific research into issues such as energy and water efficiency, effective insulation, noise reduction, lighting and air quality and the wellbeing of occupants – along with wider environmental issues such as climate change and carbon reduction.	http://www.homequalitymark.com	industry body	government information	business	assessment			business	assessment
Innovate UK	**I UK**	Department forBusiness, Energy& Industrial Strategy	Innovate UK is the UK's innovation agencyInnovate UK is an executive non-departmental public body, sponsored by the Department for Business, Energy & Industrial StrategyWe work with people, companies and partner organisations to find and drive the science and technology innovations that will grow the UK economy.We're an organisation of around 300 staff, drawn mainly from business.	https://www.gov.uk/government/organisations/innovate-uk	government	government information	government body	guidance			state	research
The Institute of Environmental Management and Assessment	**IEMA**		IEMA is the worldwide alliance of environment and sustainability professionals, transforming the world to sustainability.	http://www.iema.net								
International Garden Cities Institute	**IGCI**		The International Garden Cities Institute is the realisation of a long-term ambition by founder Letchworth Garden City Heritage Foundation to bring together expertise to showcase Garden Cities from around the world as a solid modelfor new development, in recognition of their global in uence.	http://www.gardencitiesinstitute.com								
nternational sustainability alliance	**ISA**	BRE	The BRE International Sustainability Alliance (ISA) is a membership organisation that welcomes property owners, occupiers and investors who wish to come together to share best practice in the sustainable management of their property portfolios to improve financial performance	http://www.internationalsustainabilityalliance.org	membership	independent research	business	assessment			business	advisory
International Well Being Institute	**IWBI**		The WELL Building Standard™ is an evidence-based system for measuring, certifying and monitoring the performance of building features that impact health and well-being.WELL is administered by the International WELL Building Institute™ (IWBI), a public benefit corporation whose mission is to improve human health and well-being through the built environment.	https://www.wellcertified.com	industry body	lobby group	business	assessment			business	assessment
knowedge transfer network	**KTN**	Innovate UK	KTN is the UK's innovation network. It brings together business, entrepreneurs, academics and funders to develop new products, processes and services.	https://www.ktn-uk.co.uk	academic						state	research
Built Environment KTN	**KTN BE**	KTN	The KTN Built Environment Community delivers the Innovation Network function for practitioners in the urban living sectors. It's a purpose build vehicle to bring the community sub sets together to share best practice, linking funders to finance seekers, inspire collaboration and showcase new opportunities for the UK's small businesses in this area. A wider mission is also to bring these businesses closer to the research bases, bigger tier operators and collaborative opportunities outside this sector.	https://connect.innovateuk.org/web/modernbuiltktn	government	independent research	funded	guidance			state	research

Materials KTN	**KTN M**	KTN	The Materials Community aims to bring together the materials supply chain to accelerate innovation, improve global competitiveness and sustainability.	https://connect.innovateuk.org/web/materialsktn	government	independent research	funded	guidance		state	research
Local Authority Building Control	**LABC**		Local Authority Building Control (LABC) is a not-for-profit membership organisation that represents all local authority building control teams in England and Wales.							state	assessment
Local Government Association	**LGA**	govt		http://www.local.gov.uk/environment-planning-and-housing;jsessionid=473B2CF02DA72407F9B12B70DA2F71CF.tomcat1							
self build association	**NaCSBA**		Our mission is to substantially increase the number of people able to build or commission their own home	www.nacsba.org.uk	membership	lobby group	business	campaign	http://www.nacsba.org.uk/committee	business	lobby
National Building Specification	**NBS**	RIBA	committed to offering distinctive, innovative specification and information solutions to construction industry professionals	https://www.thenbs.com	membership	government information	business	factual			
Next Generation	**NG**	UK GBC / HCA	The benchmark enables homebuilders, Government, registered providers (RPs), investors, employees and the public to understand the sustainability of homebuilders' operations and the new homes they build.NextGeneration (to paint a better picture of the VHBs in respect of sustainability)	http://nextgeneration-initiative.co.uk	membership	lobby group	business	campaign	http://www.trada.co.uk/membership/trada_board	business	assessment
National House Building Control	**NHBC**		NHBC is the UK's leading independent standard-setting body and provider of warranty and insurance for new homes. Our purpose is to work with the house-building industry to raise the standards of new homes and to provide protection for homebuyers in the form of Buildmark warranty and insurance	www.nhbc.co.uk	industry body	independent research	trust - not for profit	guidance	http://www.nhbc.co.uk/AboutNHBC/Howwearerun/	business	assessment
Office of National Statistics	**ONS**	govt	The UK's largest independent producer of official statistics and the recognised national statistical institute of the UK. Our main responsibilities are collecting, analysing and disseminating statistics about the UK's economy, society and population	https://www.ons.gov.uk	government	independent research	government body	factual		state	advisory
oak and park royal development corporation	**OPDC**	Mayor of London	The Old Oak and Park Royal Development Corporation (OPDC) is developing a whole new centre and community for west London. We're using the investment in rail infrastructure projects HS2 and Crossrail to create new opportunities for people in the area. The Corporation was officially launched on 1 April 2015 by the Mayor of London. OPDC is the Local Planning Authority, master developer and regeneration agency for the 650 hectare site.	https://www.london.gov.uk/about-us/organisations-we-work/old-oak-and-park-royal-development-corporation-opdc	industry body	company literature	business	factual		state	lobby
Planning Advisory Service	**PAS**	DCLG	The Planning Advisory Service (PAS) is part of the Local Government Association. We provide high quality help, advice, support and training on planning and service delivery to councils. We help local government officers and councillors stay effective and up to date. We have a 'sector led' improvement approach, where local authorities help each other to continuously improve.	http://www.pas.gov.uk							
Pinpoint	**PP**	UK GBC	Built environment professionals searching for information on sustainability can now do so using Pinpoint – a free, easy to navigate and independent online platform.Pinpoint is currently the world's only dedicated online search engine for sustainability resources in the built environment. It allows users to search for information on how to make their projects, products or organisations more sustainable.Pinpoint users are also encouraged to add their own resources as well as comment on and recommend existing information to help others find the best possible resources.	http://pinpoint.ukgbc.org	academic	independent research	funded	factual		business	advisory
Royal Institute of British Architects	**RIBA**		The Royal Institute of British Architects champions better buildings, communities and the environment through architecture and our members. We provide the standards, training, support and recognition that put our members – in the UK and overseas – at the peak of their profession.With government, we work to improve the design quality of public buildings, new homes and new communities.	https://www.architecture.com/Explore/Home.aspx	membership	independent research	trust - not for profit	factual	https://www.architecture.com/RIBA/Aboutus/Whoweare/RIBABoard.aspx	business	lobby
Royal Institute of Chartered Surveyors	**RICS**		We are a professional body that accredits professionals within the land, property and construction sectors worldwide.We regulate and promote the profession; maintain the highest educational and professional standards; protect clients and consumers via a strict code of ethics; and provide impartial advice and guidance.							business	lobby
Royal Town Planning Institute	**RTPI**		The Royal Town Planning Institute is the UK's leading planning body for spatial, sustainable and inclusive planning and is the largest planning institute in Europe with over 23,000 members.	http://www.rtpi.org.uk							
Sustainable Cities Collective	**SCC**		Sustainable Cities Collective is an editorially independent, moderated community for leaders of major metropolitan areas, urban planning and sustainability professionals. We look to aggregate content and provide resources for all who work in or are interested in urban planning, sustainable development and urban economics.	http://www.sustainablecitiescollective.com							
Steel Construction Institute	**SCI**		SCI (the Steel Construction Institute) has been a trusted, independent source of information and engineering expertise globally for over 30 years, and remains the leading, independent provider of technical expertise and disseminator of best practice to the steel construction sector.	www.steel-sci.com	membership	lobby group	trust - not for profit	factualguidancecampaign	http://www.steel-sci.com/meet-the-sci-team/	business	lobby
Supply Chain Sustainability School	**SCSS**										
Strategic Forum for Construction	**SFC**	(ex CIB)	to oversee implementation of reports' recommendations							2001	
Skillsplanner	**SP**	IUK		http://www.skillsplanner.net							
Town and country planning assoiation	**TPCA**		We campaign for the reform of the UK's planning system to make it more responsive to people's needs and aspirations and to promote sustainable development	http://www.tcpa.org.uk	membership	lobby group	trust - not for profit	campaign	http://www.tcpa.org.uk/Pages/FAQs/Category/our-governance	1889 public	lobby
Timber research and development association	**TRADA**		To provide members with the highest quality information on timber and wood products to enable them to maximise the benefits that timber can provide.We seek to achieve this aim through active and on-going programmes of information, promotion and research. Information is provided through this website, an extensive collection of printed materials and our training courses.	www.trada.co.uk	membership	lobby group	trust - not for profit	factualguidancecampaign		business	lobby
TruCost	**TRUCOST**		Trucost provides sustainability data and insight to drive resilient, profitable business models and investment strategies – and identify the transformative solutions of tomorrow.	https://www.trucost.com							
UK green building council	**UK GBC**	World Green Building Council	The organisation was founded in the autumn of 2006 and launched on February 2007[1] in response to the 2004 Sustainable Building Task Group Report Better Buildings - Better Lives,[2] which recommended the UK Government should "review the advisory bodies concerned with sustainable buildings to simplify and consolidate them and to provide clear direction to the industry" (para 1.8, p.7).	http://www.ukgbc.org	government	independent research	trust - not for profit	guidance	http://www.ukgbc.org/about-us/who-we-are/board-trustees	2006 business	research
World Green Building Council	**WGBC**		The World Green Building Council is a network of national green building councils in more than one hundred countries, making it the world's largest international organisation influencing the green building marketplace.The WorldGBC's mission is to strengthen green building councils in member countries by championing their leadership and connecting them to a network of knowledge, inspiration and practical support.	http://www.worldgbc.org							
Zero Carbon Hub	**ZCH**	NHBC	The Zero Carbon Hub was established in 2008, as a non-profit organisation, to take day-to-day operational responsibility for achieving the government's target of delivering zero carbon homes in England from 2016. Since then the Hub has worked with both government and industry with the focus on raising build standards and reducing the risk associated with implementing the Zero Carbon Homes policy.	www.zerocarbonhub.org	membership	lobby group	trust - not for profit	campaign	closed	business	research

Appendix B Industry Interview consent form

(Section 3.1.1)

A Study of Concrete Housing in the UK

PhD research by
Michael Siebert B(Arch)

Supervisors

Dr. Lucelia Taranto Rodrigues

Prof. Mark Gillott

A Study of Concrete Housing in the UK

Semi Structured Interview Guidance

Introduction

This interview is conducted with key employees of Tarmac PLC and The Concrete Centre. This form provides guidance and a brief agenda to ensure areas of interest to the study are covered but also allows for other relevant information revealed in the course of the discussion to be recorded.

Agenda

The interview aims to cover the four main areas of research, plus another more overarching set of questions to establish what the interviewees see as the future role of Tarmac PLC.

- The role of concrete in the housebuilding industry

- The role of government in the housebuilding industry

- The housebuilding industry itself

- Public awareness around the above issues

- And finally the role of Tarmac PLC

Brief description of the study design

number and type of participants
the participants will be key employees who between them will give an insight into the company's history, current policies and future aspirations. Expected to be between 5 and 10 participants from Tarmac PLC and about 5 from the Concrete Centre.

number and duration of activities participants will be involved in
there will be one 45-50 min. interview following a brief agenda to ensure areas of interest to the study are covered but also allowing for other relevant information revealed in the course of the discussion to be recorded.

equipment and procedures to be applied
the interviews will be digitally recorded and transcribed at a later date.

information about how participants will be recruited
participants will be chosen by my contacts within Tarmac based on their knowledge of the company structure.

whether participants will be paid (state how this will be done)
there will be no payments required.

plans to ensure participant confidentiality and anonymity
all interviews will be carried out anonymously and no names will be used in the transcribed data.

plans for storage and handling of data
all digitised interviews will be stored and archived at the University of Nottingham. Transcribed interviews will be held on the author's password protected computer off site.

information about what will happen to the data after the study
all information will be held for seven years . . .???

information about how any data and images may be used
all information gathered is covered by Tamac PLC's confidentiality agreement signed by the author

state whether it will be possible to identify any individuals.
none of the participants will be identifiable in the transcribed data.

A Study of Concrete Housing in the UK

Information to Participants

You are being invited to take part in a research study. Before you decide whether or not to accept this invitation, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully. If you have any queries or something is not clear to you, please do not hesitate to contact the researcher using the provided contact details.

Researcher: Michael Siebert e: laxams@nottingham.ac.uk

What is the purpose of the study?
This study aims to give an insight into the company's historical, current and future aspirations in relation to the volume house building industry in the UK. It will look at the relationship Tarmac has with the industry as well as with government regulators and the general public as the 'end user' and ask how and to what extent Tarmac should be engaging with each of these bodies.

Why have I been invited to participate?
Your opinion is of great value as a personal insight into how the company could and should be moving forwards, and for what ultimate purpose.

Do I have to take part?
It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form. In this case, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?
You will be requested to take part in a semi-structured interview to be conducted at a time of your convenience (between 0900 – 1800hrs) as agreed with the researcher. There are no disadvantages, risks or economic costs involved in your participation.

What is the time commitment for taking part in the study?
30 minutes to take part in a semi-structured interview - this will be held after signing the consent form. The questions will be made available at least 24hours beforehand.

What are the possible benefits of taking part?
The information collected will inform the researcher and help in the structuring of questions for future interviews within the housebuilding industry, local government and the BRE, and also with the general public.

Will what I say in this study be kept confidential?
All information collected about the individual will be kept strictly confidential (subject to legal limitations). Your personal data will never be revealed in the study, keeping your privacy and anonymity ensured in the storage and publication of the research material. Data generated by the study will be retained in accordance with the University's strict policy on Academic Integrity.

What should I do if I want to take part?
To participate in the study, you must fill in the participant consent form before being taken through the semi-structured interview.

What will happen to the results of the research study?
The results of the research will be used to inform the researchers Ph.D. research project: 'A Study of Concrete Housing in the UK'. If you wish, you can obtain a copy of the project report, by directly informing the researcher conducting the survey.

Who is organising and funding the research?
The researcher, Michael Siebert, is conducting the study as a student member of the Architecture, Climate and Research Group, Faculty of Engineering, at the University of Nottingham as part of his Ph.D. study.

Who has reviewed the study?
The research has been approved by the Faculty Research Ethics Committee, Faculty of Engineering, and University of Notm.

If you have any concerns about the way in which the study has been conducted, please contact the Chair of the Faculty Research Ethics Committee via the Faculty Research Administrator at joanne.deeley@nottingham.ac.uk .

A Study of Concrete Housing in the UK

Participant Consent Form

Participant

I confirm that I have read and fully understood the attached information sheet. I also give my informed consent to participate in this study.

Participant's name ……...……..

Participant's signature …… Date ……...

Researcher

I have fully briefed the participant and answered all questions asked by the participant.

Researcher's name …….

Researcher's signature …….. Date ……..…

Thank you for agreeing to take part in this study

If you have any queries or comments please e-mail Michael Siebert at laxams@nottingham.ac.uk or call 07508 161333

Appendix C Interview process table

(Section 3.1.1)

- **Interview process**
- **preparation**
  - prepare questions
  - ethics approval
  - arrange interviews
  - send information and questions to interviewee
- **interview**
  - record on iPhone
    - put phone in airplane mode
  - set scene, get job description
  - ask set questions
  - allow for follow up questions
  - get feedback
- **transcribing**
  - transfer to computer
    - airdrop if size too big to send as message
  - translate from m4a to mp3 format
    - use online media translator, Media.io
      - select file to upload
      - set output to mp3, high quality
      - download converted file
  - transcribe using oTranscribe.com
    - set speed to slow for playback
  - open Dragon software
    - plug in Logitech USB headset
    - load voice profile if not there, or double-click profile in Dragon folder
    - click red button to green to activate
  - open Word software to take transcription as spoken into Dragon
  - save and repeat exercise to correct grammar & spelling manually
  - run through again to add PA.. manually and INT by search and replace
    - use ‘show’ in menu to reveal formatting
    - replace RETURN RETURN INT with XXXX
    - replace RETURN RETURN with RETURN RETURN 03.8 (etc) TAB
    - replace XXXX with RETURN RETURN INT
- **coding**
  - Open Nvivo software
  - import file from Word
  - reference file correctly
  - code interviewee’s answers to existing nodes and add new nodes as required
  - add annotations linked to own comments
- **analysing**
  - coding
    - Nvivo process
  - annotations

Appendix D Sample Industry Interview transcripts & response data

(Section 3.1.2)

INT *It is the 16th of March. This is an interview with David Rich of Tarmac about the role of concrete in the house building industry.*
Hello David.

PA1 Hi

INT *I have got five questions here for you and then a more open question at the end so we've got about fifty minutes. I'm not expecting each answer to last exactly 10 minutes. I'm sure they'll be a lot shorter than that and at the end we've got time for quite a bit more to cover.*
So, first question is: ***What do you see as concrete's biggest failing in housing that it needs to overcome?***

PA1 I would probably say its long-standing perception, so people's general opinion of concrete and its suitability for housing being different to what people expect from a house. So historically we've got around the 60s concrete tower blocks and post-war prefab concrete housing which is not really that – it's different from what people expect - it's not really - can't think of the word now - aspirational

INT *Yes*

PA1 for people to live in that. I think yes it's the perception people are unaware of how much concrete actually goes into the house which they own and buy but they're not sure they don't really have the understanding of what that material has the potential to do without hugely changing how that house looks.

INT *So your saying there's also a failure to educate the public about how useful concrete is?*

PA1 Yes. I think that's one of the key things. If people know what something can do they are more inclined to want to have it but I don't think at the moment they know what concrete offers compared to a conventional house which is made essentially of bricks. They don't really know a new house is bricks and concrete blocks and it has concrete floors. The concrete is in there but it's not really taking on the potential of that material.

INT *The concrete is not visible in the same way that the bricks are visible.*

PA1 No

INT *So they never get to see it on a day-to-day basis as a house owner, and I suppose the perceptions stand in the way of educating people if they're not very open to listening.*

PA1 Yes I would agree with you on that point. If they're not open to change they don't potentially want to see anything different. But the way I see it is if you think about the number of houses that are painted internally whether it's a plasterboard finish that is painted or a plaster finish that is painted. Actually if you had a concrete wall you can paint that as

well and still get the benefits of the actual fabric of the material. Then you might get people to understand you can do the same thing with concrete that you can do every day with a conventional approach.

INT *Then you're into having to educate them about the benefits of thermal mass which is another level of education again.*

PA1 Yes. There probably are ways to simplify that message to demonstrate how that works in a simple way and what it actually means to the end user at the end of the day in terms of - are they potentially going to get a house which needs no heating or cooling requirements.

INT *What about its actual physical failings?*

PA1 So is that in terms of . . .

INT *Historically,*

PA1 In terms of the structural performance of the material or just how it performs in our climate?

INT *Weathering I suppose*

PA1 In our climate I think a lot of that will come down to probably the wrong choice of physical material in terms of - If it suffers from alkaline attack or chlorides in the soil you need to make sure you use the right material in terms of things like corrosion, spalling a lot of that is down to potential workmanship. I think there's probably a historical - from my experience on site I'm assuming you can get away with more with concrete I don't know I'm hoping it's improved in the past 10 years since I've been on site you kind of throw it in get on with it but yes in terms of material performance I'm not too sure.

INT *it's hard isn't it. OK thank you.*
What do you see as the innovations in concrete most likely to re-engage - *now I've broken this into* ***the public the construction industry and the government?*** *So modern innovations that the public would be excited by.*

PA1 I think for the public the things I don't know if it's really that there's too many - see there's a lot of innovation going on in concrete in different developments that people might become aware of but I really think the big areas that would excite the public would probably be performance in terms of how you can actually use it in building to offer you something different to conventionally. I suppose the aesthetic side of things in actually the ability of the material to look - so it doesn't actually look like concrete. I think that's what people would probably find most interesting. you've got other innovations in terms of see-through concrete and things like that that I think would do well they are attention grabbing.

INT *Yes I'm not even sure I understand that myself to be honest.*

PA1 They use fibre-optic wires running through the concrete

INT *So the concrete itself isn't see through but it's got a mass of fibre this go through from one side to the other so you can see a shadow on the other side. I've never seen it in real life.*

PA1 No I've not seen it either.

INT *I'm sure it exists. But I mean do those fibres actually act as a kind of structural property as well?*

PA1 I don't think they do they're purely for the visual impact.

INT *So for the public is probably more an aesthetic*

PA1 I think for the public's it's gonna be an aesthetic and performance and being able to demonstrate what the potential impact would be. I think people are getting a bit more savvy and more aware of what their impacts are on the environment. if you can demonstrate say if you go for option a is going to be X option B is can be Y and whether that's actually all concrete or hybrid with concrete making use of the materials you're putting into a building which I think is probably the biggest thing we don't do is that we build things -whether we build out of timber steel or concrete or any other material that we actually don't think about what the fabric can do or what else that can offer so that might be somewhere but I think the aesthetics is going to be the big one just to get people over the 60s feelings - the fact that it's grey and cold and horrible but there's actually a lot more you can do with it

INT *So what about the government if you had to really lobby the government about the benefits of concrete you've got coming down the line, what would really make them sit up and listen?*
It's not going to the fibre-optics is it.

PA1 No. I think from the government's perspective it's got to be any innovation that can help make housebuilding cheaper and speed it up so they can meet - trying to increase demand and targets they've set where there are shortages in the industry. So you've got the innovations around, concrete printing 3-D printing so you can actually start a production line approach but it's the same as modular building. I think if there is an innovation there which suddenly becomes incredibly . . . It's viable now and becomes more viable, more cost efficient, more attractive and actually gives the government a demonstrable way of actually going about delivering on their targets and I think that's something which would encourage the government. I'm not entirely convinced from - that the sustainability question or sustainability answers would make too much of an impact at this point in time. Obviously all the change we've had over recent previous government's but I think it's at governmental level it's got to be the ability to deliver good housing stock.

INT *So off site manufacturing as a principle? Precast rather than in situ.*

PA1 I think that's something that the government will jump upon as being the way to deliver what they want but again I think it's something you've got to be - horses for courses - it's actually a way to do . . .

INT *There's nothing they like better than getting behind something which is a profound enough difference for people to understand, so anything small and subtle tends to get overlooked*

PA1 Yes

INT *Possibly detrimentally I think*

PA1 But I think the government - it's going to be the speed of construction and the ability to deliver on housing quicker and faster. Actually there's huge demand. Then the government has to make changes because who are the people who actually have the land to do the building. They're the people who are not encouraged to build quickly.

INT *So moving onto that third section of the construction industry itself by which I think we really mean the volume housebuilders, is innovation the way to attract their attention?*

PA1 I think I'm not too au fait with the housebuilders in terms of what their drivers are but I think

INT Y*ou can guess*

PA1 Yes I can have a very negative - yes but I think innovation, it's something that most companies talk about and speak about wanting to pursue and be at the forefront of so I think the housebuilders could be convinced to go down the route of concrete if it doesn't affect there ability to deliver what the market wants. So if it looks like a traditionally built house and there is innovation there which means they can offer something to differentiate themselves and gives them something extra over the rest of their competition then I think they would reach out and grab that and actually take that on board.

INT *And do you see their differentiator being anything other than the bottom-line profit?*

PA1 I think profit's going to be a huge driver but if they can see an innovation that will drive their clients to them and potentially increase their market share or something, they're going to be interested in that. But it comes back to someone has to take that step somewhere down the line to educate that end user - the person who is actually paying the money to supply that.

INT *If they're not asking for anything different they're not going to be given anything different.*

PA1 Yes it's not even in the housebuilder's interest – it is going to be very detrimental for them to say they're not socially responsible and they should to a certain extent have a desire to be seen, viewed as being sustainable and pushing for change

INT *yes but it's only . . .*

PA1 A lot of that is going to be in response to going as far as they need to go and a little bit extra probably to push them ahead of the market, I think, without a high level of government trying to force them to change – to actually start delivering more sustainability and unless they get drivers from their customers who kind of enable them to increase their education of what they see as possible with a sustainable house so it's not aimed at - I don't know what people kind of see as being a traditional sustainable home

INT *I don't think we've got one yet*

PA1 No

INT *Excellent.* ***What do you see as the main threat to concrete's future as a building material for housing and from what other industries?***

PA1 I think it's probably timber I'd say is a big threat to concrete. I think timber in terms of the material question, whether it's actually timber concrete or steel I think there's a place for every material. It's application dependent and it's a case of using the right material for the right application but I think the issue with the different industries is the ability for industries to promote their material over other materials. I think there's almost been an ongoing battle to say my material's better than your material.

INT Y*es which comes out when you read all the different advertising and promotional literature*

PA1 Yes which I think is a huge issue because I don't think it actually addresses the situation correctly. That you need to pick the right material for the right application but with the timber industry in terms of the housing market, you've got timber, brick and block then concrete which is actually part brick and block but I think it's the ability of timber who've actually put themselves in a fantastic position with the promotion they've done around the materials which has kind of - yes they're very positive and send a positive message. They kind of - they've done well in getting themselves in with the government groups and accountants and industries and that's probably the biggest threat that the concrete industry hasn't actually been proactive enough in terms of promoting what they can offer and what they can actually do in housing, for example.

INT *Timber always seems an easier sell as an eco-product. On the surface.*

PA1 Yes. It's naturally viewed as being sustainable because you grow it so therefore people can see it must be. You can cut it down and grow it again you don't see the industrial process around it and the processes that need to go into it. But I think the timber industry is quite good at only looking at one part of the product's life and never actually considering the whole life. But I think again it's an education thing. If you market something really well people take that on board but they don't necessarily know and start questioning what is the actual whole life impact and is it actually any good when you come to the end of it. I think - I don't know what percentage of timber - a relatively high percentage of timber is actually scrapped, is burnt at the end of its life. It only is a temporary store for saving all this carbon taken out of the atmosphere but actually you're just storing it and releasing it at a later date.

INT *You can forgive the public for going for the simple description because it does get complex and you do get different stories depending on where you go for your answers but what about cross laminated timber as opposed to traditional timber frame?*

PA1 Yes. I think that's a big threat to precast because obviously it comes in panels. I think at the moment the sustainability challenge with CLT. I know that there was talk - it's all currently brought in from abroad or at least the timber is, so I think that naturally doesn't lend itself to being such a sustainable product if you're having to import it all.

INT *But again, not a known fact*

PA1 No, and you've got the other side of that. If you're importing that and you're using that as an alternative to something which is a UK-based product which is locally sourced and in fact whether that's any other timber or steel or concrete - not so much steal any more because everywhere's closed down But you've got the other side of sustainability which I think again people aren't aware of in terms of social aspect and what it means to buy material from your local builders merchant or local independent concrete producer or timber

merchant, so what does all of that mean in terms of money that then goes back into that local community where you could potentially have a local builder who's putting together those CLT products but it's coming from virgin fields, but it is a huge threat and I think the way it is being promoted - the benefits it offers is primarily a lot of it's in the uplift on timber rather than any sort of . . .

INT *It's building on the benefits of timber as they are perceived*

PA1 It's not actually a significant improvement in terms of the key areas where materials work - where concrete would be a more sustainable option, so with CLT they talk about improvements in thermal mass but if you want to be building with thermal mass you should be using concrete because the thermal mass is still significantly better than you're actually going to get with CLT but it's because it's a higher and improvements on timber that it is perceived that actually it's closer to concrete but the difference isn't there but I think it gets . . .

INT *so it's interesting. It's still seen as possibly the biggest threat even though within your industry you're fairly confident that it shouldn't be - if I can put it that way*

PA1 Yes. I think for the areas where concrete can offer - the benefits of using concrete can't be matched by timber. It's just the perception is an issue and I think it's the perception that is just people going down the route of this product is better it's more sustainable - whether that's true or not because that's how it's been advertised and that's how it's been put forward. Actually timber might be good for this aspect but concrete's better for this one so actually it should be a combination of using the right materials for the right application, irrespective of whether it's timber or concrete. But I think that's the challenge and the threat is that people don't necessarily see that when they're steered down the way of this is more sustainable full stop. Rather than it's more sustainable in this particular application.

INT *Do you think people just end up for an easy life deciding they're going to go down one route and then they become knowledgeable about that and before they know it they're promoting it above anything else so they're very unlikely to do a combined offering because that means they're going to have to do three amounts of research instead of one*

PA1 Yes I think absolutely that's the main things and having seen what was it Haringey Council? One of the London Borough Councils saying timber is their preferred choice for new housing and it's

INT *because we know a lot about it*

PA1 because it's almost better promoted. there's a lot more information that might not be entirely true but one when you get into a certain area that becomes the focus and does become easier. I think I tried when I worked for a heavy construction material provider - it's very easy to just say that's the right option all the time when actually it's about making sure you've got a balance between the two.

INT *We're all guilty of that I think. Interestingly Bill Dunster's new house is a combination of timber frame with a lightweight steel frame almost like a Meccano set which lets you locate where the timbers go, with screeded floors, but he's been researching this long enough to know everything, so he's quite comfortable using a combined solution.*

PA1 But I think you're right. You do end up having to learn. You've got three different areas to learn how those three different things will work together whereas if just got one you can go right I can deliver a house to this standard I know I can focus on this. You almost have to broaden your knowledge area

INT *And your workload. So how do you feel the government regulations and them taking their foot off the pedal to zero carbon affects the timber industry as much as it does your industry? It's not helping is it.*

PA1 I'm not sure in terms of SAP details what the impact will be on timber or concrete whether it's better for one or better for the other but I think yes by scrapping all or the majority of the high-level targets for sustainability - yes it's an incredibly negative thing.

INT *So that is a threat, but not necessarily more of a threat for concrete than it is for any other modern method of construction. It's not a threat to conventional build.*

PA1 No. it's a threat to encouraging people to build more sustainably because you don't have something which is - the way I kind of see it - how government legislation should be working, you want to be pushing - for the regulations to be pushing our attempts to make people improve also not moving so quickly that it leaves people behind. But you kind of want people to know there is a direction of travel that benefits and encourages the innovators to actually start going over and above that minimum ceiling and that will actually give them a strong foundation as the market moves on. You never want to be the one that having to constantly jump to catch up and make sure you're not going to be pushed back. it's kind of almost cut back and dropped off. I think is it allows people almost do the minimum to deliver.

INT *There is an argument that industry needed a breather but the reality is that a steady gradual pressure would be far better than going to fast then stopping then starting again because industry really struggles to support that kind of change.*

PA1 Yes. I think it changes the perception of the end user, the people who are going to be buying these buildings. They hear that there is a change in the government's approach and that makes you think it's not as important as we all thought - as most people have been told. It can have a negative affect on the demand and what people want and think. Yes, generally I think I can't see why it's not irrespective of whether it's needed or not. It's a - I can't understand why people don't see it as a positive thing full stop. That if you can make things more efficient then surely it's better whether it's required or not.

INT *Especially if it was going to give us a leading-edge coming out of a recession. It did seem like a very obvious route to take.*
*Excellent. Last question then. I**n what actual housing type would you see the use of concrete being most beneficial.** Where does concrete most obviously shine and show its credentials off.*

PA1 Is that housing type as in . . .

INT *within housing so . .*

PA1 so is that sort of whether it's the type of house whether it's terraced or detached or semi-detached . . .

INT *or high-rise or kit housing or. . . because if you're going to have to make inroads into the housing market it would be useful to know where would be the best place to target*

PA1 I think it would be affordable housing. In that market area because I think people who work in that area are more inclined to be looking for innovational ways that they can get more for less. Because an affordable housing spec has to be a certain budget level when you want to be able to deliver something which people can actually go and use and afford.

INT *Are you talking about running costs rather than build costs because the volume house builders should be just as interested in getting more for less.*

PA1 But I think with volume housebuilders at the moment, I don't think they have - there isn't a demand or need potentially to change what they're doing because they've got their land banks, they know exactly how many houses they can make and drop each year. They've got their processes set up they've not got anyone sort of . . .

INT *beating them with a stick*

PA1 beating them with a stick to change whereas I think there is an increasing ongoing demand for affordable housing because the market prices keep going up and it's harder and harder for people to actually get a home and then be able to run it. I think affordable housing would probably be a huge area where I think innovation offers something which might be looking for more.

INT *But what physically would it look like? Are you still thinking of conventional housing for that market? To be truly affordable and not ever so slightly less unaffordable which is really at the moment what affordable housing is, something's got to change.*

PA1 Yes. Well I think the affordable housing market is probably more - this is going to sound horrible now - well I think it's more open to being more designed to be fit for purpose which I think if you are, from my perspective if I wanted to get a house and I had issues in terms of the costs to run that house and the cost to buy that house I was probably be less inclined with getting a house which looks like a traditional bricks and mortar to actually getting a house that's fit for purpose and is actually going to deliver on those two aspect of being cheaper and cheaper to run. So for me from that perspective actually to a certain extent yes I would want it to look nice but I probably would be less against the idea of if it the different, if it's actually designed in a way that it's taken on board all of the benefits and if it doesn't mean it doesn't look like a normal traditional redbrick house, I'd be more open to that but again that might just be me, my perception because I'm open to that approach anyway.

INT *Can you imagine us ever going back to high-rise concrete housing to supply that demand?*

PA1 I'm not quite sure to be honest, I think as more people get more money and become more - no is not more money it's people who've got money get more middle-class and get more disposable income I don't think - I think it needs a change in perception of how people view owning a house whereas at the moment people want to own a house, they want the ideal house, a detached house with a big garden and a driveway, so the demand isn't necessarily there from that respect, but I don't know

INT *If the average age now for buying your first house is fortysomething there's clearly a need for something else*

PA1 there is a need in the market for something cheaper and high-rise does deliver on that then I think it will . . .

INT *It's funny isn't it. There is plenty of examples of high quality expensive high-rise housing*

PA1 but nothing in the affordable range. I think it's because . . .

INT *suddenly it goes off the acceptability spectrum*

PA1 Yes because I think the locations where probably the - I don't know - because generally you associate high-rise housing with being in the city whereas in those areas where you couldn't imagine in the suburbs somebody driving up to a 20 story building in kind of . . .

INT *well no they probably would still be in the city*

PA1 Yes I think it would be a solution but I'm not sure if . . .

INT . . . *you really want to go there*

PA1 Yes. But as you say there are plenty of examples of high quality apartments that already exist

INT *it comes down to perception again. I'm going to have to interview some very young people think to test that theory that they have a different perception*

PA1 Because I think that might be the case, because I think that's got to be . . . Yes from my age I don't want to buy and own and live in a flat. I want to have a house which has got to garden and space and be away from the city centre. But as you say at that age the average age eventually buying a house is a lot older whereas it's that younger generation that probably want to get a foot on the housing ladder and actually then in their 30s there be more inclined to be in a and making myself sound old now - a more vibrant

INT *and possibly communal*

PA1 yes - in a space that will come with more not an active lifestyle but more things happening and more things going on which you get around an area where you have got high-rise for city living because that's an aspect where you don't necessarily spend all your time there in that flat or in that apartment. So obviously the space then becomes limited in its nature.

INT *okay. That was interesting.*

PA1 It's a tough question

INT *Yes. There's also the off-site manufacturing. In what housing type would the use of concrete be most beneficial. I mean the modular approach to housing is obviously beneficial to concrete.*

PA1 Yes

PA1

INT *But again that's going to deliver a certain type of housing and not really going to produce housing estates - well - we'll cut this bit*
OK so the last question is the one which is more specific to Tarmac and Tarmac's role, and I'm not sure whether should really be asking this but ***Where do you see the role of Tarmac in this business structure to what extent do you see the company being able to influence the marketplace?*** *Because Tarmac covers a lot of industry other than the housing market so how important do you think the housing market should be for Tarmac?*

PA1 I think it should be of should be a student market because it's an area which is got a huge amount of growth because there is a huge demand and a huge shortage, so I think it is an area where there is great potential and I think that with the materials that we produce we have the opportunity to potentially be involved in delivering a product that is more - in terms of a bigger product so not just the material that we produce but the end product that the material goes into, so I think we have big role there in terms of knowledge experience and understanding of being able to help deliver that product because we have a material that actually ,when you think about it if you use it correctly and to try and make the most of it you can actually deliver something that is better than what you are traditionally getting so I think from a Tarmac's perspective I think it is quite an important market area because there is a huge area for growth. In terms of what we can do as a business to try and encourage it, I think to a certain extent being involved in projects like this is a good starting point but then we have to do a lot in terms of educating people and for us it's probably about educating people we deal with directly rather than trying to have those conversations with people who are going to be building the homes. I don't think it's necessarily our place to be having the conversation with people who are going to be buying the houses because I don't think we are in the position to be having those conversations because we don't deliver that final product we deliver a - we can facilitate. . .

INT *That's interesting because I was going to say out of those four sectors where do you think the most need further action is and that would be innovation of the material itself, lobbying the government legislation to work in your favour, convincing the house builders that you've got something they should be looking at or dealing with the whole problem public perception.*

PA1 Yes. I think for me the two key areas that need the most work would be public perception

INT *although you've said that's actually the hardest one for you to really impact on because you're not offering finished product*

PA1 We don't have that connection, and unless we're able to move into a relationship where we are the supplier for - I don't know - whether it's a new housing company set up where we would become a partner in delivering materials to it as part of a bigger group that comes together . . .

INT *So you become closer to the end product.*

PA1 Yes, and have a role there and I think that's a way we could potentially get involved because we could lend some knowledge and understanding in how that gets promoted. So I think yes it's the end user interface that needs to be influenced and I think also the government legislation side because I think they need to be in a position where their driving

it because the house builders, I think they're a very tough nut to crack because while some do have the desire and do show a desire to try and promote and change and educate, what we can do with what our materials can offer - it is very difficult when we start looking at the relationship we have with the housebuilders themselves. In terms of the big housebuilders we are kind of engaged two or three steps down the ladder.

INT *Yes, you're a supplier*

PA1 We're a supplier and generally we're a supplier of materials to someone who is a subcontractor of that house builder so our relationship is very rarely - it's rare that we actually have a direct relationship with that housebuilder. Some housebuilders will buy materials directly off us and say we buy the materials at the sub-contractual layer so the subcontractor comes to us for the materials but if we engage with the subcontractor it's very difficult for us to build that relationship with the actual builder because we've got to convince that subcontractor who quite rightly isn't overly interested because he's been told to just do this job whereas if you're directly engaged with the housebuilder we could have more of a conversation but again it's trying to change that perception in terms of what we're actually doing.

INT *And you can't - I mean you are a supplier to their industry, so you don't want to mess that up by threatening them. All you can do is - I mean do you feel as though the house builders are particularly knowledgeable about concrete but have just chosen not to engage with it or do you think there is still and educational process to be had with them?*

PA1 I'm not sure

INT *I'll find out*

PA1 Yes. I think it's probably a bit of both to be honest. I think they do know that there is the potential for them to create a more sustainable homes and I think they must be aware of that because there are examples of houses where that's happened before and there will continue to be examples, but I think a lot of it is that again if there is not the demand, why would they go and start building something that people aren't necessarily going to want, which might be, which may require them to be building a house and then educate people again to say well actually this is the house this house is better because of X, Y, and Z and they'd almost have to start educating and convincing people to change to go to that option.

INT *I think, thank you. I'm going to stop that now.*

Action list generated from annotations made as part of analysis of interview data.

interviewee David Rich, Tarmac. 01.1

annotation ref 1 **topic** 03 house building **status**

annotation There are no UK examples of volume housing in concrete to showcase other than Grand designs houses where the concrete is 'in you face' It's hard to promote something you don't need - or want - to see.

---

annotation ref 2 **topic** 04 public perception **status** to do

annotation Outside the housing market was there a fall and rise in popularity of concrete or did it just contiue and evelove / improve its image?

---

annotation ref 3 **topic** 02 political / economic **status**

annotation government agendas require tangible solutions which it can shout about - OSM, NewTowns, planning relaxations on extensions, localism bills . . . all things with positive connotations. Fibre reinforced concrete will just be seen as another disaster in the making and not something they'll want to get behind, even if they did look at the science. Not an easy enough sell.

---

annotation ref 4 **topic** 03 house building **status** to do

annotation Is there any proof of VHBs competing with each other by providing something different? What USPs have they tried?

---

annotation ref 5 **topic** 03 house building **status**

annotation The drive for delivering sustainability will either be a stick - from government legislation, public demand or competition between providers, or a carrot - it saves them money.

---

annotation ref 6 **topic** 03 methods of construction **status** to do

annotation it would be beneficial to categorise the benefits and the most appropriate building types for all OSM solutions, not just concrete's, even if only to help highlight the areas where there is clear competition as opposed to just a lack of knowledge about the pros and cons.

---

annotation ref 7 **topic** 01 materials **status**

annotation self promotion by cherry picking science (timber frame industry)

Appendix E TRADA educational resources

(Section 3.4.1)

Call our technical helpline for independent expert advice 01494 569601

Learning Resources

This academic area is designed primarily for lecturers and students of engineering, architecture and the built environment – or indeed anyone wishing to teach themselves more on these topics. This landing page provides links to all the key timber-related resources and information we have published that support teaching and learning requirements in higher education.

All lecturers and students who register on this page can access our Learning Resources linked to from below for free. They can also purchase printed publications by TRADA and other third parties from our bookshop at the TRADA membership discount rate. Student access lasts for one year expiring each August. You may renew your registration if your course continues to the next academic year – or join TRADA membership once in practice.

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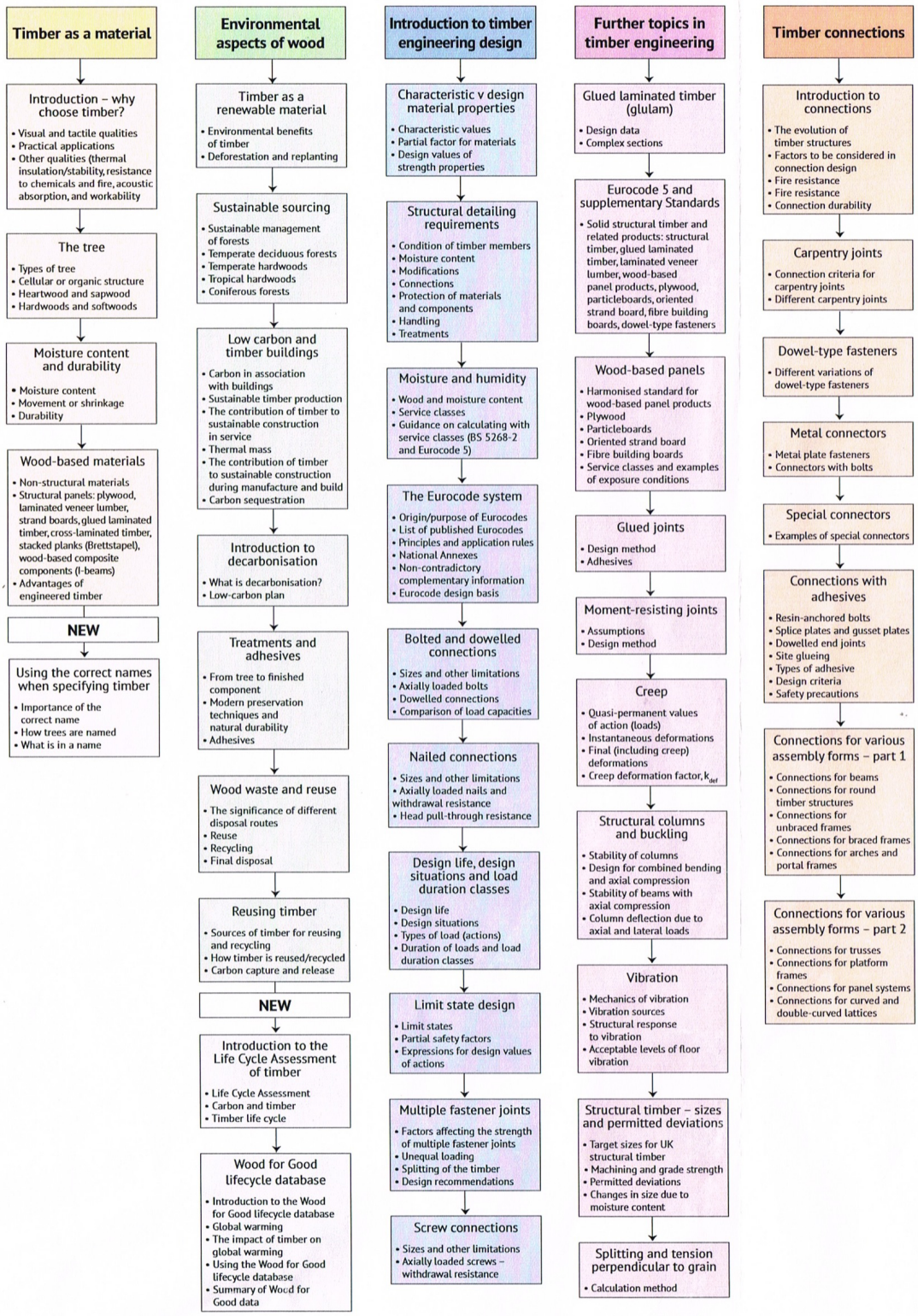
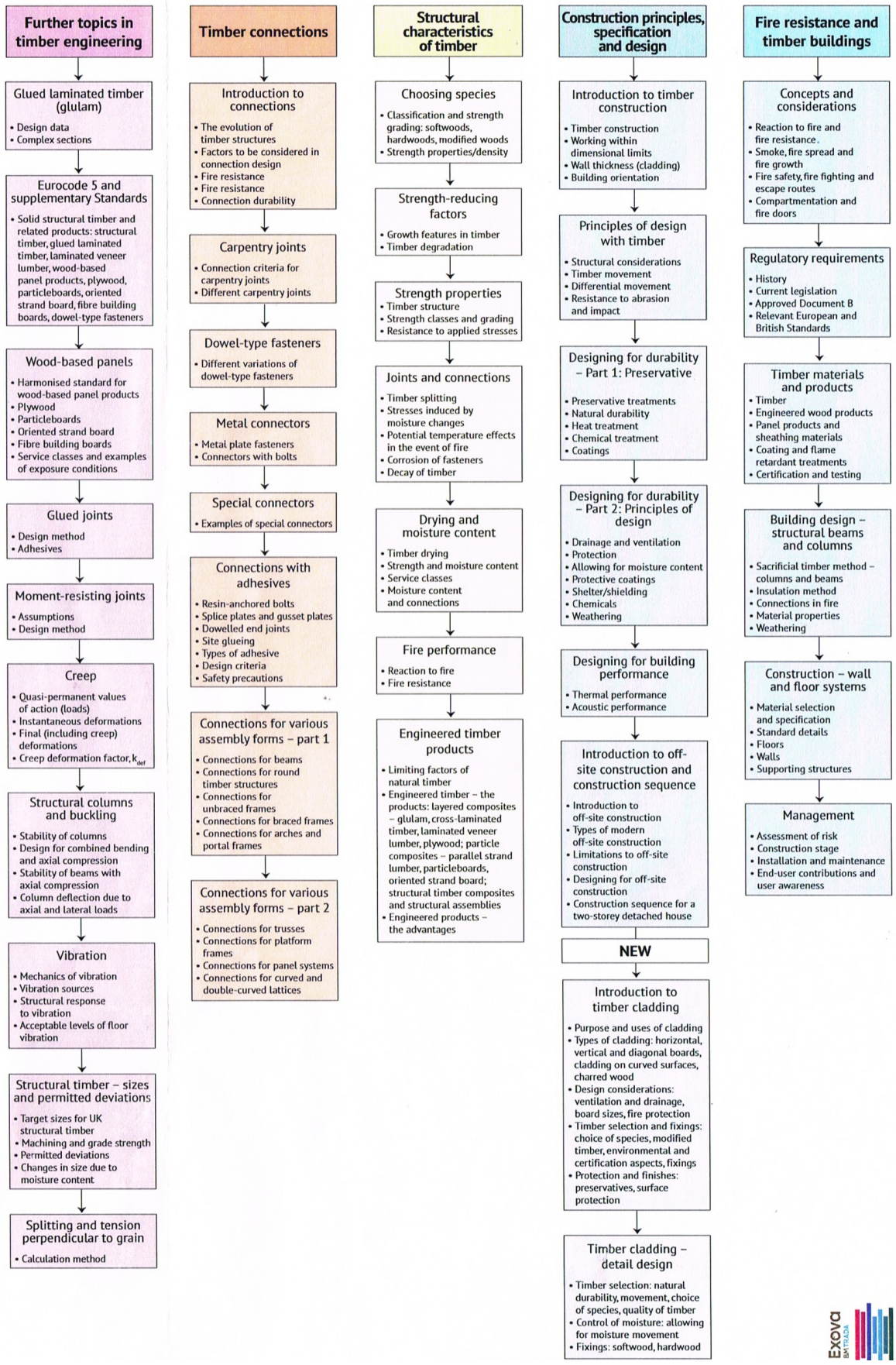
Learning resources module map



Learning resources module map



ref	date	report	title	from	purpose	key findings	quotes	recommendations	outcomes
1	1934	Alfred Bossom	**Reaching for the skies**		Bossom was an architect who went to the USA in the early 20th century, where he was involved in the design of skyscrapers. This impressed on him that construction was a process like any other, and that if all the parties worked together it could be planned in advance and then carried out to an agreed schedule. He found that contractors in the USA were able to build faster than their counterparts in the UK, but at the same cost, and as a result they were more profitable and were able to pay higher wages.	When he returned home, the deficiencies in the UK construction industry were obvious to him, and he became an advocate for change. He saw an adversarial and wasteful industry in which construction took too long, was too expensive and was not satisfactory for its clients.	'The process of construction, instead of being an orderly and consecutive advance down the line, is all too apt to become a scramble and a muddle.' 'All rents and costs of production throughout Great Britain are higher than they should be because houses and factories cost too much and take too long to build'	Similar criticisms have followed Reaching for the Skies, most notably; the Latham Report, Constructing the Team in 1994; The Egan Report, Rethinking Construction in 1998; the Government Construction Strategy in 2011 and Construction 2025, published in 2013.	"the recommendations of such reports largely fail to gain traction within the industry and the criticisms continue. It might be inferred therefore either that; under the circumstances, the industry operates more effectively than it appears from the outside; or that expectations are unrealistic; or that recommendations have been consistently poorly implemented. It is worth noting that criticism of construction is not peculiar to the UK, and that similar assessments have been made in the USA"
2	1944	The Simon Report	**The Placing and Management of Building Contracts**		commissioned to investigate how the placing and management of contracts could improve the efficiency of the construction industry. It was published in 1944 and is seen by many as the first in a long line of major, public reports criticising the modern construction industry in the UK.	The report criticised the practice of open tendering (allowing anyone to tender for a construction contract rather than using a pre-qualification process to create a short-list of suitable companies that would then be invited to tender) and suggested that **the tendency of clients to simply accept the cheapest price created a situation where tenderers would submit low bids**, and then make up their income by reducing quality or making claims. The report also recommended better training of construction managers and a more collaborative approach to design and construction with earlier	"...it has become impossible for any single Architect or Builder to have specialist knowledge and experience to deal effectively with all the new processes..... as a result specialist firms are operating on a substantial scale engaged under differing terms and conditions and to differing standards."	n 1948 Simon published a second report 'The Distribution of Building Materials and Components' which focussed on supply-side issues in the industry. Also in 1948, **The Phillips Report** on Building by The Working Party Report to the Minister of Works was published. This was followed in 1962 by the next major report into the construction industry, **the Emmerson Report**, 'Survey of Problems Before the Construction Industries'.	the Simon Report had little impact and attempts to implement its recommendations were overshadowed by the demand for rapid reconstruction in post-war Britain.
3	1964	Banwell Report	**The Placing and Management of Contracts for Building and Civil Engineering Work**	committee including leading industry figures from Taylor Woodrow Construction and others.	focussed on team relationships, construction contracts and other construction documentation, notably bills of quantities.	The report focussed on team relationships, construction contracts and other construction documentation (notably bills of quantities). It looked in detail at the traditional separation between design and construction and criticised the industry for having entrenched positions and operating with		standard contracts. The recommendations of the report were adopted by many Local Authorities although not taken up by the Ministry of Works, and action on contracts was not supported by industry bodies such as the Joint Contracts Tribunal.	The publishing of all prices submitted for tenders by participating firms is an excellent way to encourage fairer competition and was successfully adopted by many local authorities. **Meanwhile, on the ground, practice continues to be driven by market forces rather than government reports** because the
4	1967	The Potts Report	**Action on the Banwell Report: A Survey of the Implementation of the Recommendations of the Committee under the Chairmanship of Sir Harold Banwell on the Placing and Management of Contracts.**			The Banwell Report questioned why there were different forms of contract for building, civil engineering and government work and recommended the creation of a common form of contract. However, the recommendations of the Banwell Report were not widely supported, and the Potts Report failed to gain traction. Instead, industry practice continued to be dominated by market			to try to implement some of the findings of the Banwell Report

5	1987	The Brundtland Commission	**Our Common Future**	UN	to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond; • to recommend ways concern for the environment may be translated into greater co-operation among developing countries and between countries at different stages of economical and social development and lead to the achievement of common and mutually supportive objectives that take account of the interrelationships between people, resources, environment, and development; • to consider ways and means by which the international community can deal more effectively with environment concerns; and • to help define shared perceptions of long-term environmental issues and the appropriate efforts needed to deal successfully with the problems of protecting and enhancing the environment, a long term agenda for action during the coming decades, and aspirational goals for the world community.				
6	1994	Latham Report	**Constructing The Team. Govt / Industry Review of procurement and contractural arrangements in the UK construction industry**	government	the Latham Report 'Constructing the Team' was commissioned by the UK government to investigate the perceived problems with the construction industry, which the report's author, Sir Michael Latham described as 'ineffective', 'adversarial', 'fragmented' and 'incapable of delivering for its customers'.	commissioned by the UK government to investigate the perceived problems with the construction industry, which the report's author, Sir Michael Latham described as 'ineffective', 'adversarial', 'fragmented' and 'incapable of delivering for its customers'. Increase productivity by 30% by 2000. reduce dependency on tendering and allow for greater emphasis on partnerships through which skills and understanding can grow - and thereby improve efficiency and quality	Previous reports on the construction industry have either been implemented incompletely, or the problems have persisted. The opportunity which exists now must not be missed. I have tried to produce a balanced package which offers hope to all, reassurance to some, but despair to none. Above all, it needs teamwork. Management jargon calls that "seeking win-win solutions". I prefer the immortal words of the Dodo in "Alice's Adventures in Wonderland", "Everybody has won and all must have prizes".	Latham proposed that the client should be at the core of the construction process and that the industry should move away from its adversarial structure, adopting a more integrated approach with greater partnering and teamwork. The construction industry in the UK has consistently performed in a way that is thought to be wasteful compared to other industries. There is a general impression that it does not deliver good value for its customers. In part this is due to the unusual nature of the industry, where, unlike a production line, each building is a one off. But in addition, the nature of	The Latham report led to the creation of the Construction Industry Board (CIB) in 1995 to oversee implementation of its recommendations (the CIB was replaced by the Strategic Forum for Construction in 2001, chaired by Sir John Egan, author of the Egan Report 'Rethinking Construction').
7	1995	Levene Report	**Efficiency Scrutiny into Construction Procurement by Government**	The Cabinet Office	to review government procurement of construction and investigate how government could become a best practice client.	The report accepted that government was in part to blame for the poor performance of the construction industry, setting unrealistic timeframes and budgets, **not properly understanding competition or risk** and failing to create single points of		Better communication with the industry to reduce disputes. Adoption of a more commercial approach. Negotiation based on value for money. Increased training for civil servants. The creation of single points of contact.	the Government Construction Clients' Panel (GCCP) was established with membership from across government. This resulted in the creation of the Achieving Excellence initiative in 1999 to implement the recommendations
8	1998	Egan Report	**Rethinking Construction. The report of the construction task force**	In 1997, the then Deputy Prime Minister John Prescott set up the Construction Task Force, chaired by Sir John Egan	on the scope for improving the quality and efficiency of UK construction'	In the report, Sir John Egan suggested that 'the industry as a whole is under-achieving', and called for 'dramatic improvements'. He proposed that this would be possible '...if we focus all our efforts on delivering the value that our customers need, and if we are prepared to challenge the waste and poor quality arising from our existing structures and working practices'.	'...we are not inviting uk construction to look at what it does already and do it better; we are asking the industry and Government to join with major clients to do it entirely differently'. In May 2008, ten years after publication of Rethinking Construction, Sir John Egan stated that 'we have to say we've got pretty patchy results. And certainly nowhere near the improvement we could have achieved, or that I expected to achieve.....I guess if I were giving marks	The report set very ambitious targets of annual reductions of 10% in construction cost and construction time and a reduction in defects of 20% per year. the industry must replace competitive tendering with long term relationships based on clear measurement of performance and sustained improvement in quality and efficiency.	published a report on its first year of activity 'Accelerating change: A report by the Strategic Forum for Construction', chaired by Sir John Egan. In it, Egan stated 'I have been greatly impressed by the industry's efforts to apply 'Rethinking Construction' principles'. the Egan report was not entirely welcomed by the industry, and there was some perception that applying experience in manufacturing to an industry as

9	1999	government initiative	**Achieving Excellence**	Office of Government Commerce	Achieving Excellence (AE) was a government initiative launched in March 1999 by the Office of Government Commerce (OGC) following a series of cost and time overruns on high-profile construction projects. It was intended to improve the performance of government departments, as well as their executive agencies and non-departmental public bodies.		'Through the Achieving Excellence intitative, central government cleints commit to maximise by continuous improvement, the efficeincy, effectiveness and value for money of their procurement of new works, maintenance and refurbishment.'	Greater use of partnering. The development of long-term relationships. Slimming down decision-making chains. Increased training. The use of performance indicators. The use of integrated procurement routes. The use of value management, risk management and whole-life cost tools.	A suite of guidance was produced by the Office of Government Commerce (OGC) describing in detail the OGC's preferred procurement routes. 11 guides: 1 - Initiative into Action. 2 - Project Organisation. 3 - Project Procurement Lifecycle. Supporting guides: 4 - Risk and Value Management. 5 - The Integrated Project Team. 6 - Procurement and Contract
10	2001	John Bourn	**Modernising Construction**	by the Comptroller and Auditor General, was published by the National Audit Office	This report is about how the procurement and delivery of construction projects in the United Kingdom can be modernised, with benefits for all - the Construction Industry as well as clients.	The report suggests that construction costs could be reduced by between 10 and 30%. It proposed better integration and collaboration with more risk sharing, less adversarial relationships and better procurement, recommending greater use of partnering contracts		to persuade clients and the construction industry to adopt Egan best practice.	
11	2004	Barker Review	**review of housing supply**	The report was authored by economist Kate Barker and presented recommendations to the UK government	to look at what was behind the lack of supply of housing in the UK and the inability of the housing market to respond to this. Also within her remit was the role of the house-building industry, the level of competition within it, its capacity, technology and level of finance.	· In 2001, around 175,000 houses were built in the UK. This was the lowest number since the second world war. Over the past 10 years, the number of new houses built has fallen and is now 12.5% lower than in the previous decade.	Land for housing can be worth as much as 300 times its value as agricultural land. Landowners and developers generally see big windfalls when planning permission is granted, and these increases in value should be shared with the community. This would mean considerable reforms and to simplify the current system. There are issues around the relationship between the private sector as the main deliverer of housing and Government's objectives, which may not always accord with market pressures.	For government to set a goal for improved market affordability. Between £1.2 - £1.6 billion of additional funding per annum to meet predicted social housing needs. Implementation of a planning gain supplement to capture some of the benefits of development for the community. Establishment of a Regional Planning Executive to advise the Regional Planning Body on the scale and distribution of housing required to meet the market affordability target. Allocation of additional land in Local Development Frameworks which could be released by market triggers. Establishment of a Community Infrastructure Fund to help to unlock some of the barriers to development.	As a result of recommendations made in the Barker Review, the National Housing and Planning Advice Unit was formed
12	2005		**The Labour Needs of Extra Housing Output**	CITB & HBF	"This report investigates this issue by reporting the results of an extensive survey of housebuilding firms' labour needs and subsequent research into the numbers of skilled trades and office based staff required for expanded home building. It concludes that labour shortages are unlikely to hold back new housing nor unduly raise costs.	that any shortage will be due to restrictive planning controls, not to a shortage of skilled labour - as the HBF wanted. "Furthermore, construction has an extensive network of bodies planning and organising training, such as CITB-ConstructionSkills and the professional institutions, that aim to ensure a pipeline of new skilled entrants." See Farmer's comments 12 years on . . .	Capacity constraints were a concern in the Barker Report. The superficial evidence is strong. There is an endemic shortage of skilled construction labour. Reports of skills crises have occurred at frequent intervals for 50 years or more.	Taking account of already trained workers (who might need some relatively minor additional training for housebuilding) leaves a best broad estimate of 20,000 and 80,000 new UK entrants required to expand housebuilding to 250,000 and 300,000 respectively. These numbers are substantial but not impossible to achieve. So, while training issues are important in the expansion of housebuilding, it can be concluded at the same time that skills shortages are	

13	2006	Barker Review	**Land Use Planning**		The remit for the Review focused on how the planning framework in England could better deliver economic growth and prosperity alongside other sustainable development goals.	As discussed in the Interim Report, there are no silver bullets to resolve the weaknesses that that report identified. Rather, a wide-ranging package of reform is needed, addressing three key issues: Flexibility and responsiveness Efficiency of process More efficient use of land	Economic, social and environmental goals will be attained more readily by a planning system that is focused more on outcomes, and less on processes	As well as looking at how current initiatives can be enhanced, there is also the question of possible new means for providing better incentives. This section considers two of these: 'good-will' payments and 'land bids'. Both, potentially, can target a proportion of the financial gains from development at those affected by the planning decision but who	
14	2006	Stern Report	**The Economics of Cliamte Change**	govt	The report discusses the effect of global warming on the world economy. Although not the first economic report on climate change, it is significant as the largest and most widely known and discussed report of its kind	main conclusion is that the benefits of strong, early action on climate change far outweigh the costs of not acting	vast debate with many critisisms. Not peer reviewed beforehand	Spend 1% of global GDP. In June 2008, Stern increased the estimate for the annual cost of achieving stabilisation between 500 and 550 ppm CO2e to 2% of GDP to account for faster than expected climate change	
15	2006	DCLG Consultation	**Building a Greener Future: Towards Zero Carbon Development**	DCLG	Our key goal is to achieve zero carbon new homes within a decade.	Q1 Are we right about the need for new housing to lead the way in delivering low-carbon and zero-carbon housing, and is it achievable in the timescale we have set out? Q2 Have we got the assessment of costs and benefits right? Q3 Have we got the balance right between the contribution of the planning system and that of building regulations? Are there other policy instruments we should consider? Are there ways in which we can design our policy instruments to achieve the same goals more cost-effectively? Q4 Are there significant solutions to climate change that our policy framework		a package of measures which will support this ambition – consultation on a new Planning Policy Statement and on a progressive tightening of Building Regulations, and the launch of a new Code for Sustainable Homes	Superseded by Building a greener future: towards zero carbon development: analysis report of consultation responses (DCLG, 2007)
16	2006	Zero Carbon Homes							
17	2007	The Callcutt Review	**Housebuilding Delivery**	Submission of evidence by the Joseph Rowntree Foundation	1) to examine how the supply of new homes is influenced by the nature and structure of the housebuilding industry, the business models and its supply chain, including land, materials and skills; 2) to consider how these factors influence the delivery of new homes to achieve the Government's target (200,000 new homes per annum), meeting housebuyers' requirements and aspirations, achieving high standards of energy efficiency and sustainability as set out in the Code for Sustainable Homes, and progressing to a zero carbon standard; and 3) to make recommendations.	The JRF has recently funded a major programme of research that has sought to improve our understanding of how housing markets operate and the interventions that are required to counter market failure. Overall the programme has **highlighted the need for a more sophisticated approach to housing market analysis**, focusing on a broad range of issues other than house prices to take into account factors such as the local economy, job markets,	A key issue here is how far the industry leads demand or replicates what it perceives to be people's particular preferences. Learning from European models of high density flats for families could also be helpful. "But this isn't just about building more homes - it's about building better, greener homes. *Yvette Cooper*	require the Government to move away from its current 'best value' definition for how public land should be sold. The impact of this definition of best value is that land tends to be sold to the highest bidder, rather than the bidder whose plans would most benefit the public interest. Therefore the definition of 'best value' should be widened beyond monetary considerations to something that could encompass 'best value for the public interest'	GOVT response: new legal definition on what constitutes a 'substantial start' Introduce new 'fast track contracts' to help speed up the development of new homes on public sector land Give increased support to sustain the Government's drive to make all new homes zero carbon by 2016, Closely examine proposals for an annual independent customer satisfaction survey on new housing (?) Agree a 'new industry standard' to increase transparency of developers' land holders held for future housing

18	2008		**Strategy for Sustainable Construction**	The UK Department for Business Enterprise and Regulatory Reform (BERR)	to promote leadership and change to achieve sustainable goals among the public and the construction industry. The strategy sets out a number of target areas, which it labels 'means', and a number of areas where it wishes to see improvement, labeled 'ends'	to radically change the sustainability of the construction industry by: Increasing profitability through more efficient use of resources; Encouraging firms to secure the opportunities offered by sustainable products or ways of working; and Enhancing company image and profile in the market place by addressing issues relating to corporate and social responsibility.	Purpose of the Strategy This Strategy is aimed at providing clarity around the existing policy framework and signalling the future direction of Government policy. It aims to realise the shared vision of sustainable construction by: • Providing clarity to business on the Government's position by bringing together diverse regulations and initiatives relating to sustainability; • Setting and committing to higher standards to help achieve sustainability in specific areas; • Making specific commitments by	detailed actions and deliverables across all sectors of the industry
19	2009	Wolstenholme Report	**Never waste a good crisis**	by Andrew Wolstenholme of Balfour Beatty Management for Constructing Excellence.	It was intended to assess the progress that the industry has made since Rethinking Construction and concluded that, 'Since 1998 we could have had a revolution and what we've achieved so far is a bit of improvement.'	We believe that the era of client-led change is over, at least for the moment, and that it is now time for the supply side to demonstrate how it can create additional economic social and environmental value through innovation, collaboration and integrated working – in short, the principles outlined in Rethinking Construction. For Government as a policy maker, the challenge is to create an environment that incentivises innovation and speeds up the modernisation process. Above all, we need leaders who can engage the public and key stakeholders about the 'new value' the built environment brings,	Since Sir John Egan's Task Force published its report Rethinking Construction in 1998, there has been some progress, but nowhere near enough. Few of the Egan targets has been met in full, while most have fallen considerably short. Where improvement has been achieved, too often the commitment to Egan's principles has been skin-deep. In some sectors, **such as housing, construction simply does not matter, because there is such limited understanding of how value can be created through the construction** process. After nearly 30 years in the industry, I believe this tribal approach among professions is a deep-rooted problem	So what will make the industry change now when it has failed to do so before? We believe that an essential step is for suppliers, clients and Government to adopt a new vision for the industry based on the concept of the built environment. We need to abandon our existing business models that reward short-term thinking. Instead, we should incentivise suppliers to deliver quality and sustainability by taking a stake in the long-term performance of a built asset. G4C recommendation: the group demands "professionals with a strategic understanding" "one point of contact" but needs integrated contracts in place. "early contractor involvement," "a fully developed set of key performance
20	2010		**Low Carbon Construction**	Innovation & GrowthTeam	This strategy means that the public sector will become a better client - more informed and better co-ordinated when its requirements are specified, designed and procured. The strategy also challenges industry business models and practices. It will replace adversarial cultures with collaborative ones; and will demand cost reduction and innovation within the supply chain to maintain market position – rather than innovation that is focussed on the bidding process - with a view to establishing a bargaining position for the future.		**"I have yet to see any problem, however complicated, which, when looked at properly, did not become still more complicated." Poul Anderson, New Scientist** "Is the construction industry fit for purpose for the transition to a low carbon economy?"	there are three crying needs: **for clarity** – for a clearer path through all the complexities which attend the transition to low carbon; **for co-operation** – for Government and industry to work together in finding that clarity and making plans; **and for confidence** – for market failure to be addressed so that building owners and occupiers are incentivised to become customers for commercial offers aimed at carbon reduction

21	2011		**The Localism Act**		decentralise power to regions	part 6 planning: The Community Infrastructure Levy now includes the additional costs, besides infrastructure costs, that development places on an area. The Act allows neighborhood plans to be developed. part 7 housing: Each English housing authority must have an "allocation scheme" for determining priorities.			Although the act was envisaged as having the potential to bring about wide-scale decentralisation, there have been few significant examples of its implementation. leading to the introduction of the Cities and Local Government Devolution Act 2016.
22	2011	a housing strategy for England	**Laying the Foundations**	Govt	The Government is clear that we need to get the housing market – and in particular new house building – moving again.	We inherited a housing market where: • buyers can't buy • lenders are not lending • builders are not building • investors are not investing • affordable housing can do more • tenants are struggling	At the heart of this is our commitment to delivering the Zero Carbon Homes standard for all new homes from 2016,	Previous housing policies have failed. We need a new approach – one that respects local communities and gives them a greater say over decisions on new housing. An approach that works with, not against, the grain of the market. And one that seeks to provide the stable, long-term increase in housing supply which the	
23	2011		**Government Construction Strategy**		This strategy means that the public sector will become a better client - more informed and better co-ordinated when its requirements are specified, designed and procured. The strategy also challenges industry business models and practices. It will replace adversarial cultures with collaborative ones; and will demand cost reduction and innovation within the supply chain to maintain market position – rather than innovation that is focussed on the bidding process	Construction output contributes some 7% of GDP - more if the whole-life contribution through planning, design, construction, maintenance, decommissioning and reuse, is taken into account. The sector is worth about £110 billion per annum1. This comprises three main sub-sectors: commercial and social, £49 billion (£20bn public, £29bn private); residential, £42 billion (£14bn public, £28bn private); and infrastructure, £18 billion (£7bn public, £11bn private). in residential, the public sector has a relatively small new build programme (£4bn) compared to repairs and maintenance (£10bn) – the residential construction markets have different dynamics to other construction markets		The overarching aim is to reduce the cost of Government construction projects by 15-20% by the end of the Parliament	
25	2013		**Construction 2025**	Govt.	a joint strategy which sets out how industry and Government will work together to put Britain at the forefront of global construction over the coming years	• PEOPLE An industry that is known for its talented and diverse workforce • SMART An industry that is efficient and technologically advanced • SUSTAINABLE An industry that leads the world in low-carbon and green construction exports • GROWTH An industry that drives growth across the entire economy • LEADERSHIP An industry with clear leadership from a Construction Leadership Council	Hollow aspirations Coming so soon after the Government Construction Strategy, and proposing such ambitious targets, there is some scepticism that the vision is achievable. There have been a great number of reports about the construction industry, and numerous attempts to improve efficiency. Despite this, the perception persists that the industry is wasteful. It might be inferred from this either that; under the circumstances the industry operates more effectively than it appears from the outside; expectations are	It rather ambitiously proposes: 33% reduction in the initial cost of construction and the whole-life costs of built assets. 50% reduction in the overall time, from inception to completion, for newbuild and refurbished assets. 50% reduction in greenhouse gas emissions in the built environment. 50% reduction in the trade gap between total exports and total imports for construction products and materials.	The Construction Leadership Council (CLC) was established to oversee implementation of Construction 2025. This is an industry / government council jointly chaired by the Secretary of State for Business, Innovation and Skills (BIS) and an industry representative (at present Sir David Higgins, Chief Executive of Network Rail). See Construction Leadership Council for more information.

25	2014	Lyons Review	**Housing Review. Mobilising across the nation to build the homes our children need.**	independent review carried out by Sir Michael Lyons for the Labour Party's Policy Review	The Review sets out a roadmap for tackling the housing crisis to 2020	Much of the document looks at reintroducing measures which were introduced by the previous Labour government and abolished by the Coalition government, such as; moves towards spatial planning to be reintroduced into the NPPF; strategic planning obligations to be placed on local authorities (replacing the Duty to Co-operate with a Right to Grow), and the much vaunted return of Development	it is about addressing the public's concern that houses are often built in the wrong place, for the wrong people and without adequate attention to the pressures created for existing infrastructure the fundamental flaw in this plan is that it fails to take account of local politics and the dynamics between councillors who face elections and the communities they serve.	The need for a more diverse house-building industry a strong leadership role for local authorities to intervene where the private sector fails to deliver a recommendation for a 'use it or lose it' policy on planning permissions implied relaxation on greenbelt how garden cities may be implemented Public, private and institutional investment	on day one of a Labour government, Ed Miliband will echo Gordon Brown's words and establish housing as a priority before entering into a 50 day intensive programme establishing a Cross-Departmental Task Force and giving new responsibilities to the Homes and Communities Agency (HCA).
26	2014	review of progress	**Barker review ten years on**	CIH	Ten years on, and successive governments have grappled with the complexities associated with ensuring a stable supply of new homes.	This line in the report's Foreword is as painfully relevant today as it was ten years ago: 'A weak supply of housing contributes to macroeconomic instability, and hinders labour market flexibility, constraining economic growth'.	We make no apologies for repeating our call to allow councils to borrow more so they can build new homes	The only times in recent history when we have achieved the Lyons Housing Review target of building 200,000 homes a year have been when the government has played a direct and active role in providing new homes. Action must also be taken to unlock land for housing development. Options to consider include the International Monetary Fund's suggestion of increasing tax on vacant land, as well as the so-called 'use it or lose it' proposals which would	
27	2015		**fixing the foundations**	Presented to Parliament by the Chancellor of the Exchequer	creating a more prosperous nation	The UK has been incapable of building enough homes to keep up with growing demand. This harms productivity and restricts labour market flexibility, and it frustrates the ambitions of thousands of people who would like to own their own	The government does not intend to proceed with the zero carbon Allowable Solutions carbon offsetting scheme, or the proposed 2016 increase in on-site energy efficiency standards		
28	2015	Housing Standards Review	**April. Consolidation of standards**		The Housing Standards Review, concluded just over a month ago, was designed to streamline and simplify the planning process for creating quality, sustainable housing in the UK. Unfortunately, however, it appears to have caused a lot of confusion instead.	At a time when housing demand is at its highest, there is a fear that private developers might delay submitting an application until the conditions for planning are most favourable for their projects.			In London, standards for small housing developments are to be relaxed, which we feel sends completely the wrong message. Currently, in the London Plan, housing development must demonstrate a 35% improvement on Part L to secure planning consent. From the introduction of zero carbon homes in 2016, it will drop to 20%, with residual emissions being
29	2015	Collaboration for Change	**The Edge Commission Report on the Future of Professionalism**	Paul Morrell		"The recommendations in the report highlight that change is almost impossible without industry-wide collaboration, cooperation and consensus and the professions and other key institutions can lead the way in ensuring that this collaboration is in the public interest." -	The siloed nature of the built environment's education system needs to be reviewed. On the performance gap: There can hardly be a cause more deserving of cross-industry collective contemplation and action than the constant failure of its	• Ethics and the public interest, and a shared code of conduct • Education and competence • Research and a body of knowledge • Collaboration on major challenges, including industry reform in the interests of a better offer to clients, climate change	To the extent that action is required across different professions and institutions, the Construction Industry Council can and should be developed and empowered as a shared vehicle for joint initiatives
30	2015	The Elphicke-House Report	**From statutory provider to Housing Delivery Enabler: Review into the local authority role in housing supply**	independent report	To look at what councils do, and what councils can do.	• Councils should explore innovative financial mechanisms to support new housing development. • Councils should consider setting up local housing delivery organisations. • There should be a **Housing and Finance Institute** to support a step change in housing activity, unlock opportunities, boost skills, and increase capacity. • Housing development offers investment potential for local pension funds.		Our key recommendation is that councils change: from being statutory providers to being Housing Delivery Enablers. Our report sets out detailed recommendations on how housing delivery organisations can be established, and how private sector financing can be attracted	This is not an official publication of the House of Commons or the House of Lords. It has not been approved by either House or its committees

32	2016	Zero Carbon Homes ammendment defeated	**May**						
33	2016	Report from the Commission of Inquiry into the quality and workmanship of new housing in England	**More Homes Fewer Complaints**	All Party Parliamentary Group for Excellence in the Built Environment	Buying a house is probably the biggest investment that many of us will make. First-time buyers are purchasing a dream which they want to be of good quality. We need to build more homes, but I want quality homes for quality homeowners. We also need to ensure that there is a clear process whereby developers can be held to account and are responsible for correcting any below-par workmanship as soon as possible.	The weight of evidence we received suggested that as the number of new homes being built has increased, so house quality has declined. according to the 2015 National New Home Customer Satisfaction Survey carried out by the Home Builders Federation (HBF) and the main warranty provider, the National House Building Council (NHBC), 93% of buyers report problems to their builders	The UK's home ownership rate in 2014 stood at 63.1 per cent, down from 69.3 per cent in 2002. The home ownership rate for those aged 25–34 fell even more steeply from 59 per cent to 37 per cent. According to the Nationwide building society the average house price has risen around 80 per cent over that same period.	if the industry failed to make satisfactory progress, it would recommend further intervention in the form of a statutory redress mechanism for new homebuyers funded by a levy on the industry	The Oxford Economics model suggests that even increasing home building to around 300,000 for one year, almost double the current rate, would reduce prices by only 0.6 per cent given rates of household formation.
34	2016	Redfern Review	**into the decline of home ownership**	independent	an independent review of the causes of falling home ownership, and associated housing market challenges, and highlights areas for debate and future policy development	On home ownership, our key finding is that the drivers of the reduction in home ownership over the last 12 years are macroeconomic, and closely connected with the relative financial strength of young people compared to older generations. On the broader housing environment, our unsurprising conclusion is that it is supply that can make the difference. However it		Our policy suggestions in this area therefore are heavily weighted towards long-term strategy and cross-party and independent support for sustainable policies. I do believe that short-termism is the biggest problem that we have to deal with in policy setting.	
35	2016	The farmer Review (CLC)	**Modernise or Die**	Independent review commissioned by CLC at the request of government	The Farmer Review of the UK Construction Labour Model' was commissioned in February 2016 by the Construction Leadership Council at the request of the government. Led by CEO of Cast Consultancy, Mark Farmer, the report investigated the current labour model and proposed actions to safeguard the industry's future	The report suggests that the UK's construction industry faces 'inexorable decline' unless longstanding problems are addressed. In particular, the review highlights the sector's dysfunctional training model, its lack of innovation and collaboration, and its non-existent research and development (R&D) culture. It finds that high levels of cost inflation, driven by labour shortages, have caused numerous housing schemes to stall as their costs have risen prohibitively.		The Construction Leadership Council (CLC) should have strategic oversight of implementing the recommendations. The Construction Industry Training Board (CITB) should be comprehensively reviewed and reformed. A reformed CITB should reorganise its grant funding model for skills and training aligned to a future modernised industry. Investment in R&D and innovation in construction by changing commissioning trends from traditional to pre-manufactured approaches. A comprehensive innovation programme to define key measures of progress and report regularly against these. A public-facing story and image for the holistic 'built environment' process, including an outreach programme. Government willingness to intervene to help establish and maintain appropriate skills capacity. Government should promote the use of pre-manufactured solutions in the housing sector. Government should assemble and publish	

36	2017	**fixing our broken housing market**	DCLG	First, we need more land for homes where people want to live. Second, we need to ensure that homes are built quickly once planning permissions are granted. Third, we will diversify the housing market, opening it up to smaller builders and those who embrace innovative and efficient methods. It will ensure that the housing market is as fair for those who don't own their own homes as it is for those that do.	The problem is threefold: not enough local authorities planning for the homes they need; house building that is simply too slow; and a construction industry that is too reliant on a small number of big players	In 21st century Britain it's no longer unusual for houses to "earn" more than the people living in them. In 2015, the average home in the South East of England increased in value by £29,000,5 while the average annual pay in the region was just £24,542. Over the past 25 years, productivity across the whole economy has grown by 41 per cent as new technology and new ways of working make business and industry more efficient and effective. In	For local authorities: We will make it easier for local authorities to take action against those who do not build out once permissions have been granted. For private developers: In line with the industrial strategy, we will boost productivity, innovation, sustainability and skills by encouraging modern methods of construction in house building. For local communities: We will ensure they see the benefits of housing growth and have greater say over the design of	Home Building Fund; Accelerated Construction programme; Making better use of land for housing by encouraging higher densities, where appropriate, such as in urban locations where there is high housing demand; and by **reviewing space standards**

Appendix G Public Survey Structure

(Section 3.3.3)

1 Personal data gathering:

Select the type that best describes you from the categories below

Demographics:	age, gender, life stage
Psychographics:	values, beliefs, opinions, interests. The 4Cs segmentation
Sociographics:	socio-economic scale.
Current dwelling:	house type, no. of beds, type of construction.

2 Perceptions held:

What words would you use to describe:

Aesthetically:	the appearance of concrete housing
Sustainability:	the sustainability credentials of concrete housing
Social connotations:	the social and cultural image of concrete housing

(answer these questions in your own words, and then again choosing any words from the lists provided)

3 Current knowledge:

How much do you know about:

Concrete's credentials:	flood, fire and sound resistance, robustness, thermal mass, proximity,
Concrete's problems:	mortgagability, image, sustainability,
Benefits to housing:	build cost, running costs, maintenance costs, sound proofing, security,
Benefits to planet:	sustainability, resilience, longevity

(choose which statement best describes your reaction to the facts provided)

4 Future desires:

Which of these options best describes how you want to live:

house type	what type of dwelling would you realistically want to be living in now
location	where would you prefer that to be
environment	what type of environment would you prefer to be living in

image	which words best describe how you see your ideal home
ownership	which words best describe how you see yourself living in your home
construction	how do you envisage your ideal house being constructed

(select the words from the lists that best describe your preference)

These four sections all need to be dealt with in a way that best suits the information being gathered.

The first section is a straight forward selection procedure, ticking the most appropriate box to describe your circumstances.

The second section, where we are trying to understand the perceptions held about concrete housing is best conducted as a two stage process. First, the questions are asked without prompts to get initial gut reactions, and then again with a selection of words and phrases to consider and then grade as appropriate to your associations.

The third section becomes more complex, as we are not only trying to establish a level of knowledge, but also to understand if that knowledge would have any bearing on their decision making process. We therefore need to provide the respondent with a series of facts about concrete, both positive and negative, and gauge the impact this has had or will have on their vision of the ideal home.

The forth section asks questions about how the respondent would ideally like to live, irrespective of what materials are used. This is important because the housing industry needs to know where to focus its attention with respect to public attitudes towards concrete. It may well be that some of the choices made in this section are contradictory, but there will be enough information here to know what might appeal to certain respondents were it to be offered as an unrecognised alternative to what is currently on offer.

A final section might then ask respondents to state the relative importance of their previous choices, pairing the six parameters as different combinations to consider as binary options. For instance, house type over location, location over ownership, ownership over house type, etc. This form of analysis, known as conjoint analysis, in this case involving 30 choices (each of six parameters against the five alternatives), generates a far more nuanced picture of priorities that even the respondents might not be fully conscious of.

Personal Data Gathering:

Demographics:	age:	<30, 30-65, >65
gender,	M/F	
life stage	single, couple, family, empty nester, retired	

Psychographics:

Resigned Rigid, strict, authoritarian and chauvinist values, oriented to the past and to Resigned roles. Brand choice stresses safety, familiarity and economy. (Older)

Struggler Alienated, Struggler, disorganised - with few resources apart from physical/mechanical skills (e.g. car repair). Heavy consumers of alcohol, junk food and lotteries, also trainers. Brand choice involves impact and sensation.

Mainstreamer Domestic, conformist, conventional, sentimental, passive, habitual. Part of the mass, favouring big and well-known value for money 'family' brands. Almost invariably the largest 4Cs group.

Aspirer Materialistic, acquisitive, affiliative, oriented to extrinsics ... image, appearance, charisma, persona and fashion. Attractive packaging more important than quality of contents. (Younger, clerical/sales type occupation)

Succeeder Strong goal orientation, confidence, work ethic, organisation ... support status quo, stability. Brand choice based on reward, prestige - the very best . Also attracted to 'caring' and protective brands ... stress relief. (Top management)

Explorer Energy - autonomy, experience, challenge, new frontiers. Brand choice highlights difference, sensation, adventure, indulgence and instant effect - the first to try new brands. (Younger - student)

Reformer Freedom from restriction, personal growth, social awareness, value for time, independent judgement, tolerance of complexity, anti-materialistic but intolerant of bad taste. Curious and enquiring, support growth of new product categories. Select brands for intrinsic quality, favouring natural simplicity, small is beautiful.(Higher Education)

Sociographics: Socio-economic scale. A, B, C1, C2, D E

Education.
Wealth
Health
Politics

Current dwelling: house type. Bungalow, terraced, semi, detached, flat, apartment,

no. of beds, 1/2/3/4/>4

type of construction. Conventional, timber frame, concrete, other.

Perceptions held:

What words would you use to describe:

Aesthetically: the appearance of concrete housing

60s,
prefab,
grand designs,
drab,
dirty,
white and shiny,
futuristic,
old fashioned,
individual,
architectural,
minimalist,
rough,
ugly

Sustainability: the sustainability credentials of concrete housing

high carbon footprint,
polluter,
heavy,
high transport costs,
worse than timber,
worse than brick,

Social connotations: the social and cultural image of concrete housing

poor quality housing,
social housing,
post war,
grand designs,
new money,
bling,
aspirational,
experimental

The facts:

These need to be concise, verifiable and balanced, and not all positive. This is not a marketing campaign, but an attempt to establish how important certain issues are to the public with respect to choosing how and where to live.

"Concrete's versatility and unrivalled inherent benefits means that it is a material that can provide a total solution, offering long-term performance, built-in thermal efficiency, unrivalled resistance, sound insulation, and good resilience plus robustness and minimum maintenance. All of this provided from a building material that is locally and responsibly sourced"

Concrete's credentials:

flood, fire and sound resistance, robustness, thermal mass, proximity

Flood:

"Around one-sixth of properties in England are at risk of flooding

The effects of flooding, and managing flood risk, costs the UK around £2.2bn each year.

January 2017 was the wettest since records began in 1766."

The Environment Agency

"Climate change could increase the costs of flooding 15-fold by the 2080s"

Association of British Insurers

Precast concrete basements and raised ground floors are a standard feature in many German homes.

Fire:

Concrete does not burn – it is a non-combustible material and has a slow rate of heat transfer. Concrete ensures that structural integrity remains, fire compartmentation is not compromised and shielding from heat can be relied upon.

Data published for the first time by the Communities and Local Government department shows fires in timber-framed properties appear to spread further than in other types of building.

Claims and counter claims about timber frame abound leaving home owners and housing tenants confused and worried about the risks they face.

The UK Building Regulations state minimum fire resistance requirements for all new homes. This minimum requirement is for the structure to survive intact and prevent fire spread for approximately 30 minutes to enable the safe exit of people. Far exceeding this minimum, a masonry house built with concrete pre-cast floors offers over 4 hours of protection to its occupants.

The construction and type of materials used in a new home will also influence how easily and efficiently the house can be restored or refurbished after an incident such as fire or flood.

The timber frame, steel frame and CLT industries have all lobbied government to change the regulations to reduce the length of time a building must maintain its structural integrity in the event of a fire.

Sound:

"Noisy neighbours were by far the biggest single cause of residential issues nationally."
Churchill Home Insurance.

"Nearly 1 in 10 people claim to have moved house because of poor relations with their neighbours, with over half of these being due to noise."
Halifax Home Insurance, 2010

The sound insulation performance of the apartments will be dictated by three different performance measures:
Airborne sound insulation for the separating wall.
Airborne sound insulation of the separating floor.
Impact sound transmission of the separating floor.

The sound insulation properties of concrete encompasses three key acoustic parameters: mass, stiffness and damping. If isolation and resilience are combined with these three inherent acoustic properties of concrete, superior acoustic performance is achieved.

Sound insulation between dwellings is both critical and complex. Concrete provides the best, and most economic solution.

Robustness:

Robustness is the ability of a structure to withstand events like fire, explosions, impact or the consequences of human error, without being damaged to an extent disproportionate to the original cause.

Thermal mass:

Concrete has inherent thermal mass. Increasingly, this is being used by designers to reduce the operational energy consumption of buildings. While the ability of thermal mass to reduce overheating during the summer is increasingly well known, perhaps its ability to save heating energy when used as a part of passive solar design (PSD) solution is less appreciated. Consequently, it is possible for

concrete buildings to exploit their inherent thermal mass, save energy and reduce CO2 emissions on a year-round basis.

Informed designed decisions allow buildings to benefit financially and ecologically from thermal mass

Proximity:

Part of the principle of Whole Life Costing is the distances travelled by materials from their initial procurement to manufacture and finally to site. 80% of the timber used in the UK for construction is imported, whereas no building site in the UK is more than 20 miles from a readymix site, and all aggregates are UK sourced. Proximity also impacts on security of supply, both in real terms and in financial terms.

Concrete's sustainable credentials are complex and often counter-intuitive, but comparable to timber.

Concrete's problems:

mortgagability, image, sustainability

Mortgagability:
All modern methods of construction attract more attention from the CML, NHBC, etc. because they represent a potentially higher risk for the insurance industry. Without standardisation, each diversion from the norm requires special consideration, and 'approval by exception'. This in turn creates an atmosphere of distrust around MMC, panelised concrete systems in particular, and consequent issues around mortgagability.

Mortgaging a house build unconventionally can be more complicated than for a traditionally built property.

Image:
Habits die hard, and even perceptions get handed down to generations with no direct connection or visual memories of past eras. These are reinforced by linguistic terms (concrete jungle), films and TV programmes, and financial realities like mortgagability issues.

Past images persist until they are replaced with new images. This can affect the desirability of a house built in concrete for reasons that people find hard to define.

Sustainability:
At a superficial level, concrete is not perceived as a sustainable building product, and many decisions are made at a superficial level. Even when in-depth research is carried out, this is often undertaken to justify an initial decision based on these perceptions, and the argument has already been lost.

Perceptions of concrete being 'bad for the environment' are misplaced but hard to overcome.

Benefits to housing:

build cost, running costs, maintenance costs, sound proofing, security

Build cost:

Because concrete is an economic building material it has been historically used to build low cost housing. Where cost was the main driver, investment in research and quality inevitably suffered resulting in a connotation between concrete and poor quality housing. To this day these connotations exist, and is reflected in the CML advice regarding all off site manufactured housing.

But concrete is still an affordable building material that is extensively used in high quality bespoke housing.

Running costs:

The costs associated with living in a property as opposed to buying a property relate to energy costs, both for heating and cooling, maintenance costs, and alteration costs. In turn, these costs are related to the initial design of the property and the materials used.

Concrete is a robust material that requires little maintenance when detailed appropriately and used where its benefits are most apparent. Its thermal mass helps to ameliorate internal temperatures and prevent overheating which will reduce overall energy costs.

Sound proofing:

Any housing development where there are party walls or partition floors benefits from the sound reduction inherent in dense materials and from decoupling. Airborne sound insulation requires a minimum of 45dB and impact sound insulation requires a maximum of 62dB.

Concrete walls and floors with bonded absorption boards reduces impact sound and still maintains its thermal mass properties.

Security:

Security means more than a fear of theft. It is also a sense of permanence and robustness that comes from the choice of materials. Bricks and mortar are synonymous with permanence, not because the material is more robust but because we have more visual examples of its longevity than we have of concrete in this country. Not so in Rome.

Concrete needs to be marketed as permanent.

Benefits to planet:

sustainability, resilience, longevity

Sustainability:

The sustainability of a material is dependent not only on the carbon footprint of its manufacturing process, but on its whole procurement cycle (cradle to site) and also performance during its lifecycle and its disposal thereafter.

Looked at from this perspective concrete and timber are very comparable, assuming the concept of sustainably sourced timber is a reliable one.

Resilience:

As our window of opportunity to reduce the effects of climate change diminishes, the importance of resilience in the face of its consequences grows. The need to withstand erratic climatic conditions and an unpredictable shift in temperatures favours the use of robust materials, and also ones that can be sourced locally. (But Companies are increasingly sourcing their cement from countries such as Turkey where lower environmental standards make it cheaper to produce. Because three of the four biggest companies in the UK are foreign-owned, it won't take much more to push them away from British production, and when the pound falls in value and imports become too expensive our industry will be gone.)

Maintaining our locally produced building materials is an essential part of building resilience.

Longevity:

The less we can afford to buy with respect to housing, the more important its permanence becomes.

Concrete delivers permanence

Future desires:

Which of these options best describes how you want to live:

house type what type of dwelling would you realistically want to be living in now?

flat, terrace, semi, detached, apartment, high rise, with private garden, some outdoor space, shared outdoor space, roof garden

location where would you prefer that to be?

urban, rural, suburban, isolation, city centre, urban village, well connected, close to amenities

environment what type of environment would you prefer to be living in?

social, communal, private, part private part communal, sustainable, gated, expandable, adaptable, controlled

image which words best describe how you see your ideal home?

fit in, stand out, individual, personalised but similar, understated, grand, considerate,

ownership which words best describe how you see yourself living in your home?

as a home owner, as a tenant, sharing, communally, for a supplimentary income, short term, long term

construction how do you envisage your ideal house being constructed?

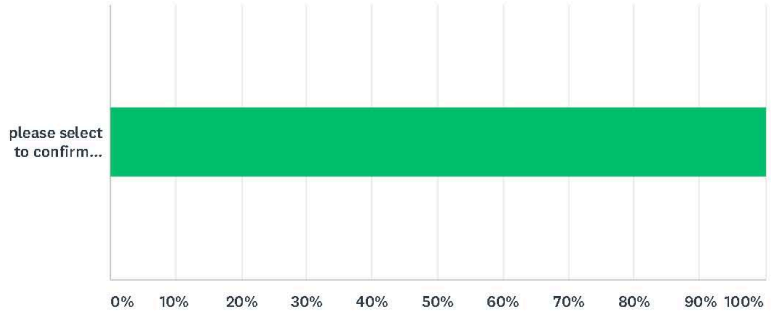
spec house, bespoke, self build, custom build, OSM, kit house,

Appendix H Public Survey as published on-line

(Section 3.3.5)

Q1 I have read the above & understand the terms under which this experiment is being conducted and consent to participation.

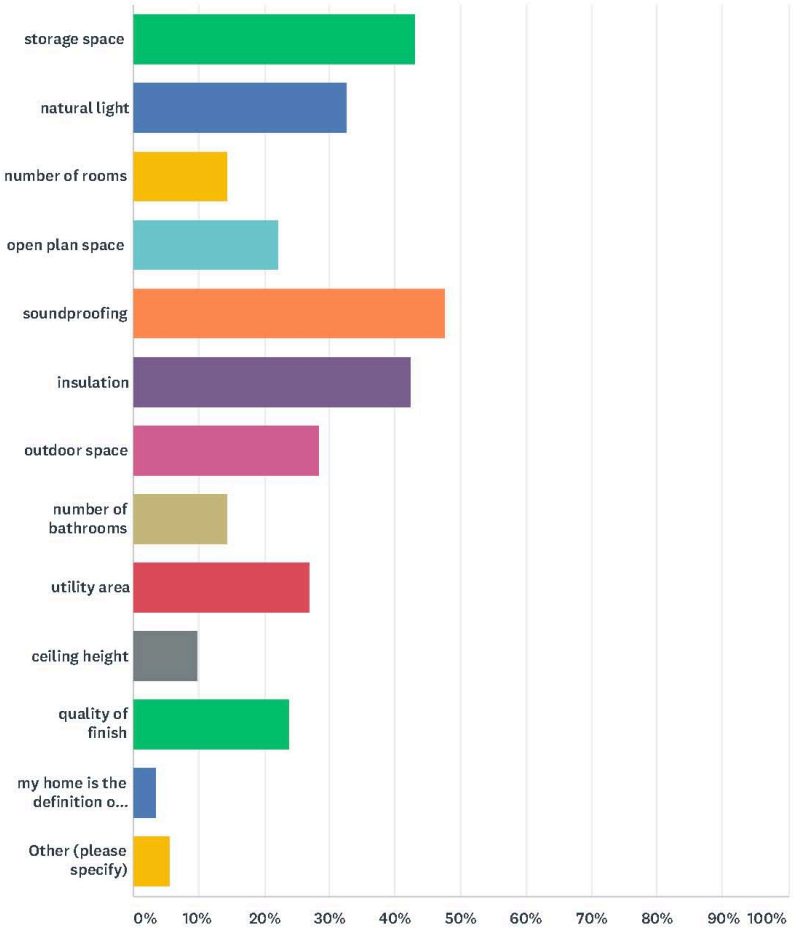
Answered: 227 Skipped: 5



ANSWER CHOICES	RESPONSES	
please select to confirm consent	100.00%	227
TOTAL		227

Q2 Which, if any of the following would you say are inadequate in your current home? Select whichever boxes apply.

Answered: 193 Skipped: 39

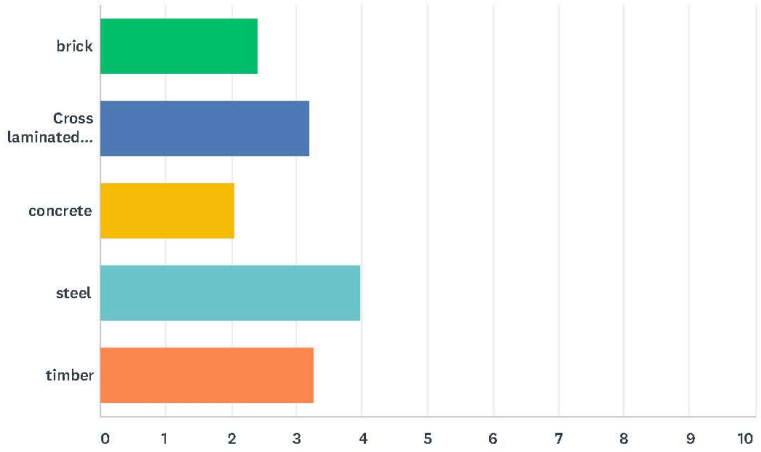


ANSWER CHOICES	RESPONSES	
storage space	43.01%	83
natural light	32.64%	63
number of rooms	14.51%	28
open plan space	22.28%	43
soundproofing	47.67%	92
insulation	42.49%	82
outdoor space	28.50%	55
number of bathrooms	14.51%	28

utility area	26.94%	52
ceiling height	9.84%	19
quality of finish	23.83%	46
my home is the definition of perfection	3.63%	7
Other (please specify)	5.70%	11
Total Respondents: 193		

Q3 Which of these materials do you think have the best soundproofing qualities?

Answered: 144 Skipped: 88

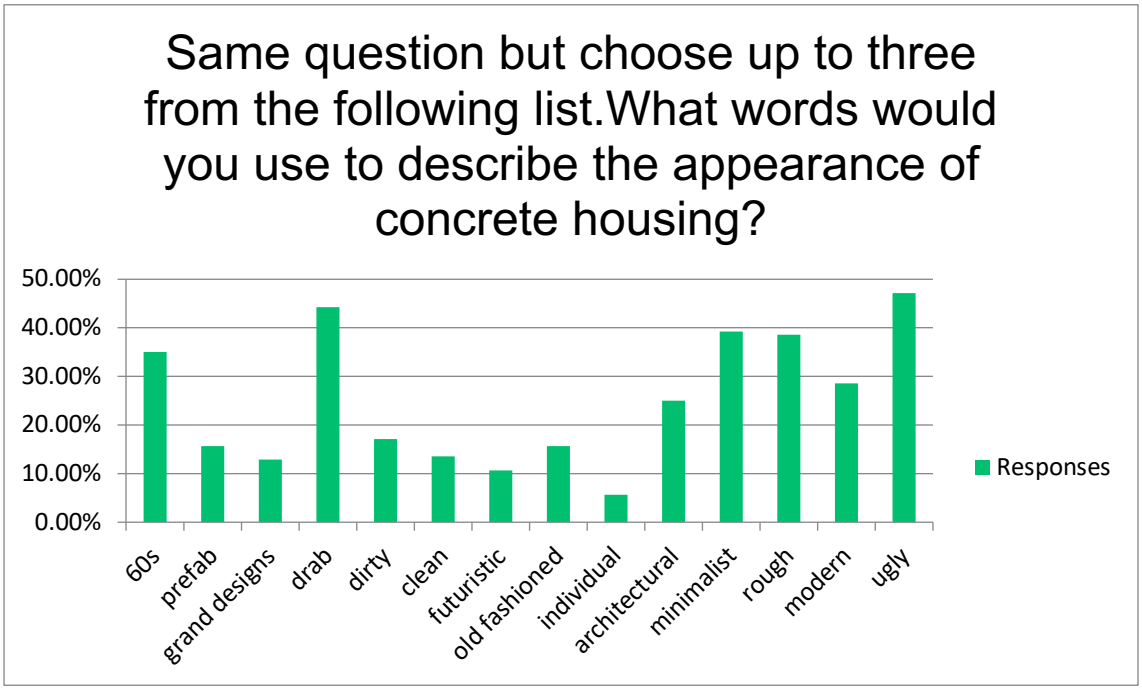


	1 (BEST)	2	3	4	5 (WORST)	TOTAL	WEIGHTED AVERAGE
brick	23.66% 31	37.40% 49	19.08% 25	14.50% 19	5.34% 7	131	2.40
Cross laminated timber (CLT) - it's like a structural plywood	16.94% 21	13.71% 17	22.58% 28	25.00% 31	21.77% 27	124	3.21
concrete	48.89% 66	20.00% 27	13.33% 18	11.85% 16	5.93% 8	135	2.06
steel	5.43% 7	6.98% 9	20.93% 27	17.05% 22	49.61% 64	129	3.98
timber	7.63% 10	22.90% 30	22.90% 30	29.01% 38	17.56% 23	131	3.26

Appendix I Public attitudes to concrete

(Section 3.3.4)

Survey results the question "What words would you use to describe the appearance of concrete housing?



Dismall Grey Gloomy Cheap Plain
gross
In some cases can look good
It is limited by the vision of the person designing it
Grey
Slick
drab to brutal
Concrete block work just painted is prison cell like. Cold. Public.
Ugly cheap
Brutalist
Bold
Dull, ugly, industrial
Bland, dull, cheap, depressing in quantity
interesting or in some cases bland
Rough, brutalist, cheap

Boring, industrial unless they are modernised
Grey, Ugly, Depressing, Dull, boring, unoriginal, cheap
Generally ugly but can look nice and modern
Grim
Grey isn't the nicest of colours
Fixed geometry, looks neat with good paintwork
cold
ugly
Looks tough and well build.. Very structured buildings
Ugly. Spartan. military
Modern
Ugly, durable, sturdy
Brutalist, mid century modern, dated
Solid
Ugly
Ugly, bland, unfinished, cheap
Brutalist, bare, monochromatic, minimalist, vast
Depends on the design, but in general quite bland
Bold, grey, abstract
Bold, imposing, dull, aesthetically-unpleasing
Brutalist Modern Dull
ugly without an overlayer
Simple, neat, strictly
Unattractive. Needs painting
Brutalist
Insipid, dreary.
Depressing
ugly
robust, grey, brutalist, industrial
Contemporary utilitarian
Brutal
Utilitarian
1960's, drab, boxy, not aesthetically pleasing, cheap
Boxy, grey
Austere
Dull, Industrial, brutal
industrial
Not Good
Dull, purpose-built, 70s
Ugly, grey, dated
It can look very basic and unappealing.
ugly
Dull / Gloomy

grey boring industrial displeasing rough age-poorly
Square Beige Ugly
Cody effective
Modern, drab, cheap
Imposing
Prison, drab, grey, boxy
shit
Colourless, stark, straight
Depressing, cold, bleak
Ugly
Low cost
Ugly, bland, scary
Ugly, plain, no character
Bleak Industrial
Grey, ugly, modernist
Ugly, utilitarian
Brutalist but beautiful, something different and exciting about it
Bland
Dramatic, versatile, imposing
Grey, boring, ugly, stained, poor
harsh, dated, unattractive
Grey
ugly
sometime ugly sometimes beautful
hard, functional, dominating
Sometimes drab, monotone, harsh, but can be modern, interesting, quiet
Grey, dull, hard, uncompromising
brutal, flat, grey, modernist, ugly
cold uninviting dull bleak
Hideous
Functional, timeless, versatile
No character
Ugly. It's always some dull, moncrome colour with harsh edges and angles
Dated, tenement, robust, cheap
hideous
Grey. Functional. Cheap looking. 60s.
ugly and grey
Horrible.
Dull, depressing, grey
Ugly, cold, lacking charater
Modern
awful
dull

Clean lines, smooth or textured finished, understated natural grey colour, combines well with timber, reassuringly solid construction

Generally dull and drab.

rare brutalist spartan

Rendered. Post Modern. Severe. Brutalistic.

dull and boring generally but can be nicely shaped

Potentially ugly

varied

clean

Modernist

Brutal

Stark, monolithic with limited domestic appeal

grey

It can be beautiful if modelled, crafted and detailed very carefully, and form street-based design as showcased at the Alexandra Road Estate by Neave Brown. However the majority of concrete clad / built housing has an unwelcoming design and feel that pervades UK perceptions of concrete.

Depends on how they are finished!

brutal but beautiful

Ugly, brutal, Communist

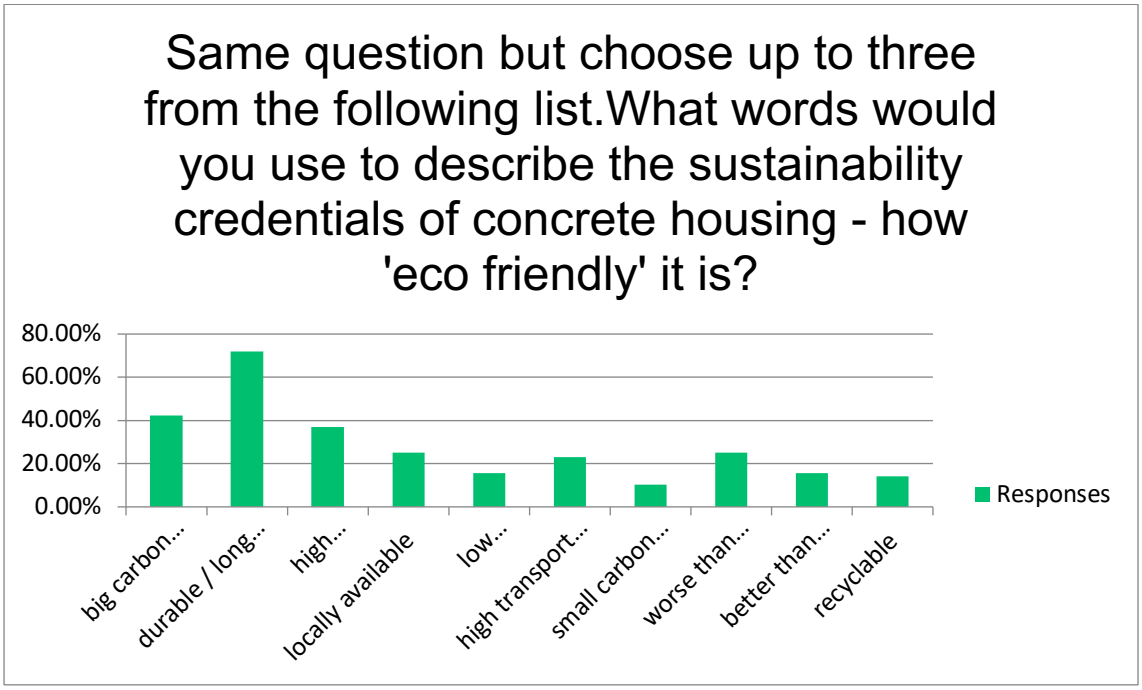
ugly

Brutalistic, severe, dominating, rough.

Drab and Institutional

Modern

Survey results the question “What words would you use to describe the sustainability credentials of concrete housing?



Lasts a long time

poor

Not good

the long term investment outweighs the embedded carbon , as concrete can act as a thermal store reducing the need for heating using fossil fuels. It can also be made using eco-concrete that lessens its impact.

Not sure!

thermally efficient store

adequate

Unsustainable

Bad

poor

Efficient

Cheap and easy to make. No import

Detrimental, no end of life, no recycling

not sure

easily made plentiful

I am not strictly aware of how sustainable the extraction of materials are. Certainly using river sand is not sustainable at all being the second most used material, as concrete is literally everywhere. Furthermore it is not biodegradable since concrete buildings in disuse just lie around like a carcass in a desert. Once seeming like a good idea, and then just a skeleton to be vandalised

by some depressed teenager who expresses his emotions in poorly drawn graffiti... and that's what they call modern art. Who am I to judge they say...

Simple, durable

Bad but could provide good insulation do good in long run

Good for thermal mass, bad for initial carbon footprint

I know a lot of fossils fuels are burned in cement kilns to create the cement

I have no idea...

-

poor, lots of CO2 in manufacture of concrete (cement)

Its eco friendly to me

unsure.. solid

High

High initial energy to produce, but sustainable in the long run. Good insulator. Durable.

Terrible co2 footprint when being produced, does last a long time when finished

Sufficient

Heavy thermal weight

Good insulation

Depends on the integration, possibly poor, possibly great

Good thermal properties, reducing the amount of energy needed for heating. Raw resources like sand though are limited and can be hard to get

Neutral

Natural components, useful, multipurpose

Unsustainable Non-renewable Pollution Extensive production process

long lifespan

Don’t know

Difficult to dispose of.

Not intuitive

Prosperous

Unknown

none

Robust, low embodied co2, long-life, recyclable, re-useable

Not sustainable

Unknown

Modest

Poor, damaging to the environment,

Good if made properly

Insulating

limited life-span, spalling,

?

Low credential but improving with recycled materials

unsustainable, poor quality

Unsustainable, high carbon footprint

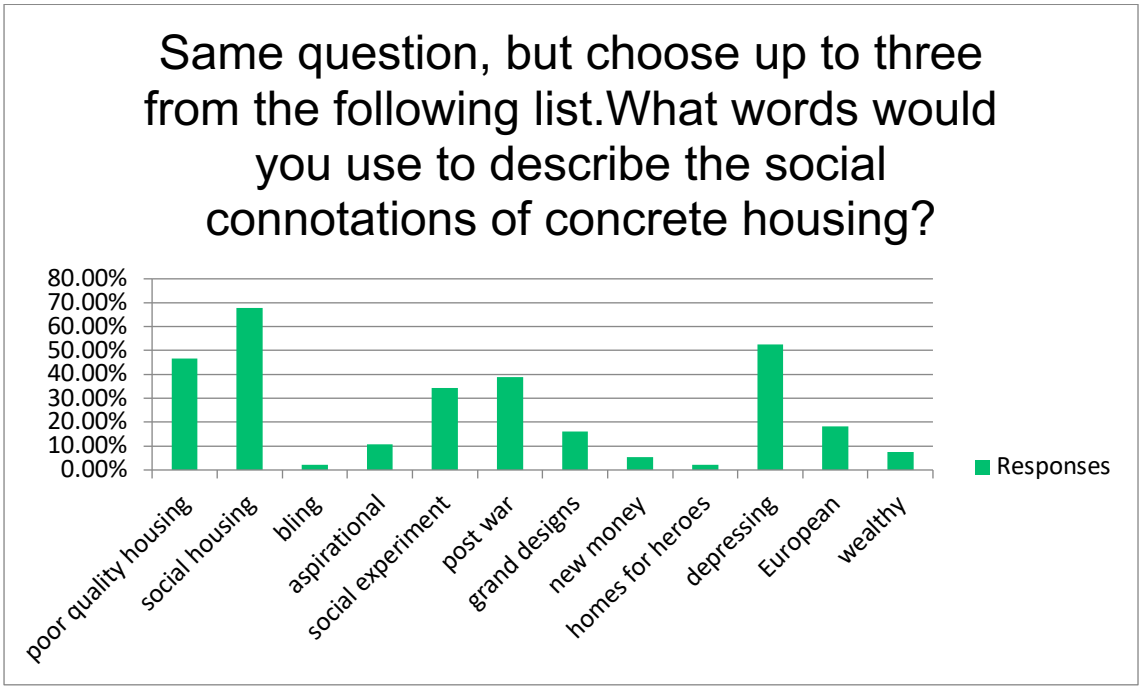
The production of concrete is not very eco friendly, however it has very good post construction characteristics.

depends on what's in the concrete - may be recycled aggregate; GGBS; durable; easy to insulate
Recyclable
minimalist long-lasting tough
Acceptable
Cheap
Long-lasting, hard-wearing
Over engineered
Don't Know
dubious
Durable, tough, clean
No idea
Long lasting
Not very much considered
Durable,
Hard wearing, durable, solid
Not that sure
Strong, long lasting
I honestly don't know anything about it
Cold
Not very sustainable
functional, cost-effective, eco-credentials dependent on manufacturing methods
I would say it's probably not as bad as other materials might be but my knowledge isn't very broad. I don't think it's sustainable because you hear about concrete cancer and about it rotting and leaking which suggests that it lacks durability and longevity
unsustainable, basic
non-renewable, lots of run off
poorly finished , need substantial additional insulation
longlasting
poor, resource hungry, inefficient
quiet, solid, long lasting, insulating, prefabricated, quick to build
Durable, heat retention
hard wearing, solid,
solid
not sure
Not
last for years
What’s all this with concrete Housing?It never seems to work in countries with heavy rainfall, like ours- that’s what I think.
Moderate
unsustainable
Energy intensive but could last a long time. Unless pulled down for ugliness.
it is easily accessible and i guess cheap. but having to change/fix breakages will cost more
Poor.
Poor

I don't know
Durable
I understand that concrete can help to retain heat
modest
Long usage lifetime
Long-lasting therefore contributing to sustainability.
undermarketed underrated durable
Poor - kicks out a lot of co2! Energy intensive.
high initial energy use but then durable and low maintenance
highly (I would imagine)
zero
unsure - isn't concrete bad?
Good
Long life but lot of energy required in its creation
I can't think of any!
good for heat retention terrible for CO2 emissions during manufacture and cannot be reused as concrete
That it can be used effectively as a thermal store when designed carefully.
I have no idea
tricky - very unsure about the embedded carbon
Am led to believe it's not environmentally friendly
drainers

Poor. High co2 release. High energy input to create.
Needs energy to produce but can be reused
I don't know

Survey results the question “What words would you use to describe the social connotations of concrete housing?



Bullied Chavy Dull Drugs
modern but ugly
Cheap type of housing
poor as in the low fines type of post war concrete housing
Cheaper
hard solid
cheap and nasty
Cold.
Poor
dunno
Communal
poor. tower block
Council housing, cheaply made, important to those who have little expendable income
depends on how is used in the design of the home
tower blocks estates lower economy housing
In the mist of boredom one might engage a conversation with himself or a wall, but I would always hope in no reply, as the fear in being judged by concrete would just be too much. Concrete infrastructure on the other hand are known as crucial meeting points for delinquents and addicts whom look down on society and their so called advances. Concrete then become their scape goat resembling the ugly side of society, where to hide and run away from it... they vandalise it as best as they can. At other times they embrace as an only option, but that is normally moments before

throwing themselves on a trafficked motorway... So one might ask...why concrete? Well it is just a cheap short time solution that avoids the bigger picture. we are an empire sitting on thousands of years of progress, shaped not in gold, marble or even stone. But some composite material that to build is destroying the wonders of once a great natural world. Disgusting.

I have no idea what this question means
Council housing
Poor areas and council housing
Somewhat a comprimise between cost and utility, association with council housing
detached
poor/lower income areas
If properly planned, there wont be a problem
council
Good
Council housing/high rise
It has connotations of council houses and high rises
Closed off
Council Estate
Cheap and quick build, low standard of living
Rough, depressing,
Generally associated with high density housing, built in the mid-to-late 20th century
Off-putting
Dull, cheap, Unappealing
N/a
-
Don’t know
Would assume to belong to a poorer person
"council housing"
Unwelcoming, hostile, frigid.
Poverty
none
Oppressive, secure, safe
Unsociable
Inflexible
Uniform
Associated with council or social housing, cheap to build, no thought or architectural input
Poor, lower class
anti
cheap, low quality, high-rise slum dwelling
prefab
Poor
low income, council run
Low cost, low class
Mass market with limited individual variation.

council housing; affordable housing
Ugly / Boring / Dreary
basic mass lower
Budget Prefab
Social housing
Affordable, cheap
Not in keeping with area
low budget, affordable, mass produced

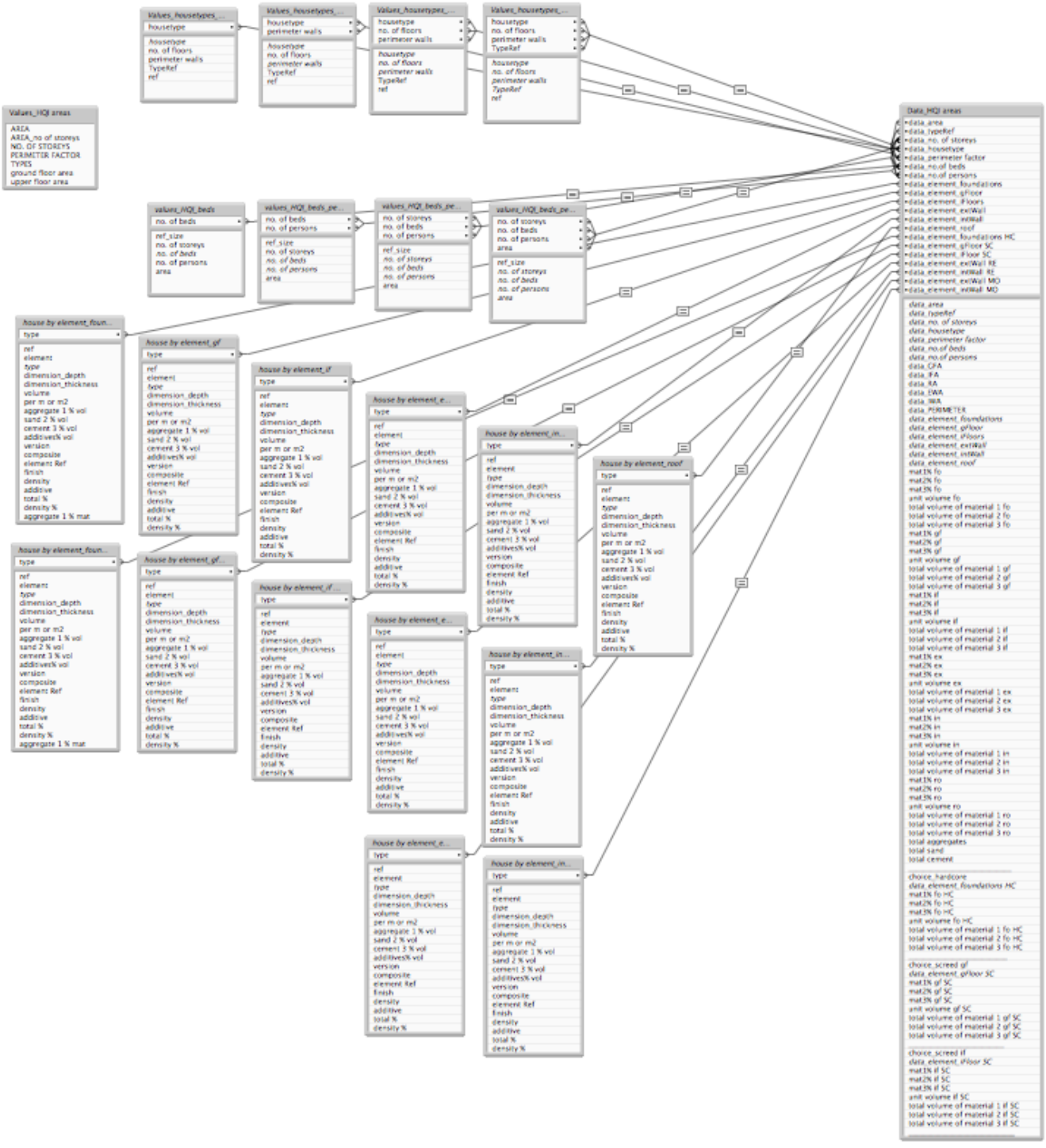
Ugly, rough, unhealthy
Not nice, cheap
Packed in
Class based
Great
Cheap, rough
could be either end of the spectrum
Council social housing, flats, high rises
Poor, council buildings
Pretentious, rich, people who like to stand out
Cheap
Idealistic, positive, subjected to right-wing ideological attack
Not brilliant, I studied planning in Sheffield and contrete I always associate with the poverty and decline of Park Hill and other estates like this made out of concrete. I think of this material as part of the problem for generally low socio-economically positioned people who to my knowledge have generally lived in houses made of such material and have generally not had a pleasant experience
social housing, basic design
council estate, park hill, rough
unloved
uh
high value and low value housing, architecturally innovative and mass produced low end blocks
uniform, urban, poor lifts, deprivation, poor, damp
High rise, 1960s
poor mans building material
lower cost housing
Soulless, grey, uninspiring
utilitarian, budget, durable
Council housing
Utilitarian, and inexpensive.
Slums, poor design, cheap, low cost
deprived
Crime
i don't know
Antisocial

council estate low income households
poor quality, low income, disadvantaged housing area
Misunderstood
not good
puzzling
Acceptable, unacceptable, modern, old, fashionable, unfashionable, depends on use and location
Council housing or cheap housing
unpretentious individual non-aspirational
60s. Prefab. Poor.
utilitarian. ubiquitous, uniform,
Historically connected to low socio-economic groups Modern day possibly more futuristic
poor
I'm not sure there are any social connotations?
Deprivation
Challenging
post apocalyptic. housing that divides society
60's LA housing (actually '70s) AND high end private housing
A poor reputation generally due to its associations with failing sink estates, tower blocks and a brutal living environment. The best examples of UK concrete homes should be more widely showcased and visited as examples of great places to live.
no social connotations
unsure
Detached, unfriendly
oppressive

60s - worn, drab, crumbling, social housing!
Institutional, Local Authority
contemporary museums, rich people

Appendix J Structure of relational database

(Section 4.1.3)



Appendix K Sample outputs from the Concrelator

(Section 4.1.3)

Material Use Calculator	2 bed 2 story detached, brick and block, concrete slab & timber 1st fl.

House type parameters		*Enter values to define typical house type and size based on occupany*
Housetype	Detached	
No. of external sides	4	
No. of storeys	2	
Housetype Reference	I	**unique reference for house type**
No. of bedrooms	3	
No. of persons	4	
No. of storeys	2	
Internal floor area	84	**calculated from HQI index figures**
Ground floor area	42	**Internal floor area / no. of storeys**
Intermediate floor area	42	**Internal floor area - ground floor area**
Roof area	46	**ground floor area * 1.1 (25° pitch)**
External wall area	108	**assumes 2.6m storey, 20% glazing**
Internal wall area	108	**assume equal to external wall area**
Perimeter length	26	**assume square footprint**

Construction type		*Enter values to define construction methods*	
Foundations	strip	hardcore?	150mm
Ground floor	slab	screed?	65mm
Intermediate floors	non	screed?	65mm
External walls	BWa, BR	rendered?	non
BW=blockwork, BR=brick, a=aerated, l=lightweight, d=dense		mortar	10mm_blockwork &
Internal walls	blockwork, aerated	plastered?	10mm
		mortar	10mm_blockwork
Roof	non	basement	basement - non

Material quantities	aggregate %	aggregate quantity m³	sand %	sand quantity m³	cement %	cement quantity m³	all m³
Basement	0	0	0	0	0	0	0
Foundations	53	10	32	2	15	1	14
Ground floor	53	3	32	4	15	2	9
Intermediate floors	0	0	0	2	0	1	3
External walls	0	0	14	4	6	1	4
Internal walls	0	0	14	4	6	1	6
Roof	0	0	0	0	0	0	0
total volume of materials	total agg	13	total sand	17	total cement	5	36m3

Material Use Calculator	2 bed 2 story detached, brick and block, concrete slab & b&b 1st fl.

House type parameters		*Enter values to define typical house type and size based on occupany*
Housetype	Detached	
No. of external sides	4	
No. of storeys	2	
Housetype Reference	I	**unique reference for house type**
No. of bedrooms	3	
No. of persons	4	
No. of storeys	2	
Internal floor area	84	**calculated from HQI index figures**
Ground floor area	42	**Internal floor area / no. of storeys**
Intermediate floor area	42	**Internal floor area - ground floor area**
Roof area	46	**ground floor area * 1.1 (25° pitch)**
External wall area	108	**assumes 2.6m storey, 20% glazing**
Internal wall area	108	**assume equal to external wall area**
Perimeter length	26	**assume square footprint**

Construction type		*Enter values to define construction methods*	
Foundations	strip	hardcore?	150mm
Ground floor	slab	screed?	65mm
Intermediate floors	beam and block, block d	screed?	65mm
External walls	BWa, BR	rendered?	non
BW=blockwork, BR=brick, a=aerated, l=lightweight, d=dense		mortar	10mm_blockwork &
Internal walls	blockwork, aerated	plastered?	10mm
		mortar	10mm_blockwork
Roof	non	basement	basement - non

Material quantities	aggregate %	aggregate quantity m³	sand %	sand quantity m³	cement %	cement quantity m³	all m³
Basement	0	0	0	0	0	0	0
Foundations	53	10	32	2	15	1	14
Ground floor	53	3	32	4	15	2	9
Intermediate floors	85	3	0	2	4	1	6
External walls	0	0	14	4	6	1	4
Internal walls	0	0	14	4	6	1	6
Roof	0	0	0	0	0	0	0
total volume of materials	total agg	16	total sand	17	total cement	5	39m3

Material Use Calculator	2 bed 2 story detached, timberframe, concrete slab & b&b 1st fl.

House type parameters		*Enter values to define typical house type and size based on occupany*
Housetype	Detached	
No. of external sides	4	
No. of storeys	2	
Housetype Reference	I	**unique reference for house type**
No. of bedrooms	3	
No. of persons	4	
No. of storeys	2	
Internal floor area	84	**calculated from HQI index figures**
Ground floor area	42	**Internal floor area / no. of storeys**
Intermediate floor area	42	**Internal floor area - ground floor area**
Roof area	46	**ground floor area * 1.1 (25° pitch)**
External wall area	108	**assumes 2.6m storey, 20% glazing**
Internal wall area	108	**assume equal to external wall area**
Perimeter length	26	**assume square footprint**

Construction type		*Enter values to define construction methods*	
Foundations	strip	hardcore?	150mm
Ground floor	slab	screed?	65mm
Intermediate floors	non	screed?	non
External walls	non	rendered?	non
BW=blockwork, BR=brick, a=aerated, l=lightweight, d=dense		mortar	10mm_brickwork
Internal walls	non	plastered?	non
		mortar	non
Roof	non	basement	basement - non

Material quantities	aggregate %	aggregate quantity m³	sand %	sand quantity m³	cement %	cement quantity m³	all m³
Basement	0	0	0	0	0	0	0
Foundations	53	10	32	2	15	1	14
Ground floor	53	3	32	4	15	2	9
Intermediate floors	0	0	0	0	0	0	0
External walls	0	0	0	2	0	0	2
Internal walls	0	0	0	0	0	0	0
Roof	0	0	0	0	0	0	0
total volume of materials	total agg	13	total sand	8	total cement	3	25m3

Material Use Calculator	2 bed 2 story terrace, timberframe, concrete slab & b&b 1st fl.

House type parameters		*Enter values to define typical house type and size based on occupany*
Housetype	Terraced	
No. of external sides	2.5	
No. of storeys	2	
Housetype Reference	F	**unique reference for house type**
No. of bedrooms	3	
No. of persons	4	
No. of storeys	2	
Internal floor area	84	**calculated from HQI index figures**
Ground floor area	42	**Internal floor area / no. of storeys**
Intermediate floor area	42	**Internal floor area - ground floor area**
Roof area	46	**ground floor area * 1.1 (25° pitch)**
External wall area	67	**assumes 2.6m storey, 20% glazing**
Internal wall area	67	**assume equal to external wall area**
Perimeter length	16	**assume square footprint**

Construction type		*Enter values to define construction methods*	
Foundations	strip	hardcore?	150mm
Ground floor	slab	screed?	65mm
Intermediate floors	non	screed?	non
External walls	non	rendered?	non
BW=blockwork, BR=brick, a=aerated, l=lightweight, d=dense		mortar	10mm_brickwork
Internal walls	non	plastered?	non
		mortar	non
Roof	non	basement	basement - non

Material quantities	aggregate %	aggregate quantity m³	sand %	sand quantity m³	cement %	cement quantity m³	all m³
Basement	0	0	0	0	0	0	0
Foundations	53	9	32	2	15	1	11
Ground floor	53	3	32	4	15	2	9
Intermediate floors	0	0	0	0	0	0	0
External walls	0	0	0	1	0	0	1
Internal walls	0	0	0	0	0	0	0
Roof	0	0	0	0	0	0	0
total volume of materials	total agg	12	total sand	7	total cement	2	21m3

Appendix L The Decision Making Tool Workshop

(Section 5.4.1)

A workshop organised to trial the Decision Making Tool brought together a range of employees from different sectors and at different levels of decision making authority. The aim was to embed the process across as broad a spectrum of people as possible, from those using the tool to gather and assess data to those controlling where any research was to be focused. To be successful it was necessary to show a number of improvements over the processes currently being used, including evidence of more 'thought through' policy decisions and a more efficient, time saving process, that could be interrogated in the future to redefine strategies as the influencing factors change.

The strategy for promoting the tool focused on the similarities between the tool itself and the innovations it aims to help promote. Both must deal with the same set of barriers defined within the tool as those perceived risks at a company level, at an industry level and those relating to the broader economy – disunity, complexity and uncertainty. Risk management begins at home, and ensuring that there is collective buy-in at the company level is the necessary first step.

To help establish that confidence in the system as a worthwhile undertaking, the workshop then focused on a known issue that is currently being dealt with unsuccessfully and showed what the barriers were preventing its progress and how they could be either removed or avoided. The issue chosen was thermal mass, and proposed options available were discussed under the headings of 'changing the message', 'changing the product', 'changing the market' and 'changing the policy'.

Each of these options were shown to represent different strategies that could be all be pursued independently on different timelines, with changing the message being an immediate solution through to changing policy being the most long term, but possibly the most necessary. Recognising that these are not exclusive options, but are in fact connected over time was an important outcome intended to encourage longer term policy making.

The second objective of this example was to show how inter-related all the company issues that the group had been asked to brainstorm actually were. An anticipated barrier to acceptance for using this approach was the need to look holistically at the outset at all the issues known to exist. Looking at one issue, such as thermal mass in isolation can be shown to result in flawed policy decisions because of a lack of awareness of how any one issue can impact on many other seemingly unrelated issues. It is only by understanding these interrelationships at the outset that a sound overall strategy and a hierarchy of both importance and 'order of attack' can be put in place.

Appendix M1

Advisory bodies and Information sources (Section 6.1.1)

Objective: *to show the degree to which each sector's knowledge can vary depending on the sources used.*

Availability and access to information is often not the main barrier to knowledge, with all reputable sources, and some less reputable, now having a web presence. Authenticity and subjectivity, with that in mind, can be far harder to define or filter out from what can be found all too easily. A review of information sources was carried out with a view to establishing how to find the sources and organizations most beneficial not only as data sources but as potential collaborative partners going forwards. This review looked at objectivity, connectivity / reach, clarity & depth of information and currency. Of equal importance, it was decided, was knowing where the rest of the industry gets its information from, and what kind of information is seen as relevant to their sectors. To establish this, a questionnaire was devised and sent out to gather that data, and compare it against the perceptions known to be held from the industry interviews (Chapter 3).

The plethora of advisory bodies within the construction industry were referred to in Chapter 3 where it was suggested that this was a consequence of the industry's fragmentation (Farmer, 2016) and that whilst a reduction in the replication of information and effort should be encouraged, that would be difficult to achieve within the current adversarial environment. Understanding how to navigate this information source would therefore, in the short term, be more beneficial than trying to rectify a symptom of a far more intractable underlying cause.

The main objective here was to firstly categorise these bodies and establish their purpose, their motivation, and the accuracy and impartiality of the information they contained, and then to establish to what extent they are relied upon by industry as an information source. The first task was a data gathering exercise together with the development of a database system for holding the information needed to make the necessary assessments. The next step of discovering to what extent they were used and by which sectors required the creation of a questionnaire that was sent out by email to industry stakeholders. All of the advisory bodies covered were found through their presence on the internet, the assumption being that all would have a web presence as their main if not only window to their client base.

The main information gathered during this exercise was about their purpose, taken from their mission statements, their relationship to the industry they were promoting, method of funding, and whether their role was primarily that of a research body, a campaigning group, assessment board or purely an information source. Without undertaking to check the specific information the sites contained, the extent to which they could be seen to be impartial from their business structure was used as a guide to the objectivity of the information provided. This was not to suggest that the information held on more promotional sites might be false, but that the choice of information used could potentially be

skewed to show a product in its best light. As the exercise progressed it also became necessary to record the date the bodies were established, their current levels of activity and their affiliations with other bodies, as many were found to be part of or born out of parent organisations.

The complexity of the exercise as it unfolded justified the need for this case study, as it became clear how 'information overload' could be seen to be counter-productive for the industry when trying to make direct correlations between products and solutions. The tendency for promotional sites to show all products in their most favourable light, and the lack of agreed industry standards means that it can be, at best, very difficult to find reliable comparators to work with. The concern was that, faced with this level of conflicting claims of superiority, practitioners were more likely to 'short circuit' the process and make their decisions based on less significant, but more straightforward factors.

These concerns were amplified by the results of the 'information sources' questionnaire that sought to establish where the industry looks for the bulk of its information. These results are discussed in more detail at the end of this section, but the key finding was that the most popular sources were those that provided the information in the most practical format on the most accessible platform. As in other walks of life, convenience, often against our better judgement tends to overrule other more important factors. *'There is no competition against instantaneousness.'* —Erastus Wiman Head of Canadian Telegraph System, 1899. These finding concur with the paper *'Equilibrium and Disorder in Human Decision-Making Processes'* (L Toma and Gheorghe, 1992) where it is suggested that in reality the time taken to make decisions is based on the inelastic attention span or time available for the decision maker, resulting in more complex decisions being the least well considered.

The insights gained from this study into the industry's decision making processes shows how such an awareness provides the innovator with valuable information when deciding how and where to promote new products to specific audiences, and what facts from competing markets need to be countered. It also helps by showing which bodies are best connected with the markets being pursued, and through which media. Websites in themselves are mostly passive platforms, with more meaningful connectivity coming through Twitter, Facebook, Linkedin, blogspots, etc. so use of these by different businesses was also recorded.

There are also many umbrella sites that serve as signposts to other related sites, or subdivisions of the parent site. Boards of directors from these bodies were also collected so that directors performing more than the one role across different sectors could be highlighted as active players most likely to be of benefit to an innovator. The extent to which these board members were active participants was harder to define, with a presence on social media platforms being one measure of involvement, but an absence by no means being evidence of the opposite.

The conclusions drawn from this exercise were very much in line with the concerns raised at the outset of this research. That is, the way in which the industry informs itself is overly influenced by convenience that can all too easily short circuit a quest for the truth. The possible reasons for this are discussed later (6.4.4), and are equally important to understand if this issue is to be tackled rather than just recognised and complied with. The more immediate concern however is how to filter this mass of information, advice and commentary so that those organisations that are most influential, most objective and best connected can be used more beneficially.

Whilst conclusions can and will be drawn from this research on this matter, as has been stated before, the aim here goes beyond providing immediate answers and also focuses on the process that would need to be used to easily replicate these tasks in the future. These are two different but equally important outcomes, as the reasons behind the lack of rigour going into this level of research by industry practitioners is more likely to be the result of the lack of time available than an inability to understand the complexity of the arguments at hand.

There are some key questions that come from this study:

accuracy / objectivity
- avoidance of biased promotional material that skews the facts to create a favourable impression.

questions:
Is the site promoting a specific product or material?
How is the site / organization funded? – government backed, membership fees or by a specific industry?
What is the site's agenda? Is it truly objective or is there a hidden bias?

connectivity / reach
- importance of using a site / organization that is well connected and visible (social media connections)

questions:
Is the organization part of a larger concern?
Who are the board members – are they from the right sectors of industry / government?
Do they have social media links? (Facebook, Linkedin, Twitter)

clarity / usability
- easy access to user friendly data in a transferable format (downloadable data files)

questions:
Is the site set up to provide useful quantitative data to promote its products?
Is this regularly maintained and current data?
Is the data based on industry recognized comparators?

depth / thoroughness
- ability to answer questions and engage in a deeper analysis

questions:
Is the organization a research facility that can engage in broader or detailed discussions?
Or a pressure group that will be motivated to help get to a deeper level of understanding?
Is it open to debate the opinions of industry, government and the public?

currency / relevance

- able to reflect any changes, events, new releases (news / reporting sites)

questions:

Is the site providing a daily newsfeed on events?
is it a source of information or a resource for holding information from elsewhere?
Can the latest news updates be found more reliably through search engines?

These questions are important because many advisory sites that are not government related information sites now depend on promoting sales of their own products, or membership fees to fund their research and perhaps maintain their objectivity. This might be seen as a measure of credibility, but does not negate a practitioner having to decide which sites to subscribe to and engage with. What is the cost of membership? What are the benefits in terms of exposure, influence, access to information, discussions, opinions? Depending on how an organization can be of benefit, this is not just a financial but a time and resource commitment. Ensuring that the above criteria can be met will help find the most appropriate sites to participate with and effectively, invest in.

By way of example, if the concrete industry wanted to further its understanding of and involvement in the off-site manufacturing debate, what connections would be most beneficial? As in all sectors there are businesses competing for the same role as the central information source, in this case the long established not-for-profit 'Build Offsite' organization (www.buildoffsite.com), and the more recent, advertising funded 'Offsite Hub'(www.offsitehub.co.uk), spanning its own in-house Offsite Magazine, Explore Offsite conferences and Construction Awards. In addition to these, there is the 'Supply Chain School' funded by industry as an educational resource with an arm dedicated to off-site manufacturing, now also linked to the Offsite Hub. At a more strategic level, the Construction Leadership Council (CLC) works between industry and government to drive industry improvement, looking specifically at BIM, off-site manufacturing and whole life costing as a means to achieving this. Depending on the concrete industry's objectives therefore - influencing government policies, ensuring concrete has a presence within the educational and training sector, promoting the use of offsite concrete solutions to the housing industry - there are options to consider.

An initial web based review would suggest that the Offsite Hub was well established and well connected. It would not reveal the fact that it is recently established, an umbrella site only for its own business interests, and fully funded through advertising, opening up the potential for bias in its reporting. None of its board members are named so it is not possible to trace any connectivity. Neither would it be immediately obvious that Build Offsite has industry specialists on its board advising the CLC and has instigated the BOPAS scheme (Buildoffsite Property Assurance Scheme) to provide warranties for unconventional methods of construction. Table A:1 below shows a comparative excerpt from the database compiled of all advisory bodies found that impact on the UK's housing delivery system.

Appendix A Advisory Bodies

	Build Offsite	Offsite Hub
sector ref	3	
sector	housebuilding	collaborator
company	BuildOffSite / CIRIA	offsite hub
info provider acronym	CIRIA	OSHUB
purpose	The Buildoffsite Housing Hub was set up at the start of 2015 to support a substantial increase in the use of offsite construction methods to increase the overall supply of new homes in the UK.	The Offsite Hub is an online information centre dedicated to keeping the world of offsite manufacturing and technology connected. Showcasing the latest and most exciting developments in offsite technology and with a broad appeal to all those interested in the world of prefabrication and factory-based construction methods
web address	www.buildoffsite.com/sectors/housing/	https://www.offsitehub.co.uk/home/
funding status	membership	membership
business status	business	business
focus	all	all
info type	campaign	umbrella
personel	http://www.buildoffsite.com/content/uploads/2015/04/Exec-group-chart-April-2015_pdf.pdf	
established	2015	~
advisory sector	business	business
advisory role	lobby	promotion

Table A:1 sample comparison of web based information sources

The Information Sources Questionnaire

Part of the process of deciding which organisations are relevant to a company's needs is understanding how the rest of the industry - its markets and client base - use their websites. To determine this a questionnaire was developed and sent out to different sectors within the housing industry. Its aim was to gather sector specific data about some key aspects of information gathering: what information, by sector, was of most interest to them, where they went for that information, both in terms of the source – academic, industry, government – and the medium they chose to access that through, and finally the level of detail they felt was required for the task. Figure A: 1 below shows the questionnaire with the boxes shaded to visually represent the frequency of responses to each option provided.

Information Sources Questionnaire

As part of my research I need to establish where the housing industry gets its information from. The following questions are set out in a format that will allow for direct comparisons, but will not necessarily work for everyone, so please ignore boxes that are not relevent to your sector.

0 = not applicable 1 = slight 2 = average 3 = considerable - or just a tick or cross if that is more appropriate

please state your industry role:

SUBJECT MATTER:

What subject areas are of most concern to you?	materials / method of construction	policy / legislation	house building / company news	public opinion / trends	*comments / other*
	19	18	12	14	

SOURCE:

Where do you usually find this information?	Academic papers	Government publications	Industry literature	general media	*comments / other*
materials / method of construction	8	11	13	6	
policy / legislation	2	20	12	11	
house building / company news	2	5	15	13	
public opinion / trends	2	7	9	17	

INTERPRETATION:

At what level do you get this information?	full publication	executive review / summary	commentry / analysis	in conversation	*comments / other*
academic papers	1	12	6	4	
government publications	13	14	10	5	
industry literature	13	11	9	4	
general media	4	5	7	6	

FORMAT:

In what format do you access this information?	printed form	websites	digital media	conferences / meetings	*comments / other*
academic papers	0	13	9	6	
government publications	0	15	9	10	
industry literature	6	15	9	10	
general media	2	12	14	1	

VALIDITY:

How much of your knowledge do you feel is down to:	cumulative experience?	original thought / innovation?	trust in authorities / procedures?	gut instinct / perception?	*comments / other*
materials / method of construction	17	8	8	5	
policy / legislation	7	1	14	1	
house building / company news	6	1	9	3	
public opinion / trends	6	1	9	10	

Figure A: 1 Information sources questionnaire responses

The results from this were analysed to see what differences, if any, there were between sectors of the industry and the type of information being sought. The limited feedback received to date means this is very much a tool to be used rather than a set of results to be acted upon, but even this limited

response begins to show how important such an exercise can be in gathering empirical evidence to either confirm or refute the perceptions thought to exist. These are a few key examples of the insights gained.

Areas of interest: Broad, with a higher than expected interest in public opinion but a reliance here on general media as a source together with gut instinct and perception.

Government policy: There is a high level of trust in information accessed on government policy, which is most often read at source, rather than through opinion pieces, but always digitally or in a conference setting.

Academic research: Academic papers are rarely read, but when they are they tend to be on materials and construction, executive summaries only, and usually digitally.

Communication: Printed literature is rarely used compared with the internet as an information source, and discussion between individuals and original thought play a minimal role in the decision making process.

The objective of this case study was to show how important it is to differentiate between information sources and to know who within the industry is using which ones, both to better understand what potential clients or collaborators know, and also how best to reach them. The database of information providers created forms the basis for an ongoing resource that will need to be updated rather than referred to whenever it is needed, but nevertheless provides the framework for the questions that need to be asked of any organization as a precursor to any deeper engagement.

Appendix M2

Findings from the Public Survey (Section 6.1.2)

Objective: *to highlight the lack of information held about the public's opinions and how much those opinions vary.*

The known gap in the knowledge gained from the industry interviews was the views of the general public. The fact that the rest of the industry were of the opinion that the public's opinion was of little consequence meant this was something that had to be resolved, resulting in the development of an on-line public survey, that has been completed by over 150 people. Its aim was to triangulate three areas of information – what the public know about the construction of their housing, what they want from housing, and who they are, demographically, psychographically and sociographically. Without this information, 'the public' are an amorphous mass of people who are assumed to not only have little say in what is ultimately being built for them as clients, but presumably are also assumed to all think alike.

The need for a public survey has been discussed in section 3.3. After some initial trials and discussions regarding ethics, the survey was written and launched on-line using Survey Monkey, where it was run for four months. In total, over 150 people completed the survey, with a good mix of participants. Because of the set of questions defining 'the public' it was possible to intervene during this time and focus the survey at different age groups, etc. as was seen to be necessary to ensure a broad coverage. The hardest age groups to attract were the over 65s (18% of the UK population), and those educated up to GCSE level only (almost 50% of the UK adult population), but the fact this was known to be the case meant that this can either be addressed in the future or allowed for. Being aware of such limitations is critical to the way in which the data from public surveys is used, and in this case the failure to attract over 50% of the country's demographic meant that, without some serious caveats, the results gathered were of limited use outside of a pilot study to be built upon at a later date.

This account follows the survey in the order it was written, taking each section in turn, and concluding with an analysis of the data broken down and sliced in the many ways needed to extract the information that was known to be missing at the outset. A full copy of the survey is in Appendix H.

The first question was to obtain consent, answered by 100% of all respondents, after which the drop off began, which is recorded here, and also of some interest.

Question: Which, if any of the following would you say are inadequate in your current home? Select whichever boxes apply.

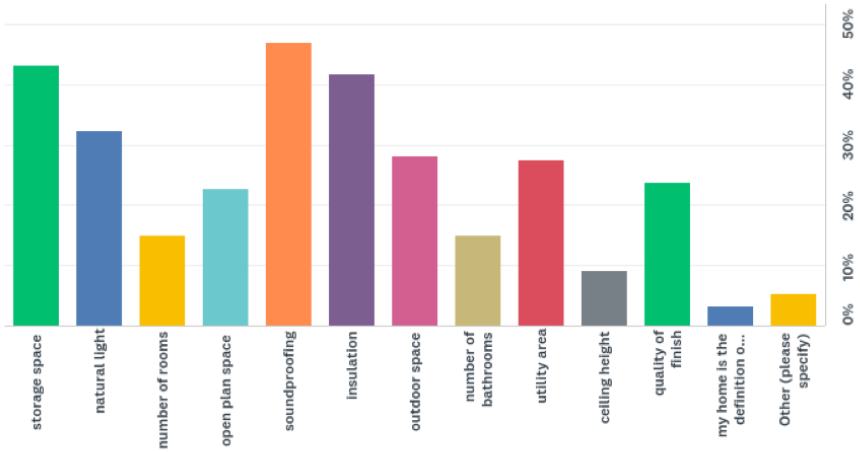


Figure A: 2 Survey responses, example output

This was very much a 'warm up' question, and also one that could be used to validate the responses with other similar preference surveys. Through the analysis of this survey there are numerous opportunities to drill down into the data to see how the general picture compares with different categorizations of the public – by age, gender, nationality, education – and even any combination of these criteria. It was the major trends we were looking for, so the analysis looked for those disparities rather than recording every possible permutation, whilst making sure that the number of participants in any one category did not become insignificantly small.

In this question, the overall figures showed the four most mentioned inadequacies to be, with the most popular choice first, soundproofing, insulation, storage space and natural light. Soundproofing was unexpected, whist the other three reflected similar recent surveys that had been found.

Looking at the figures for the different age groups showed a consistency with these four issues remaining the most important throughout with some differences beyond that, with the under 25's wanting more outdoor space and more open plan space. Whether that reflects a correlation between youth and 'volume entertaining' at home or an emerging trend which they will carry with them into their later years is unknown. Under 25's also put more emphasis on quality of finish and number of bathrooms, neither of which would be expected to become any less important with age, as they are more likely to be expectations born out of their experiences growing up - perhaps exacerbated by the over-generous specification of modern university accommodation, in turn fed by students' loan-induced ability to pay more than is necessary and the tendency to use student halls as hotel accommodation for conferences over the summer months.

Whilst this is all speculation based on an interpretation of the results, we are at least now able to speculate based on some level of evidence, rather than just making assumptions based on very generalized perceptions of 'the public' as a whole. Interestingly, the same data split by gender showed very little variance other than a male desire for more rooms. Garden sheds were not an option in the survey.

Perhaps the most important finding here however was the importance given to soundproofing, or more accurately perhaps, the belated realization of the importance of soundproofing having

experienced living in a poorly soundproofed house. Unfortunately, the one question not on the survey was 'age of property' which might have given an insight into the worst performing properties. We can however compare the results by house type:

House type	% of respondents choosing soundproofing as an issue
Terraced house	61%
Semi-detached	67%
Detached	34% (soundproofing beaten by insulation as the no.1 issue)
Apartment block	71%
Flat, converted	37% (soundproofing beaten by outdoor space as the no.1 issue)
Flat, high-rise	0%

The only one of these that will almost definitely be constructed from concrete is the high rise flat, which is a useful example of why the next section, on the performance of materials was seen as an important exercise in establishing whether the public know what the material benefits of concrete are. It is important to point out that for the first half of the survey there is no mention made of the emphasis on concrete in this research, and indeed, the survey was deliberately not sent out to anyone who knew of the researcher or the purpose of the research beforehand.

Questions on Public Knowledge

The seven questions asked in this section covered the main material attributes relevant to housing needs, and each was asked of five different construction materials – steel, brick, concrete, wood and CLT.

Question asked:	***Most popular answer:***
Best sound proofing qualities:	**Concrete**
Most waterproof:	**Concrete**
Most fireproof:	**Concrete**
Least travel distance:	**Concrete**
Least detrimental to the environment:	Timber, brick, CLT, **Concrete,** steel
Absorb the most heat:	**Concrete**
Most durable:	Steel, **Concrete**

From these results, knowledge of concrete's credentials does not seem to be an issue, except for in one very important area, that of environmental impact. More likely, these answers reflect the public's perception of concrete as a material rather than their knowledge, as there is little reason to assume

that any of the participants have any in depth knowledge of these materials outside their everyday experiences either within the housing industry or elsewhere. The perception, certainly from the interviews carried out, is that concrete is environmentally damaging, whilst timber, a natural harvested resource, has either a negative impact or at the very least a neutral impact on the environment.

For many reasons, discussed in detail in the following section 6.1.3, this is a negative perception that should be confronted, and its foundations questioned. These results suggest that this is the one barrier to acceptance that is currently blocking the remaining six positive connotations that the public has with concrete. It is not a co-incidence that these answers reflect the accepted science in each of these areas, but whilst six are relatively straight forward and uncontroversial, environmental impact is open to interpretation. Has the right answer prevailed, or is this an example of industry influence creating a belief system that has been left unchallenged for long enough for it to become enshrined in regulation?

Questions on Public Perception

The next section focuses on areas where the public is perceived to have perceptions about concrete. If that sounds vague, it is effectively how the housing industry is currently operating – basing its decisions on what it thinks the public thinks about concrete. Again, what is missing is any evidence of this, and a more nuanced picture of who thinks what when broken down by the many parameters available in the data.

The three areas investigated were aesthetics, environmental impact and social connotations. A selection of terms were provided to choose from, but only after requesting the participant to answer the question in their own words first. The purpose of this element of the question was to compare gut reactions with more considered answers when shown both the positive and negative aspects of concrete to choose from. But on a more general level the aim of these three questions was to establish whether the industry's perceptions about their customer, 'the public', were correct, and if so, whether these beliefs varied within the subdivisions that were being captured.

Aesthetics:	open	chosen from lists
negative comments	77%	62%
positive comments	20%	38%
neutral comments	3%	~

Aesthetically, the results seem to confirm the widely held belief that the public don't like the look of concrete, with the words chosen to describe concrete being overwhelmingly negative, and very polarized, with few respondents giving balanced answers. There are assumptions made here based on the tone of the answers given, as for instance Brutalism, whilst for many being a negative term, is

for some a thing of beauty. Minimalist was another term that was used by both camps, showing that aesthetics can be very subjective – hence the need for a more nuanced perspective.

From the list of words, 'drab', 'ugly' and 'rough' were used more often than 'old fashioned', 'prefab' and '60s', which would suggest that this is an ongoing dislike, and not one based on past connotations, at least when assessing the public as a whole. But what if these comments are sliced by age to compare the responses of those over and under 25? Unfortunately for the concrete industry there is very little movement in opinions to detect. Drab rough and ugly score highest across the board. One possible lesson to draw from this is that whilst the TV programme Grand Designs has undoubtedly done much to raise the aspirational profile of concrete, this is seen as being at the fantasy end of aspiration, and does not appear to translate into every day experience and expectations.

One positive to be drawn however, is the degree to which opinions changed when confronted with a balanced choice of words rather than being left to draw on individually held perceptions. A near doubling of positive associations at this point would suggest that many of the beliefs held about concrete are relatively 'un-thought' and more assumed. A number of participants actually wrote 'I am lead to believe' at the beginning of their open answers which again shows an openness to being persuaded otherwise. When split on gender, female dislike of concrete is stronger than male but not to any meaningful extent.

Environmental Impact:	open	chosen from lists
negative comments	25%	46%
positive comments	40%	54%
neutral comments	34%	~

Open answers given in this section were more positive towards the environmental credentials of concrete than had been expected, and by a substantial margin, but with a third of respondents unsure, and a third of those giving both pros and cons in their answers showing a recognition of the complexity of the argument, which should be seen as encouraging. When asked to select from the key words, durability, perhaps a less obvious environmental benefit, was chosen by almost all respondents as a positive with an equal spread across all other options.

Social connotations:	open	chosen from lists
negative comments	82%	82%
positive comments	10%	18%
neutral comments	9%	

To refer here to positive and negative comments would be inaccurate, as it would assume an association with council housing as a negative. There was however an overwhelming tendency to associate concrete with council housing with only three respondents linking the material with high end aspirational architecture, with one of those suggesting the link as one with "pretentious, rich, people who like to stand out". The words used were surprisingly varied and do not make for a

comfortable read, but do need to be seen in their entirety and are listed in Appendix I. Possibly the most important message to take from this is the need to ensure that this association is not perpetuated by promoting concrete as a low cost, visible solution. Either low cost or visible, but not both.

Question: What percentage of the price of a typical UK house do you think is due to: material costs / labour costs / land value / fees and overheads / profit?

The last question in this section was to find out how aware the public are about where the costs lie in the provision of their housing. The breakdown shown in Figure A: 3 represents a simple approximation of the actual figures that vary substantially across the UK, with land values in particular skewing these figures. A plot for a family house in the Black Country at £15k is less than a tenth of that in many London boroughs, with a consequential impact on all other costs. Despite this, the answers given were surprisingly accurate, in that the percentage of a house's value due to the land value was known to be proportionally more than the other segments, albeit by less than the national average.

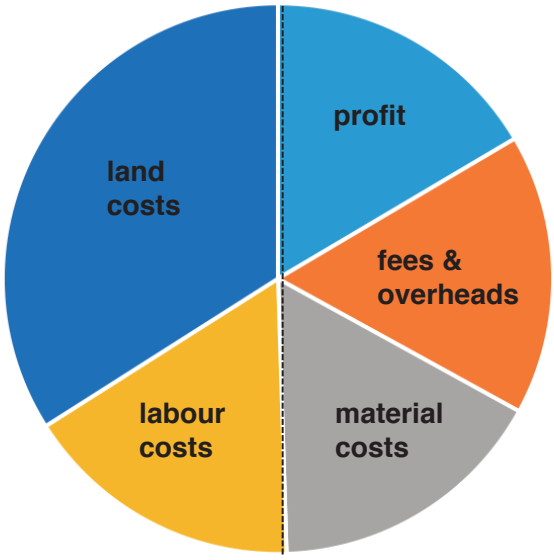


Figure A: 3 approximate breakdown of the costs of housing in the UK.

The need to ask this question stems from the fact that the use of more expensive materials does not in reality impact on the final property price as much as might be expected. An increase of 20% in material costs chosen for their sustainability or resilience benefits might result in less than a 3% total increase, especially after a degree of labour cost savings are taken into consideration.

The principle behind the next section of the survey, was to establish what type of accommodation different sectors of the general public currently lived in and also what they aspired to. Perhaps not surprisingly, the overwhelming response was for a detached house with garden. (Figure A: 4), but with good transport links, internet connection and amenities classed as more important than where that property might be. Most respondents (90%) wanted to own their own home, they wanted it to be

sustainable, adaptable so that they could stay there for a long time, but nothing too outlandish, just noticeably different. Within this, however, will be pockets of the general public who will aspire to something radically different, and the final section of questions is where the ability to define who those groups are will be found.

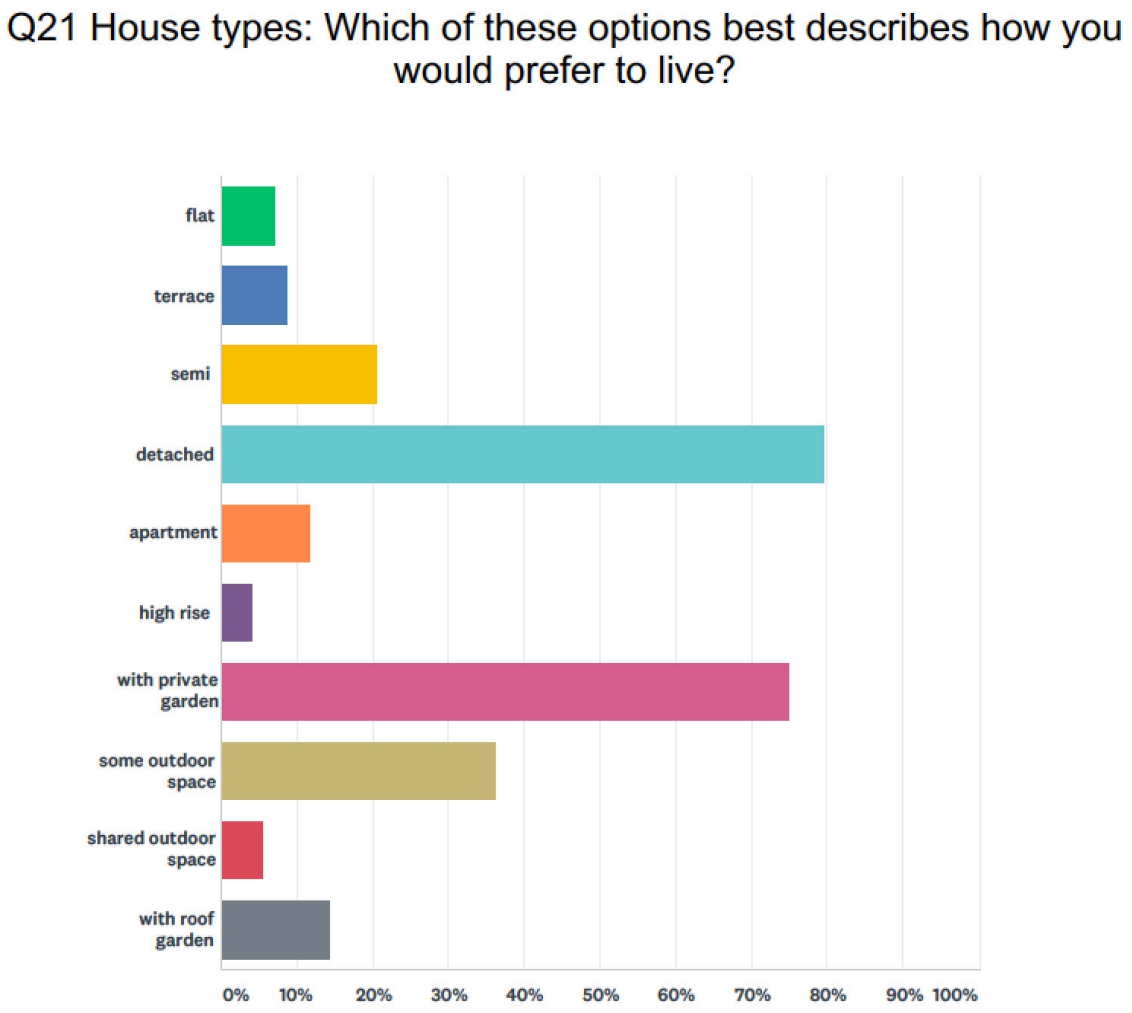


Figure A: 4 Preferred house types

Questions defining the general public by type

These questions are all providing a more nuanced picture of what the public know or believe to be true, but it is how this knowledge varies between different sectors of society that is of importance from a marketing perspective. The next set of questions was therefore asked to help define those groupings in terms of demographics, psychographics and sociographics. To make any meaningful sense of the many subsets within this data would require a broader response than that so far achieved, as stated at the outset. As a next step, focus groups would be a better method for reaching the specific sectors mentioned now that the on-line survey has highlighted the gaps to be focused on.

Appendix M3

Timber .v. Concrete (Section 6.1.3)

Objective: *to question the validity of some industry 'facts' and show how perceptions, if left unchallenged can become accepted as proven.*

An important aspect of knowledge is its reliability. Even pier reviewed evidence is fallible, and under scrutiny, some 'facts' are little more than long established perceptions. The public survey highlighted that the public's knowledge of concrete is surprisingly accurate and positive, except for when asked about its environmental impact. To apply the principle of one barrier being as detrimental as ten, this needs to be challenged – something that is rarely done, so strong is the belief that concrete can never be shown in a positive environmental light. This case study was based on establishing the carbon footprint associated with a typical family house built of timber compared with that of an equivalent house built of concrete. The results are revealing, but also unearth the incredible difficulties associated with proving the case for timber. If this perception of concrete as an environmental disaster is the main barrier to its adoption as a building solution, it is a barrier that deserves more attention.

The public survey (section 6.1.2) posed a series of questions about the performance of the main structural building materials used in housing – wood, brick, steel, concrete and, looking ahead, potentially CLT. The findings from this were surprising in that they showed a relatively accurate understanding of the science of these materials and consequently that concrete scores highly on many fronts – durability, sound proofing, fire proofing, heat absorption, and water resistance. Even more surprising was the knowledge of the fact that concrete as a material travels relatively short distances in its manufacture and delivery. The only question in fact where concrete scored badly was on 'detriment to the environment', where it came second only to steel.

In comparison to these other factors, detriment to the environment is a far more complex concept, as sustainability, resilience and environmental impact are all inter-related and can be measured in many different ways, and over different time frames. The consequence of this, something posited at the outset of this research, is that when confronted with complex arguments and limited time to expend upon them, snap judgements are likely to be made based upon gut instincts, preconceptions and general perceptions (section 6.1.1). The sustainability credentials of timber are a case in point, where it has become an accepted 'fact' that timber is good for the environment in the same way as concrete is 'known' to be bad. When decisions such as this appear so clear cut, there seems little point in spending valuable time confirming what has already been agreed upon, and very soon, the claims become enshrined as facts, never to be contested again.

It was decided therefore to investigate these claims and to see whether or not they could be substantiated. For the concrete industry, having shown how positive the connotations are in all other respects, there is a clear need to remove or at least reduce this barrier to acceptance. Because this research is focused on the housing industry it was decided to use housing as the measure of comparative environmental impact, looking at a typical family house and the carbon emissions associated with one predominantly built of timber against one built of concrete. As has already been alluded to, there are many ways of defining environmental impact, as there are many ways of defining

sustainability, with little consistency across the industry due to the benefits to be gained by any one sector in using one measure over another. The debate raging over EPDs (Environmental Product Declarations) and the use of 'cradle to gate' as opposed to 'cradle to grave' is one such example of this reality, considered in detail in section 6.4.4. For this exercise, it was decided to aim for a fair measure that was not necessarily the most beneficial for concrete, but one that was simple to define. This was an important point, as timber's environmental story is simple, easy to understand, and 'feels right'. A complex scientific counter argument, no matter how powerful, would be unlikely to undermine established perceptions as effectively as an equally simple 'counter-perception', albeit one backed up by scientific evidence.

Taking a typical family detached house, therefore, provides a recognizable starting point for a direct comparison. Measuring the carbon footprint of a house requires quantities of materials used, and a direct association between that material and carbon. That association must include the manufacturing process for both materials, that being concrete's Achilles heel, but manufacturing for timber must also include the entire growth cycle. This would be a genuine cradle to gate calculation in other words. Cradle to grave would be more beneficial for concrete, but opens up more contentious issues of measurement that would add more heat than light at this stage. What is being compared in reality is the carbon emissions due to the manufacture of enough concrete to build a house against the carbon emissions due to the logging of enough timber to build a house - plus the sequestering potential lost by the felling of those trees. It is here that the current argument in favour of timber has managed to equate 'zero carbon' with 'sustainably sourced'- two very different concepts – and where it will be shown that the reality is not as clear cut as has been suggested.

Definition of a typical house:

Above ground construction only: Foundations, being concrete in both cases would cancel out.
Floor area: 100m2 (HQI index: 4 bed 5 person, 2 story, 97m2).
Many U.S. calculations were found for 'typical houses' at 150m2, but it was decided to stay within meaningful HQI figures and calculate this for a mid sized UK family house.

Definitions of Carbon:

There is a worrying level of confusion within the industry and even at the Forestry Commission over the definition of carbon. This exemplifies the way in which the research behind the facts often becomes secondary to the answers sought. There are three possible figures that could be used in these calculations; Carbon (C), Carbon Dioxide (CO^2) or Carbon Equivalent (CO^2e). The confusion has arisen over the use of the term carbon to mean CO^2 in the industry in general, whilst in the timber industry, strictly taken to mean Carbon, as in 50% of the dry weight of timber. The atomic weights of carbon (12) and carbon dioxide (44) means this equates to a 3.7x difference, often misunderstood and misused. CO^2e on the other hand is, as its name suggests, a figure that includes all other greenhouse gasses based on a global warming equivalence to CO^2. Because of the confusion that exists in many published figures, it was decided to use the more accurate and less easily confused CO^2e figure in these calculations.

Housetype 1: Concrete construction.

For the concrete house, the Concrelator (Chapter 4) was used to calculate the volume of concrete used above DPC level, assuming a typical thermal mass construction with a concrete slab ground floor, concrete block cavity walls, screeded beam and block upper floors and a concrete flat parapet roof. The total volume was calculated at 53m3 with an average density of 2400kg/m3, using 7m3 of cement. This, in other words was an extreme case with the figures chosen at the higher end of the scale for the quantities of concrete used.

For the global warming potential (GWP), the MPA's (Mineral Products Association) EDP data was used for the various components.

Element	GWP / m3	Volume	GWP
Hollowcore flooring, 2400kg/m3;	333kg CO^2e / m3	16m3	5.3 tCO^2e
Concrete blocks, averaging 1425 kg/m3:	106kg CO^2e / m3	27m3	2.9 tCO^2e
Aircrete blocks, 460kg/m3:	122kg CO^2e / m3	10m3	1.2 tCO^2e
Total GWP for a typical family house:			9.4 tCO^2e

Table 0:2 GWP of concrete elements used

Housetype 2: Timber construction.

For a typical timber frame construction, with 195mm timber stud walls, 100mm partitions, suspended timber floors, timber decking, sarking and cladding, the volume of timber used was calculated from a number of independent sources at 26.5m3, at an average density of 350kg/m3. Again, figures were found for 150m2 houses, but a formula of 0.093t/m2 was used together with a dry weight density figure of 0.35t/m3 to arrive at this figure of 26.5m3 of timber. The GWP figure for softwood timber is 73kg CO^2e/m3, but the variance in the GWP of timber products, reaching 525kg CO^2e/m3 in some cases, meant that to get an accurate figure, the volumes of timber products needed to at least be approximated. This was therefore done for sheet products using the Concrelator to estimate areas, which once deducted from the total left a figure that represented the remaining softwood timber frame.

Element	GWP / m3	Volume	GWP
OSB cladding to external walls:	248kg CO^2e / m3	2.6m3	0.64 tCO^2e
Chipboard flooring:	315kg CO^2e / m3	2.2m3	0.69 tCO^2e
Remaining timber frame:	73kg CO^2e / m3	21.7m3	1.58 tCO^2e
Total GWP for a typical family house:			2.91 tCO^2e

Table 0:3 GWP of timber elements used

Reaching a conclusion:

Were that the end of the exercise, these figures would suggest a comprehensive three times advantage for timber over concrete, with the added benefit of the reduced weight of a timber construction potentially reducing the concrete used in the foundations as well. But the EPDs for timber products are not factoring in the 40 year 'crop cycle' of the trees themselves. Cradle-to-gate is defined as "the carbon emitted to bring the material or product from the cradle (earth) to the point it leaves factory gate after processing and manufacturing" (UK Green Building Council, 2015, p. 11). This is true for all materials, but in the case of timber, there is an assumption being made here that is a gross simplification in their industry's favour. The assumption is that a sustainably managed forest represents a zero carbon resource other than that due to logging. For this to be true, there has to be a zero impact on the sequestration rate of that supply source when that forest is logged. The simplification at play is that a managed forest is fully 'restocked', meaning that there is a continuum between crop cycles. The dynamic calculation that is required to find the actual impact of logging as opposed to the logging itself is, in reality, so complex that it has not ever been successfully completed. (Morison *et al.*, 2012).

"Only about 50% of the carbon in a tree is in the merchantable stem. While assessment and prediction of stem yield is routine and well established, assessing total C stocks relies on a considerably less detailed empirical foundation. Comprehensive quantification of the C cycle of example woodland stands is still very limited, and there are only two sites in the UK where stand-scale CO2 fluxes have been directly measured over the medium or long term."(Morison *et al.*, 2012, p. 97)

A meaningful calculation would involve allowing for climatic, geographical and arboricultural variations, molecular science, soil types, cultural and political influences, tax incentives – a seemingly endless list even before the debate about how to measure these impacts fairly is considered, such as cradle to gate versus cradle to grave, the permanence of sequestering, impacts on biodiversity, and the feasibility of policing a global marketplace to ensure compliance.

At the outset of this exercise, it was suggested that to counter the widely held perception that timber represents a more eco-friendly building solution than concrete, an equally simple 'counter-perception' was needed. The task of unpicking the complexities of this calculation represents the complete antithesis of this, unless the outcome can be encapsulated in a simple irrefutable message, one that at least puts concrete on a par with timber. If that is the required outcome, the question becomes less one of the endless parameters that ought to be considered, but about establishing one undeniable fact that overrules all other arguments.

The calculation below shows that a hectare of forest provides enough timber for 22 houses once every 40 years. The construction of each of those houses through the manufacturing process of the timber products used, has been calculated to have a GWP of 2.9 tCO2e. But each of those houses also contains around 9 tonnes of timber, which, since a mass unit of biomass has on average 50% of carbon, equates to 9t/2 x 44/12, = 16.5 tCO2e locked in for the lifetime of that property. (Barquin *et al.*, 2014)

At 60 years, that is arguably taken as permanent sequestration (Maréchal and Hecq, 2006). The net benefit is therefore:

16.5 tCO2e *(9 tonnes of 'locked in' sequestration)* - 2.9tCO2e *(the GWP due to the manufacturing process)*

= 13.6 tCO2e sequestered for the lifetime of the property.

But the loss to the environment from the felling of those trees on a forty year cycle also has to be considered, and this, it can be shown, equates to 33 tCO2e / house.

(10tC/Ha/a - 5tC/Ha/a * 40 years /12 *44 /22)

where:
5tC/Ha/a is an average annual sequestration rate for a UK forest logged on a forty year cycle*
10tC/Ha/a is the average annual sequestration rate for a UK forest after 100 years, undisturbed**
40 years is a typical crop cycle of a Sitka Spruce in the UK
/12*44 is the conversion from C to CO2e, based on their atomic values
/22 is the number of houses than can be built from logging one hectare of forest.

* "As an indication, trees in Europe capture on average 200 tonnes of carbon per hectare over a period of 40 years." (http://www.sicirec.org/definitions/carbon-capture)

** "*in general, woodland management with timber harvesting results in lower average tree C stocks when compared with management without disturbance. . . . the average C stock retained by the woodland after 100 or more years is about 960 tCO2 ha-1, while with harvesting, the average C stock in trees, coarse woody debris and HWP is about 420 tCO2 ha-1, less than half the undisturbed value"* (Morison *et al.*, 2012)

The final figure arrived at is therefore 33 – 13.6 = 19.4 tCO2e, over twice that of a concrete house.

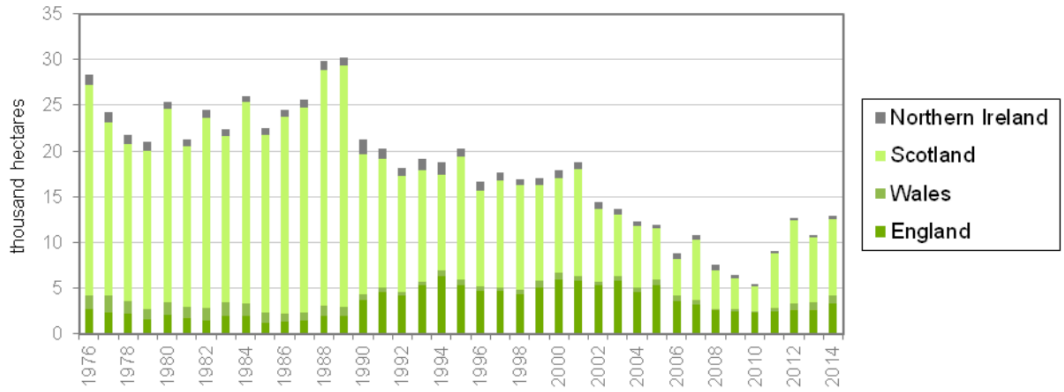
The difference between the two values for timber of 2.9 tCO2e and 19.4 tCO2e is therefore due to how one calculates the impact of logging on a forest's sequestration rates. The figure of 2.9 tCO2e assumes that there is no impact, ie 100% restocking occurring continuously in at least 40 one hectare forests, and no difference between the average sequestration rates over a cultivated forty year cycle and a natural hundred year cycle. The figure of 19.4 tCO2e in comparison, merely assumes there to be an average sequestration rate of around 5 tC/Ha/year lost when that hectare of forest is logged on a forty year cycle. (Morison *et al.*, 2012)

There are many other arguments that could be used to strengthen the case for concrete further – current UK restocking rates, closer to 66% than 100% (Figure A: 5), the lead in to the forty year restocking cycle, conveniently ignored, the self-confessed deficiencies in the Forestry Commission's data collection, the fact that *"if there is no change in the area of forests and no change in the volume of wood in the built environment there is no change in sequestered carbon on a global level and hence no effect on carbon emissions.",* or the fact that "*only about 50% of the carbon in a tree is in the merchantable stem",* not to mention the impacts on biodiversity, the costs of policing custody chains, and the fragility of supplies due to climate change.

There are seemingly endless avenues to pursue, so complex is the task of calculating the impact of harvesting timber on the environment, but the aim here is to arrive at a simple calculation that can

be easily explained, is seen to be fair, and can be backed up by empirical facts. It is then up to the timber industry to refute the argument made and supply the facts to support their case, but it is up to the concrete industry to first draw attention to the misinformation that is leading to erroneous policy decisions being made at a governmental level.

Chart 3: Area of new planting, 1976 to 2014



Source: Forestry Commission, Natural Resources Wales, Forest Service, grant schemes.

Figure A: 5 decline in restocking levels in the UK (Forestry Commission 2016, p.11)

"7,800 ha of previously harvested woodland were restocked in 2015-16 (Forestry Commission 2016a). The National Forest Inventory has noted that restocking in Scotland between 2006 and 2015 totaled 79,100 ha, which was significantly lower than the 135,300 ha harvested during this period (Ditchburn et al. 2016). The shortfall is attributed to a combination of factors:

- *The time lag between felling and restocking (typically 2 to 5 years, possibly increasing),*
- *Under-reporting of restocking, and*
- *Failure to restock harvested areas.*

Under-reporting of restocking is thought to be significant, due to changes in grant aid, with grants no longer available for restocking of Sitka spruce. Monitoring of grant provision is the key method for monitoring of restocking. This highlights a deficiency in the data collection, which makes assessment of the extent of failure to restock felled areas difficult." (Tatchell-Evans, 2016)

This case study is important for many reasons. It exemplifies the need to follow issues of concern back to their root causes, and to ensure they can be dealt with first, before expending time and energy elsewhere. It also exemplifies the power of perceptions over factual evidence, and how important it is to question long held beliefs. If this is to be tackled, however, it also exemplifies the need for collaboration between bodies who might have a vested interest in seeing a change in currently accepted policies. Without that support, even with the backing of empirical evidence, this might still prove to be an impossible task.

Appendix M4

Static .v. Dynamic modelling (Section 6.1.4)

Objective: *to show the importance of empirical evidence and how it can be used to bring about change.*

Whether a barrier is perceived to be one of public perception or industry inertia, it will invariably need to be dealt with at some point at a governmental level. Promoting the benefits of thermal mass is no exception, and the case for change needs to start not with the public or with the housing industry but with the government bodies responsible for the regulations that dictate the decisions being made. If thermal mass is to be used as a promotional tool for concrete construction, then the regulations must first be changed to reflect that benefit. That requires evidence, not just of the science of heat absorption, but of the social benefits, the financial savings to be made and the environmental impacts of not adopting this as a solution. It also means proving the feasibility of making the required changes, none of which can be done without the support of some influential allies, and at least the awareness of the public. These are all themes built upon later, but this case study focuses on the first hurdle, the need for evidence.

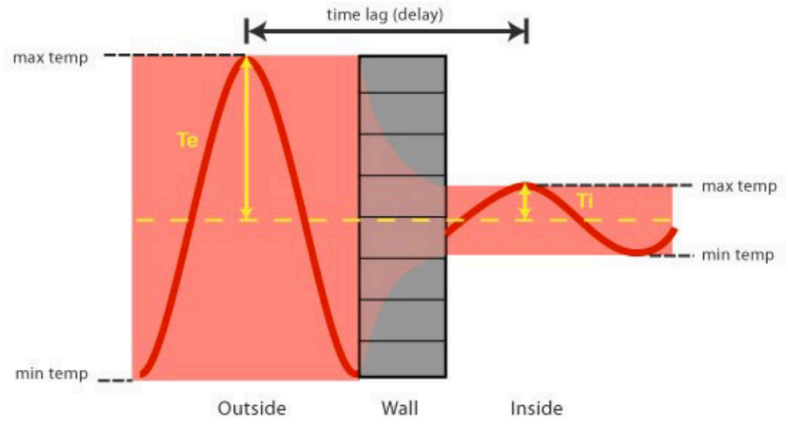


Figure A: 6 the principle of decrement delay due to thermal mass (Greenspec, 2018)

It was decided to make a case study out of this conundrum because it encapsulates so many of the issues raised by this research: the importance of confronting seemingly immovable barriers, the need to understand different market sectors' motivations in order to do so, and the debilitating effect that uncertainty can have on innovation. Whilst this study has researched the facts behind the argument, its primary purpose is to show the importance of the process itself and how it can result in a very different strategy being adopted to that currently being followed.

The BRE's Standard Assessment Procedure (SAP) is a 'static modeler', used throughout the UK's housing industry to calculate the energy performance of its buildings, as required by Part L of the Building Regulations. SAP has been in existence since 1995 with its sixth upgrade released in 2017, but is still working off the same steady state principles that do not capture the dynamic relationship

between the internal and external environment. This limitation is particularly relevant to the concrete industry because of the way the benefits of thermal mass, one of concrete's leading credentials, do not get picked up without there being a mechanism for measuring the fluctuations of temperature through the building's structure – which is what a dynamic modeler would achieve.

How the concrete industry should be approaching this problem exemplifies what this research aims to illuminate – the need for a holistic understanding of the market, embracing their own business partners, the government and the public, and what motivates each of those sectors to make the decisions they do. Armed with that knowledge, the concrete industry would then be in a position to decide whether the Standard Assessment Procedure is indeed a barrier that needs *confronting*, *sidestepping*, or just *accepting* as a dead end. Each of these options will result in a different course of action that can be assessed for its feasibility before deciding on which route to take. This study looks at the first of these three options and what it entails. *Sidestepping* is discussed in section 6.2.2 and *accepting* in section 6.2.3, using further scenarios.

The first task in confronting a barrier is to establish where that barrier actually sits. To give a brief synopsis of how the concrete industry has historically approached the promotion of thermal mass as a way to encourage the use of concrete, this begins and ends with what might seem an obvious strategy of 'convincing your largest customer'. In this case that is the volume house builders, constituting between eight companies half the entire housing market (Communities and Local Government Committee, 2016, p. 3). The perceived reason from the industry interviews for them not being open to the concept of thermal mass tends to focus on the public's dislike of concrete. The real reasons, less openly discussed and far more complex, are dealt with in section 6.3.3. Their overriding motivators, however, known to drive the volume house builders, are 'will this increase my bottom line profit?' and 'am I being encouraged / forced into doing this by either my customers or by regulatory requirements?' The answer to both of these is currently 'no', so as a supplier, the concrete industry has three options, which are to make the product cheaper than the existing solution, convince the public that they want thermal mass, or get the government to enforce its use. This effectively moves the barrier down the road, but only as far as the crossroads where one barrier has now been replaced by a choice of three – but that is still progress in terms of understanding the issues to be addressed.

Looking at these three alternatives, the role of the public was discussed in Chapter 3 where it was revealed through the industry interviews how the public voice was deemed to be an irrelevance by the industry as a whole. Perhaps considering our endemic shortage of housing, now seemingly the accepted norm, this should not come as a great surprise, but it is an uncomfortable truth that has to at least be acknowledged when considering which barrier to confront. If the accepted reality is that the public get what the public are given, in this instance, their opinions might not represent a key decision making factor.

The second option of reducing the comparative cost of a thermal mass solution is a complex one which ultimately results in little benefit to the provider or the customer (section 6.4.5), which leaves bringing about a change in our regulatory system as the only realistic option left to consider. Can the BRE be convinced to change from using SAP to a dynamic modelling system that recognises the benefits of thermal mass? To answer that requires a deeper understanding of how the BRE operates, and as

suggested earlier, an understanding of what their motivations are. This is not a case of explaining to the BRE how their over simplified methodology is limiting the concrete industry's ability to sell their products – this is about explaining to the BRE how they could benefit by their own measures by making these changes.

First of all, a dialogue with the BRE established that they cannot act outside the existing regulatory framework, regardless of whether or not they agree that SAP is skewing the market by misrepresenting the impact of thermal mass. The issue at stake is one of overheating, and how that is to be regulated in the light of possible rising temperatures due to climate change. The true barrier has therefore yet to be correctly positioned, and belongs not with the BRE, but at the door of the MHCLG and their decision whether or not to make the necessary changes to the Building Regulations to fully recognize this concern. Only then could the BRE even consider making their assessment procedure reflect the building regulations' measurement of overheating and the benefits to be gained from utilizing thermal mass.

This might seem like an enormous task, and that would be because it is. But at least it is now the real task, the one that could result in a change in the building regulations, that could result in the BRE adopting an assessment procedure that recognises thermal mass, that could then be used to persuade the volume house builders that they need to change their methods of construction, that could result in better, more affordable housing – that could be built with more concrete.

The task, if it is to be accepted, is therefore to explain, not to the BRE, but to the government now, how *they* could benefit by *their* own measures by making these changes, which begins with understanding their motivators. The government consists of many divisions of its own, all with *their* own conflicting requirements, three of which are of interest here. Housing (within MHCLG), the Committee on Climate Change, CCC (within BEIS) and, as always, the Treasury. The Housing Department's remit is to provide more housing more affordably and the CCC needs to ensure we meet our targets as laid down in the Climate Change Act. And the Treasury for their part needs to make sure our limited resources are distributed proportionately and in the country's / government's best interests, making their motivation value for money, and possibly speed of return on their investment.

To take this a step further, the CCC therefore needs to understand the role of passive solar design in reducing energy bills – both heating and cooling – and combatting climate change. They also need evidence. The Housing Department on the other hand, need to understand how concrete solutions can provide quality volume housing solutions more affordably than is currently being achieved, and how this is being held back by one unintended side effect of SAP which is effectively preventing the housing industry from considering concrete solutions. That, finally, is where the task begins, and what defines the evidence that needs to be gathered.

Amongst the evangelical few, there is a firmly held belief in the benefits of thermal mass and passive solar design techniques. Like the PassivHaus fraternity, these protagonists tend to punch above their weight, with a powerful voice, but with relatively few built examples and even less empirical evidence to back up their claims. The evidence that is required here, however, goes beyond empirical evidence of the concept, as it also needs to prove viability and feasibility in a volume market. There are in fact four areas that need to be evidenced, which should form the basis of a strategy, as defined here:

that thermal mass saves energy,
that these savings are not recognised by SAP,
that it is feasible to expect the industry to adopt a dynamic system that will,
that the impact this will have on sustainability and productivity will be enough to justify the effort.

Unfortunately, none of these are givens. According to the BRE *"A simple dynamic version of SAP is one possibility being looked at for the next but one version"*, which will be some years off, but this is probably the right timescale for generating the evidence needed to back up these propositions:

thermal mass saves energy - in the right conditions this can be shown to be true, but defining those conditions and applying them to our housing needs might generate a subset of that housing for which this is viable. Defining that subset of viable housing would therefore be key to the case being made.

thermal mass benefits are not recognized by SAP – this is known to be true in that the heat capacity of the structure is not calculated. There is a simple Appendix P calculation that sits outside of SAP that is used to check for overheating, but this is currently very difficult to fail, and does not feed into the SAP calculation results. Thermal mass can therefore only currently be used to reduce the energy required to power an air conditioning system by showing less demand due to lower peak temperatures. This means that if the property is passively ventilated, no benefit can be gained. In this situation, SAP is far more likely to show thermal mass as a negative, increasing the overall heating requirement, so there needs to be evidence of why this might be an incorrect assumption.

Is it feasible for the industry to adopt dynamic modeling – this changeover would represent a substantial increase in the workload for practitioners, which has historically been used as a reason for not changing the current system. If there were a way of reducing this barrier, either by implementing a simpler form of dynamic modeling or subdividing the residential market into those sectors that should change – such as modular apartment blocks - and those that need not – individual housing, these options should be investigated.

Do the benefits, in the government's eyes, justify the effort involved – this will be a decision based on returns on investment, as it should be, but also on the timescales involved, which arguably it shouldn't. The reality of our parliamentary system means that short term benefits are more likely to be adopted, and anything that will take longer than 5 years to show any measurable benefit will struggle to be heard. This at least needs to be understood, together with the development costs when making a case for change. As for the actual benefits, they need to be measured in terms of carbon emissions and affordability of housing through either increased speed of construction or reductions in material or labour costs.

The following tasks are therefore what would need to be undertaken to provide this evidence:

thermal mass saves energy – Define the subset of housing for which this is true by applying the known principles and then gathering the evidence from built examples of those housetypes. (Section 6.4.2)

thermal mass benefits are not recognized by SAP – A comparative analysis of a lightweight and a thermal mass construction using both a static and a dynamic modeler to prove that the difference between the results by each method increases with the addition of thermal mass. (Section 4.4)

Is it feasible for the industry to adopt dynamic modeling – Whether or not the housing industry needs to be subdivided into sectors that either do or do not have to provide dynamic modeling data is something that rests with the MHCLG and the Building Regulations. There is already a grey area when defining care homes and student accommodation, both of which behave very similarly to some non residential developments where dynamic modeling is already a requirement. This is a discussion that can be had at governmental level, but represents one of two approaches that could be taken regarding feasibility. The alternative is to find a middle ground technical solution that recognises thermal mass without having to carry out individual calculations for every property permutation or orientation.

Do the benefits, in the government's eyes, justify the effort involved – a reasonable assessment needs to be made of the volume of housing that would be affected by these changes, and how this would impact productivity in the short term and sustainability in the longer term. It is for this reason that the argument needs to encompass the overall benefits of concrete as a construction material rather than just those benefits attributed to thermal mass.

Conclusions

That constitutes an action plan for making thermal mass an attribute of concrete worth promoting. It is far removed from selling dense concrete blocks to volume house builders, but it does not negate the need at some point to return to that task. Before embarking on this as a course of action however, it would still be advisable to consider that next step and the feasibility of getting volume house builders to adopt an alternative solution even with this fundamental barrier removed. It must be noted that removing the main barrier, whilst an essential first step, has little bearing on the many other barriers that have been 'parked' in the process. The volume house builder will still need to be either pushed into change, or see an upfront financial benefit in doing so. It is for this reason that 'sidestepping' might still become the next best strategy. (Section 6.2.2).

Appendix M5

Understanding Government Process (Section 6.1.5)

Objective: *to question whether it is the government's level of understanding, motivation or ability to bring about change that is the real barrier.*

The concept of 'alternative realities' is what happens when different sectors are driven by different motivations, or in academic terms, different ontological viewpoints. The previous study is predicated on the understanding that a government needs proof in order to act. Establishing the true motivations of a government and how much knowledge that government already holds however, is extremely difficult to ascertain. When facts become hard to pin down, perceptions often flourish, and this can mean even the most well researched industry policy decisions being based on perceived political motivations. The purpose of this study into the history of government reports on the housing industry is to highlight the danger of reliance on political policy decisions that promise more than minor adjustments to the existing system. Without fully understanding a government's objectives and ability to bring about change, as opposed to its manifesto promises, reliance on political policies can be shown to be a very high risk strategy.

The Information Sources questionnaire discussed in section 6.1.1 suggested that when the industry needs to access information on regulatory requirements, it goes directly to government documents, reports and white papers, where the government's intent is clearly defined. Whilst this has not been expressly asked, there is an assumption that this information is seen to be honest, objective and unbiased, if for no other reason than it is being accessed at source, free from interpretation.

In Chapter 3, a thorough review of the government white papers was carried out and their impact was discussed in the light of the Farmer Review, which can be seen as a culmination of many years of effort by governments of all descriptions to address the construction industry's many 'failings'. The fact that these reviews have, by the government's own admission, failed to have the impact expected (Farmer, 2016), would suggest that there are some underlying issues that have not as yet been understood. The only alternative explanation to this would be that the underlying issues are understood but are either seen as too intractable to confront, or are not in any government's interest to confront. Neither of these options make for comfortable reading, as they either suggest that our governing body is ill informed or complicit in its own failure to bring about the changes sought, but they do nevertheless need to be considered.

This is an extension of the previous argument in section 6.1.4 (Static .v. Dynamic) in that no strategic decisions can be made regarding innovation without first knowing what the barriers are to success. The debate about thermal mass concluded that the government needed evidence before it could enact any changes to the building regulations, which in turn would allow for the assessment procedure to be updated to reflect those new requirements. The assumption being made, however, was that the government is, in this instance, ill informed about the issues, and not just avoiding problems deemed too complex to confront.

In principle this case study is therefore a broader version of the same argument about barriers to innovation, with the same choices available – confront, avoid or accept, but with one important difference. If the government is ill informed, then the solution is to provide evidence. If, however, the answer is that the government is complicit, the next choice would be to sidestep the problem, but in the case of legislation this is not a realistic option, leaving only acceptance as the remaining choice. What makes this choice of two options such an important difference is that this defines the end of the road in terms of barriers to address. There are no more junctions ahead where alternatives can be found. The final barrier either has to be confronted or accepted, and what has become clear from this research is that time and time again, that final barrier is a political one.

Regardless of whether a government's inability to bring about change is due to a lack of knowledge, a lack of motivation, or just a lack of power to act, the immediate outcome is the same, but how to bring about a change of policy in any of these scenarios is not. A lack of knowledge requires evidence to be provided, but a lack of motivation requires a deeper understanding of what it is that would motivate a government to act. This was discussed in the previous section, and has been central to the whole discussion, whether selling products to clients, promoting solutions to the public, or in this scenario, making a case to government; understanding what their motivations are is where any marketing strategy should begin. Only with this understanding can the knowledge be provided in a language that will be heard.

So the question is – does the current government know why eighty years of well-meaning White Papers have had so little impact? Is there an underlying barrier that remains undiscovered, or are successive governments well aware of what needs to be done, but choosing not to act out of inability or self interest? Getting a straight answer to this question is not easy, since few politicians would ever confess to a lack of knowledge, motivation or ability and expect to remain in a position of power. Anecdotal evidence, however, would suggest that there is a combination of all three barriers at work, with the emphasis on any one factor changing over the lifetime of a government. Addressing government bodies therefore requires persistence and a clear understanding of what needs to be achieved. It requires evidence, vision, clearly defined objectives, strong partnerships and focused promotion, all of which are discussed in the following study.

Figure A: 7 the state of the construction industry 1934 - 2017

"The construction industry is chronically underinvested due to a combination of economic, market and behavioural factors."

"There appears to be very low usage of more collaborative and integrated design, procurement and construction delivery models"

"One of the critical features of the industry is its extremely poor level of productivity." "Low profitability is a long standing problem for the industry."
Mark Farmer 2017 Modernise or Die

"It is an adversarial and wasteful industry in which construction takes too long, is too expensive and is not satisfactory for its clients"

"All rents and costs of production throughout Great Britain are higher than they should be because houses and factories cost too much and take too long to build"
Alfred Bossom, 1934 Reach for the Skies

The current initiative

At the time of writing, the CLC (Construction Leadership Council) were invested in a programme of work to promote the benefits of Smart Construction to the UK construction Industry. This was a continuation of the campaign that the many White Papers referred to in Chapter 3 have been leading with, at best, incremental success. As an invited participant to this process the author was able to observe and to some extent influence the direction this project was taking. The stated objectives were sound (Construction Leadership Council, 2017), in that there was a recognition that to support the government's 'Industrial Strategy and Construction 2025' proposals, it needed to:

• 'recommend actions to unlock the supply and demand conundrum affecting the provision of additional housing adopting smart construction.'
• 'help stimulate demand for innovative housing delivery models, with minimal intervention in the market'
•'encourage as much collaboration as possible'

As a body they undertook market analysis, reaching the conclusion that:

'in order to achieve the delivery of additional homes in a short timeframe there are some housing providers and market sectors that are more likely to adopt smart construction methods such as offsite than others.' – referring to all the sectors making up the other 50% of our housing delivery system other than the speculative housing providers.

The reasons given for believing this to be true are also sound, and have also been used in this research, but the flaw in their proposition for the long term success of this initiative, it is suggested

here, is no different to that concealed within all previous attempts to bring about change in the housing industry. Referring to the off-site manufacturing industry, the CLC reports the government's belief that:

'After a relatively short period the costs will come down to a point where pre-manufactured construction systems will be viable for production and development throughout the UK.'

The purpose of this case study is not to discuss the reasons why this might prove to be a fundamental non sequitur (section 6.4.5), but to point out that sustaining a belief in the ability or even the intention of governments to bring about the changes that are known to be needed can prove to be a poor foundation on which to build future strategies.

Appendix N1

Residential towers: Trent Basin & Nottingham One (Section 6.2.1)

Objective: to illustrate how material choices can be dictated by cumulative factors or by one single factor that can override all other considerations.

Two residential towers, both in Nottingham, both built in the last few years by contractors Willmott Dixon, one concrete frame & concrete panels, one light gauge steel frame. The question asked was why they had been built the way they were, and what was that decision based upon? The purpose was to show that material choices are rarely made because of a preference for a material per se, but because of what that material can deliver, something that can change from project to project. Any attempt to influence that choice therefore requires an understanding that goes beyond the credentials of the material being promoted and includes an understanding of the needs of the client, the developer, the planners or a specific site.
The decision taken at Trent Basin to use a light gauge steel frame solution was one based on cost – but what factors dictated their definition of cost? Nottingham One, on the other hand, a site close by within the City centre, was designed as a concrete construction for one defining reason that overruled all other considerations.

These two sites were chosen because they are both recently developed residential sites in Nottingham, using the same contractor but different methods of construction. Both clients and the developer were interviewed with a view to finding if there had been a 'key motivating factor' that dictated the material choice, or whether it had been a decision reached through a balancing of positives against negatives.

The purpose of this exercise was to expose the breadth of factors involved in making what might appear after the event to have been a relatively straight forward choice.

Nottingham One residential tower.

Figure A: 8 Nottingham One tower – concrete construction

This was part of a larger mixed development which had a difficult birth, with the original contractors going into liquidation due to the downturn in the market in 2008. The project was resurrected in 2012 under the control of Willmott Dixon, who completed the 237 apartment development the following year, winning the East Midlands RIBA Award in 2016. Most of the information available in the public domain comes from the publicity generated from this award, where much is made of the benefits of concrete. What is interesting however, is how much these proclaimed benefits differ from the actual reasons why concrete was initially chosen.

Over its long gestation there were a number of planning applications made as the market changed, with the tower at one stage being earmarked as a hotel. The choice of concrete as the most appropriate constructional solution can be traced back to the planning process and the constraints applied throughout these discussions. There were height restrictions, as is often the case with inner city infill sites. There was also a requirement for parking provision based on 70% of residents plus one space per 100m2 of office space on the ground floor. To achieve a viable density with these restrictions, on a mixed development site where the ground floor could not be sacrificed to car parking meant having to factor in two floors below ground level. The cost of this was further exacerbated by a high water table which ultimately lead to the realization that concrete was the only solution possible – nothing else would be heavy enough to counteract the water pressure and keep the building in the ground. As it was, the contractor had to continuously pump 130l/s out the basement carpark until the building was five stories high, and heavy enough to counteract the ground pressure.

The tower, on which this research was originally focusing, was then constructed in concrete because of the choices dictated by the rest of the development. Had that not been the case, would the tower have been built differently? Three other factors then come into play that may have resulted in a concrete tower irrespective of the actual practical benefits of continuity. CLT was considered but at the time of building, there were still height restrictions of four stories in place due to the fire regulations prior to BS9999 2017. A steel frame would have resulted in a floor thickness of close to 500mm with services, whereas the concrete floors were 225mm including screed and underfloor heating. Again, the height restrictions imposed by the planning authority meant that this allowed for an additional floor of prime residential property space. The final factor that would have possibly swayed the decision was the need to cantilever the entire tower over the district heating scheme main duct that runs alongside the canal. These are all financial considerations that were fed into the decision making process, none of which were key motivating factors in themselves, but had an overall cumulative effect. The key motivating factor however, the high water table, was the one that could not be countered, and in this case was so defining that there was no other choice that could have been made.

Not surprisingly, the publicity material chose to focus on the benefits from the end user's perspective, rather than the actual reasons that dictated the choice. The promotional brochures talk about the sound proofing benefits both between floors and from the main road, the thermal mass, and proximity of supply from an environmental perspective, and even – in the more upmarket penthouse apartments – the aesthetics of the exposed acid etched concrete soffits to the balconies.

This shows how far removed the promoter's task is from that of the contractor, who has to balance constructional practicalities with the planning requirements and the need to maintain financially viability. With the benefit of hindsight, it can be seen that promoting these 'end user benefits' of concrete to a developer at the outset of a project would have been unlikely to influence the decisions that were made at a far more practical level.

Trent Basin residential tower.

Figure A: 9 Trent Basin tower – light gauge steel construction

In many respects the 10 story residential tower at Trent Basin presented a similar scenario, with the tower being part of a larger project, but with one important difference. The client at Nottingham One was Nottingham City Homes, a housing association, whereas at Trent Basin, the properties were being built speculatively. Unsurprisingly, when the client was asked the straight question, 'what was the fundamental reason for choosing a steel frame solution' the answer was 'cost', but the way in which financial viability is defined can vary considerably between developers, depending on the way a project is financed.

The way in which Trent Basin has been developed has not followed a pre-arranged plan, and has, like Nottingham One, had to react to events, whether that be changes in legislation, economic downturns, or the shifting priorities of those controlling the finances. Also, like Nottingham One, the decisions made relating to the tower were tied into decisions made for the site as a whole. The difference comes in how Trent Basin's speculative build programme was less driven by speed on site, and more so by the market and how it responds to a site as it develops. In this respect it is ironic that Nottingham One, where the rental income stream would have benefitted from a fast turnaround, was not able to choose the speedier steel frame modular solution due to the site conditions, whereas the Trent Basin development chose a steel frame solution despite speed not being a defining priority. It is in unpicking this decision where lessons about how to promote a construction solution on a site specific basis can be learnt.

The story of Trent Basin is one of many reasons why concrete could have offered a more appropriate solution versus one reason why it did not, and that one reason ultimately dictated the decision. Not only did the decision about how to develop out the site remain fluid throughout the build programme, so too did the design of the individual houses. This was not a conventional speculative build programme, and had strong sustainability drivers at play together with ties to the University of Nottingham to collectively bring about a working demonstrator site for sustainable district heating. With many interests to contend with, it is not surprising that delays were encountered, and changes were made late into the programme. There were in effect, many conflicting requirements that made any up front solution difficult to accommodate, such as an off-site manufactured solution, with its need for early decision making, standardization and cost benefits through speed of construction. But despite this, a steel frame solution was chosen, with one reason being because for the concrete industry to even be interested, the site would have to have been agreed and committed to up front as a single phase development.

Had that route been taken, and early decisions adhered to, there would have been two residential towers and eighty eight properties build as one programme. As it is, the properties in the first tower were slow to sell, and the pricing structure recommended by the estate agents found to be out by some considerable margin. (Apartments cannot command the same price outside a city centre where there is no alternative, and if the option of a conventional house with a garden is available, that will always be seen as preferable unless the apartments are markedly less expensive).

Having chosen to use a modular steel frame solution for the tower as part of a phased development, the developers were therefore able to amend their plans and their time scales for the rest of the site to suit the demand. Were this a development in inner London, or for a housing association, there would have been a very different set of priorities, but in a provincial city, in an uncertain economic climate, and with Brexit looming, there was little confidence in the market demand holding up. The frustration, however, lies in the ways in which these market forces have led to a less appropriate, and in many ways, a less economic solution. Additional costs were incurred due to late changes in design, such as with the lifting of the first floor to allow for non residential use at ground floor level. Straying beyond the natural limitations of a standardized building solution, by applying balconies, irregular angles and higher than required levels of insulation resulted in either further cost and delays or a value engineering exercise that ‘dumbed down’ the original design solutions. None of these limitations would have been so apparent with a more flexible solution, such as that offered by concrete, but the trade off would have been the financial risk associated with a continuous build programme.

The reality of the decision making process that this points to, is that making direct financial comparisons between construction choices is such a complex exercise that even after the event it is difficult to ascertain what the actual drivers were. In the absence of that information, those critical decisions are often made based on potentially less reliable data. In this instance, the main contractor had an interest in using Fusion, a company that produced light gauge steel frame, as they had already formed a relationship with that company, and were comfortable with the construction process and the supply chain mechanisms, all of which might have allowed them to offer a better price on the project than if they had used an alternative system. This together with the client’s gut feeling that the size of the programme would be too small to interest the concrete industry, and that the economic

climate was too unpredictable to risk too much commitment up front, was enough to justify the choices made.

Conclusions for the Concrete Industry

Looking at the 'what if' scenarios is often a useful way of getting to the real reasons why decisions are made. If the Nottingham One site had not had a high water table, would the project have been built differently? Would the site have ever become a mixed material development or would another factor have dictated a similar outcome, such as floor depths, sound proofing, or current knowledge of existing systems, construction methods and supply chains. It is unusual for a decision to be dictated by something as definite as was the case here, with most decisions being ultimately driven by more direct cost implications when stripped down to their essentials. Without the need for a critical weight to hold the building in the ground, the decision may well have turned on any of these factors, none of which can be easily measured for their financial implications. The comparative cost of the raw materials used is clearly of little relevance in isolation, but neither is construction costs per square meter if a shallower floor depth can add another story to a development. Sound proofing can be achieved, as can ventilation levels, regardless of construction methods, but at what additional cost? Given enough time to evaluate these options, all these factors can be costed, but what price benefit should be attached to knowledge of existing systems, construction methods or supply chains?

The fact that this last parameter can potentially account for greater savings than all the previous factors combined, and the fact that it is so difficult to quantify, can lead to some skewed decision making, especially by smaller contractors than Willmott Dixon, and developers who find that specializing is the only way to remain profitable in such a competitive marketplace.

Turning to Trent Basin, was a light gauge steel frame the most appropriate solution? The contractor had a clear association with Fusion from previous projects and was keen to promote this as a solution on this occasion, as were Fusion keen to have a prestigious demonstator site in Nottingham. Willmott Dixon and Fusion have recently won a contract in Nottingham with Nottingham City Homes to provide a retirement village which will no doubt have benefitted from this exposure. It is unclear whether or not Trent Basin's developers in turn benefitted from a reduced price for their tower, especially as the second tower never materialized in the evolving plan. The tower was clearly not a typical project for Fusion, as there were design requirements that were not part of the standard package, and a desire on the developer's part to achieve sustainability targets that were above those required by building regulations. These divergences, including the raised first floor height all added to the overall cost, and since speed was not a beneficial criteria - exemplified by the choice of brick cladding - it is unclear why this was the most appropriate solution in the circumstances.

The 'what if' to be considered in this case therefore, would be concerning the speculative risk in an uncertain economic climate. With more stable conditions, both economically and politically, regarding building regulations and planning requirements, would the decision have been taken to set up an 'on site offsite' production plant and build out the entire site in one phase using a concrete panelized solution? From discussions had with the developers, it would seem that barring this one problem of

needing a phased development, a concrete solution would have been a far more appropriate response to the original brief and the client's aspirations for the site.

What both these sites highlight though, is the gulf between the reasoning behind the decisions made and the reasons given for making them after the event – between the practical choices and the promotional story. Trent Basin is the sustainably driven housing solution, but built from steel frame and brick cladding, whilst it is Nottingham One that has, out of necessity, used the sustainably sound solution with thermal mass, proximity of materials, resilience, even specially designed acoustic trickle ventilation. Knowing who or what will dictate the final decision is therefore the key to knowing how to promote a specific solution. In these particular cases, both were decided by factors outside the housing industry's control – unfavourable ground conditions and unfavourable economic conditions. But in many cases the key motivational factors for a specific site, once understood, can be used to ensure that the solution being promoted for that site is shown in its best, or most appropriate light.

Finally, for the tool being developed, this case study highlighted the problem of comparing many disparate factors. Whilst it is possible in hindsight to question some of the decisions made, what process would lead to a more appropriate outcome and would attributing a score to any one factor's importance really help in this endeavor? What this study would seem to suggest, which is taken up in Chapter 7, is that it is the hierarchy or the order in which decisions are taken rather than the weighting of any particular decision that is of importance when assessing alternative solutions.

Appendix N2

Affordable housing provision: Nottingham City Homes (Section 6.2.2)

Objective: *to show the importance of understanding a client's motivations before marketing a product.*

This case study was chosen to show how much a client's objectives can influence their choice of material solutions. Whereas all sites can differ in their requirements, if a client has a clear policy developed around their needs, that represents a market that can be defined and worked towards. In this instance the head of development at a Housing Association was interviewed to discover what they saw as the positives and the negatives of concrete as a material choice. Again, the answers given highlighted the importance of understanding a sector's motivations before attempting to promote any particular solution.

Nottingham has over the years built and maintained control over more social housing than anywhere else in the UK outside London (Matthews, 2015). It has in Clifton the largest council estate in Europe, and has the highest proportion of solar powered roofs per capita in the UK. As a sector of housing provision in Nottingham, therefore, Nottingham City Homes, the city's largest provider of social housing, should be of considerable interest to those businesses trying to promote innovative solutions.

The reason for pointing this out is that there is a very natural tendency for suppliers to focus on the biggest, most consistent markets, which in the housing industry is the volume house builders, representing two thirds of our supply with 50% being controlled by just 10 companies. In comparison, the remaining 50% consists of a fragmented collection of providers, all with their own agendas, motivations and revenue streams. The purpose of this case study is to show that size of market is just one of many factors to consider when selecting the most fertile ground to seed an innovation, and although Nottingham City Homes (NCH) is larger than most Housing Associations, this is not the main reason why they could prove to be a very beneficial partner.

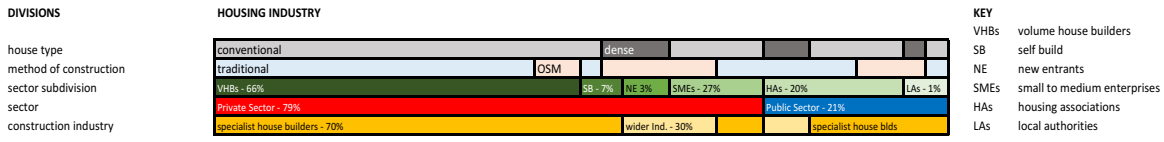


Figure A: 10 approximate breakdown of delivery methods

Interviewing NCH highlighted the silo mentality that our housebuilding industry is so often accused of. From their perspective, despite the government's recent proclamation that local councils would be central to our renewed national house building campaign (Barker, 2018), material and product suppliers continue to show little interest in them as a sector. This is not a refusal to do business with Housing Associations, but does reflect a lack of understanding about this sector's purpose and

motivations, resulting in a disconnect between the products being promoted and their specific needs compared to those of the volume house builders (P.08.1, p.17).

Housing associations are just one of many sectors that need to be better understood to ensure that the right products are being promoted in the right way to the most appropriate markets. This is in contrast to the current approach, and where the accusation of the silo mentality arises, which is to promote all products only to the biggest market available, and to do this irrespective of that sector's needs. An obvious example of this would be the promotion of concrete to the volume house building market through its thermal mass properties. The disconnect here is due to the volume house builders' disinterest in the performance of their properties after day one, especially if this is going to impact on their sale price, or in any way disrupt their build programme or supply chain. Nottingham City Homes is therefore used here as an example of what can be learnt about a sector's motivations by asking the right questions, and how this knowledge can impact on which products are promoted and what language is used in doing so.

Returning to the findings from the literature search (Chapter 1.4), all change - such as the adoption of a new method of construction - requires a decision to be made, and that decision comes with three principle prerequisites: the 'decider' needs to have knowledge of the innovation, needs to be motivated to consider that innovation, and needs to be in a position to be able to adopt that innovation once convinced. Knowledge, Motivation and Ability. This is a two way process, however, as the 'promoter' first needs to understand the decider's motivations before being able to impart that knowledge in the right language. The promoter also needs to be sure that the decider has the ability to follow through, which also requires an understanding of their business model. This all represents knowledge that stems from an understanding of the client and the market in which they operate.

Nottingham City Homes build social housing for rent. That alone means their requirements are fundamentally different from those of the volume house builders. Value for money is equally important for both, but it is how this is measured that differs. Knowing that the maintenance of every property built will be an ongoing responsibility transforms the mind set of a developer. Resilience, longevity, durability are all valued far higher than by the speculative builder and this impacts on the choice of materials, with whole life costing factored in as a genuine financial exercise, not just a box ticking procedure to comply with regulatory requirements. The first point made by NCH with respect to this need is the 60 year life span guarantee that is regularly associated with all modern methods of construction. This has become an accepted 'accountant's term' (London Assembly Planning Committee, 2017, p. 34), but fails to recognise how detrimental this can be when trying to promote anything innovative against a backdrop of conventional Victorian housing now well into its second century and showing little sign of unmanageable deterioration. This is a very real barrier to innovation for some, and whilst today's young softwoods are rightly seen as being prone to decay and attack, concrete perhaps should be designated a far longer lifespan than the 60 years it is automatically afforded.

The issue of warranties is the Catch 22 of the construction industry. For innovation to progress, incremental improvements need to be made, but until any one permutation of a modern method of construction has been trialled for at least 60 years, it will always be seen as unproven, loaded with the

potential to fail at any time (L.07.1, p.2). As a consequence of the 'by exception' method used by the warranty industry to guarantee housing that incorporates these products, insurance premiums remain high and mortgages remain disproportionately difficult to secure. The detrimental impact this has on the buying public's confidence further exacerbates the problem by deterring the uptake needed to give any innovation the critical mass that ensures its survival and evolution.

To relate this to concrete and the needs of a housing association, many council houses in the 1950s and 60s failed due to a plethora of experimental concrete based systems that had very little time to trial their innovations before being rolled out to house the baby boom generation and to replace swathes of housing demolished in slum clearance programmes (Grindrod, J 2014). The problems encountered were a combination of material failures and constructional failures, the effects of which are still impacting on today's decisions when assessing the innovative solutions on offer (London Assembly Planning Committee, 2017, p. 21). Spalling concrete exposing rusting reinforcement, failed gaskets, condensation issues and poor weathering have all fed into the public's, the industry's and the insurer's perception of concrete as a high risk option. The fact that many of the failures that occurred were not specifically caused by concrete as a material, but by working practices, political expediency and developer greed is to some extent immaterial, as the association is now well established - perceptions become reality and have to be dealt with as such. The experience of NCH was to find that the very real concern for them about failure due to spalling had been dealt with by a new generation of panelised concrete system builders by merely increasing the coverage over the reinforcement "by the thickness of my finger" (P.08.1, p.5). So powerful was the visual image of exposed and rusting reinforcement that this alone was enough to halt the research being done into concrete systems as a potential solution – even before straw bale was ruled out. Had the solution been one of a thinner, lighter, fibre reinforced concrete solution, they suggested - something that made a break with the discredited past - the conversation would have been taken further.

The next issue that would have arisen, had that conversation continued, would have been the practicalities associated with large format panels and their delivery to site. Another fundamental difference between housing associations and the larger volume house builders is the size of sites developed. Many housing association sites are small brownfield infill sites, often with restricted access and limited space for storage. Again, from their own experience, deliveries of panelised components were only available if delivered on articulated lorries requiring cranes on site. Had the suppliers better understood their market, in this instance the solution would have been for all deliveries to be made on wagons limited to the size of fire engines, this being the largest vehicle that all sites are designed to accommodate. The underlying and wider issue this relates to is that if a new solution does not work for all eventualities, (not all sites are too small, but enough to be an issue) then that solution will not be as viable, since the existing method of construction would have to be continued alongside the new.

Again, not an insurmountable problem, were this a market that was being actively pursued, but the next requirement that was raised during the interview was more problematic. NCH, along with many housing associations see their role as more than just a provider of housing. There is a strong community involvement that is part of the ongoing commitment to the housing they provide through maintenance and the collection of rent from their tenants. From their perspective everyone benefits from that community being stronger both financially and socially, and part of that strengthening

comes from keeping work within the local area, referred to as the 'local pound' (P.08.1, p.8). On that basis, any form of off site manufacturing is seen as detrimental to that effort, even if supplied from within the same county. NCH have had conversations previously with timber frame manufacturers about 'delivery only' solutions so that at least the erection could be carried out by local labour, trained up by the manufacturing company, but the warranty issues regarding split responsibilities can be seen as too complex for this to be a viable option either.

Finally, from the housing associations' perspective, there is the sense that their business is of little interest because there is a minimum contract size seen as viable for any form of off site manufacturing, with many housing association projects being small scale due to the size of the plots being developed. The only positive, in fact, something shared with the private rented sector, is the need to build out fast to bring forward the start date for the rental income - something the speculative build market has no interest in. For them, the speed of build is dictated by sales rates which can rarely be pre-defined, creating their own disconnect with, amongst much else, the off-site manufacturing solution.

So where does this information leave the concrete industry and their interest in this particular market? Are they right to ignore this substantial and growing sector, or is there a way in which concrete products could be tailored to suit their needs? In other words, with the better understanding gained through this process of what motivates the social housing sector and the restrictions they have to work within, what language should be used to make concrete an appealing option?

Clearly not all housing associations are the same, and some will be developing larger sites with high density standardised housing that will favour off-site, large panelised solutions, the benefits of which will outstrip those of using local labour. But for NCH, their requirements are well defined and do not support such a strategy. Their need is for a solution that delivers value for money – a given – but though housing that is durable and resilient, with low running costs, that can be built with local labour with the flexibility to work for all sites, large or small. In addition to this they have an aim to define a new standard for housing based on their own space standards and attention to the social needs of their customers, something that has also been shown to be mutually beneficial as it reduces the turnover of their tenants. Like many housing associations, now being encouraged back into house building on a substantial scale, they want to work with suppliers who can provide complete solutions rather than individual products, and are very keen to collaborate at this level.

"Last summer we asked partner organisations, residents and a wide range of interested parties to help us shape our new Corporate Plan." (Nottingham City Homes, 2012)

Whether this is actually recognised by government or not, this reaching out is partly due to the fact that many councils and even some housing associations have lost much of the expertise they once had, and find themselves confronted with an overwhelming array of new products that have arrived on the market since they were last involved at this level. (P.05.1, p.15)

This is therefore an opportunity to create a new packaged solution that can be promoted to this growing market based on their very well defined criteria, many of which feed into the credentials that concrete can offer, and discussed in Section 6.3.5. What should be avoided at all costs however, is anything that resembles a large panel concrete cladding solution, for four good reasons highlighted by the process of this research: Past associations with poor quality spalled concrete housing, the practicalities of delivering to and handling on small sites, the detrimental impact to the local pound,

and the requirement for large contracts to achieve viability. Far more appropriate perhaps, would be a solution that was geared around a range of smaller pre-cast, standardised components that could be mass produced and stocked locally for immediate delivery, a concept discussed in more detail in section 6.3.1.

Social housing represents a growing market that needs to grow much faster than it currently is (Figure A: 11) (Communities and Local Government Committee, 2016, p. 20). It is a market that is driven by affordability, both in terms of build cost and running costs. There is an open invitation being made for collaborative solutions that work on their terms, terms that have a closer synergy with what concrete can offer than the many other markets being pursued. City councils work within collaborative networks that help to promote best practice solutions, and also provide access to the political processes that need to be challenged. All these factors, when looked at collectively as this process encourages, suggest that this is a market to be prioritised by the concrete industry.

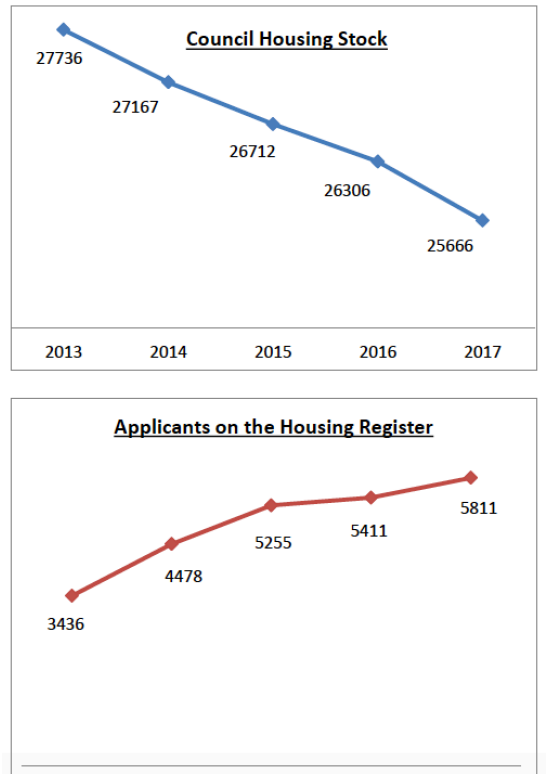


Figure A: 11 Nottingham City Homes Corporate Plan 2018 - 2021

Appendix N3

The London market: 1, Hyde Park (Section 6.2.3)

***Objective:** to show the importance of understanding the local economy and how much location can dictate the decision making process.*

Geographical location also influences decisions but London is a special case with the value of property in London being more than the UK's next 20 largest cites combined (Dorling, 2014). *1 Hyde Park was chosen as a case study because it is one of the most expensive real estate developments in the UK, and is also a predominantly concrete construction. In this instance, the disproportionate value of land as a percentage of the total property value distorts the decision making process, in that material cost becomes less important than material benefits. London is a special case in other ways too, with its high labour costs and its own Mayoral powers allowing the introduction of fine enforced carbon emission targets* (Braidwood, 2016). *Are these 'special case' factors beneficial for the concrete industry, does the process being developed pick these up, and could they be promoted in other parts of the UK?*

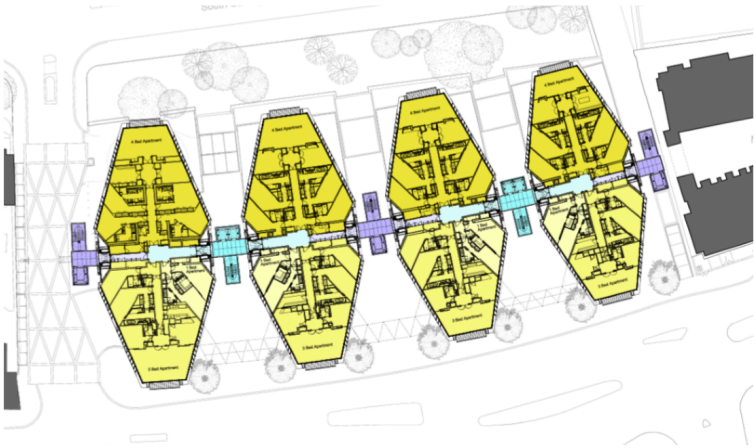


Figure A: 12 Site plan showing 4 repeating floorplans, increasing in size to optimise the site

To what extent does geographic location dictate the decisions being made? London is often referred to as a 'special case' but with a 440% increase in property prices over the past 20 years (Robin Hatin, 2016), it has a profound influence on housing policy that sometimes understates how different the hierarchy of parameters can be elsewhere. As an introduction to this discussion, 1 Hyde Park has been taken as a case in point.

1 Hyde Park in Knightsbridge is one of the most expensive real estate developments in the UK with apartment prices of up to £70k/m^2. At this, the highest end of the market, the proportional breakdown of a property's sale price into labour costs, material costs, land value, etc. is going to be quite different from the national average for residential developments (LABC, 2018) with land value taking a far higher percentage of the whole. Consequently, the decisions taken about materials and methods of construction are more likely going to be dictated by performance than by cost alone, which makes this an interesting case study to understand how those factors were considered to result in the final choices made.

Whilst this development is described in the press as a predominantly concrete construction, in reality it is a true hybrid, with post tensioned slabs, precast columns, in-situ concrete walls and steel bracing and framing to the lift shafts and stairwells. It is an example of how, when the capacity, finance and time are available to fully research the different options, all solutions have their roles to play, and hybrid solutions may well deliver the best outcomes.

When interviewed, there were many reasons given by the developers for using concrete on this project, but the fundamental reason was flexibility. Although the design appears to consist of four replicated lozenge shaped units, each is of a slightly different size due to site constraints and the need to optimise the land available. This lack of modularity was the initial reason for favouring a concrete solution. Also of importance however was the need to minimise the floor depth in order to maximise the ceiling heights and number of stories, and to achieve high levels of acoustic insulation. The structural precast columns were designed as an aesthetic feature, with smooth finished concrete on show. Fire compartmentation was an added advantage rather than a driver and thermal mass was not seen as a consideration even with the use of underfloor heating throughout.

Because of the higher than usual land values and the consequentially smaller percentage of the total cost being due to materials and labour, it could be said that the choices made were dictated more by appropriateness than cost, and therefore a truer reflection of a materials' performance credentials. Comforting as this might be for the concrete industry, it does also suggest that in other situations when cost implications are added into the equation, bottom line cost trumps performance.

There are in fact many ways in which geographic location has been shown to impact on the choices made – proximity of material supplies / transport costs, availability of local / skilled labour, local planning requirements, climatic conditions, etc. But London, with its Mayoral powers, has its own additional differences that make it a special case worthy of individual consideration. One example of this is the Mayor of London's decision to ignore the government's abandonment of its zero carbon policy in May 2016, by introducing its own requirement for all new housing developments over 10 to

reduce their carbon emissions by 35% more than the Part L minimum (Energy for London, 2016). For those developers failing to comply, the regulation is backed up by a fine set at £60 per tonne of carbon dioxide generated per year for a period of 30 years. Whether or not this is a genuine attempt to drive the sustainability agenda and improve the quality of housing in the capital, or just a cynical development tax on affordable housing is a separate debate, but in the absence of any consistent policy from central government, it shows how London, with its unique London Plan, can in theory at least, drive and fund its own sustainability agenda.

The question being asked relating to this, is how should this local knowledge affect the way in which the concrete industry promotes its products? Superficially, the combination of proportionally high land values reducing the impact of comparative material costs, and sustainability targets driving a zero carbon agenda look positive for the promotion of concrete solutions. There are more factors to consider, however, before a clear picture of this market begins to emerge. Another impact of high and increasing land values is that the fine for non-compliance in London is clearly set too low, being far less than the cost of achieving the required reduction in carbon emissions in all but the most affordable of social housing. As a result, this policy is not driving sustainability, it is unclear whether the fines are even funding it (despite an FoI request made on this issue (Siebert and Robinson, 2018)), and the only known outcome is to make affordable housing less affordable as a direct consequence.

High land values and subsequently property values also result in higher labour costs, exacerbated at least in the short term by Brexit. These two factors, more so than in other regions, are driving the Capital's renewed interest in off-site manufacturing due to the ability to avoid the cost of a limited London based labour force by manufacturing elsewhere and transporting panelised or volumetric components direct to site. The fact that London's 'sunshine belt' now covers a radius of over 100 miles however, with land, property and labour costs remaining high for some considerable distance, means that importing these components from the continent is also seen as a viable solution, once the concept of off-site manufacturing has been accepted. This has further contributed to London's 'special case status', with its available docks making the regular importing of building materials and components more commonplace. This is explored in more detail in section 6.3.1, but for the first time, our construction industry is competing with overseas suppliers for not just building materials, but panelised components and even, if flat-packed, whole housing solutions.

Having considered this complete package of additional London based factors, there is an overriding sense that if off-site manufacturing is to succeed anywhere, it will be in London. So what does that mean for the concrete industry's role in housebuilding, particularly with respect to its well-rehearsed claim of proximity of materials, claiming no major building site to be more than twenty miles from a readymix supplier. There are some positive but counterintuitive messages here that often get drowned out by the perceptions of concrete as a heavy, bulky material, but also some inconvenient truths that are equally unknown by many decision makers. It is true that aggregate is a ubiquitous material and sources are relatively interchangeable, meaning that it is unnecessary to transport the majority of the weight of concrete very far. Ironically, the caveat to this is the prescribed use of recycled aggregate, which, being less readily available often has to travel far greater distances. But this claim is for in situ concrete requirements only – precast concrete components travel greater distances like many other materials. In reality, carbon emissions due to transportation are of less

consequence than might be thought, especially when travelling by sea, but are equally difficult to calculate to a degree that would have much influence on the decision making process. Whole life costing requirements, still in their infancy, are yet to filter through to the cost analysis stage in any meaningful way, although the implications of this are discussed in more detail in section 6.4.4. Were one to dig a little deeper, it would be discovered that the concrete industry also ships in much of its cement requirements, an increasing proportion of its sand, sharp sand now becoming a limited resource (Pushkareva, 2011), and even its eco components, fly ash and GGBS, both of which are now less easily sourced in the UK due to the demise of our coal and steel industries.

Setting these complex factors aside, the perception of concrete as a heavy material unsuited to offsite manufacturing and transportation prevails. If off-site manufacturing components were to be manufactured elsewhere and transported into London, they would surely be timber - or CLT, light gauge steel frame – anything but concrete? The fact that London is regularly supplied with concrete twin wall components from Belguim (section 6.3.1) is not necessarily going to dislodge this perception, but the reality is that for the London market the weight of imported components is not the defining issue that it would be for other locations. Despite this barrier however, Laing O'Rourke, FP McCann, Forterra and others are fighting to buy up or build capacity around the UK to supply precast concrete wall and floor components to the housing industry, specifically in London, the UK's construction powerhouse. But, discounting shipping distances, none of these sites will be as close to the centre of London as their established competitors on the continent, such as Kerkstoel in Antwerp.

The viability of off-site manufacturing, something the concrete industry must consider carefully, is therefore very location sensitive and dependent on travel distances, comparative labour costs and the materials being used. What works in London is further affected by the value of land as a proportion of the overall build cost, regulations specific to the region, and its proximity to ports and the Continent. London is a substantial market, but it functions like a sector in its own right, differing from the rest of the UK just as much as Housing Associations differ from the speculative house building market. How location feeds into the concrete industry's policy making decisions, whether that's London or elsewhere, is therefore another piece of the jigsaw to be considered.

For the decision making tool, this highlighted the complexity of the many unrelated factors that not only have to be considered but comparatively measured. The sense however, that the process in drawing attention to these issues was merely resulting in more questions, bringing more doubt than it was clarity led to the further development discussed in Chapter 7.

Appendix N4

Tokyo's story (Section 6.2.4)

Objective: *to highlight the role of the economy and long term trends in dictating the choices made by both governments and industry.*

Examples from overseas are often used to suggest how the UK's housing industry could operate more productively, but without a full understanding of other countries' economies, false comparisons can easily be made. Northern European countries have similar climates, lifestyles, societal structures and are therefore often thought to offer potentially workable solutions for our housing industry (6.3.1). But Japan is also of interest because it could be seen as having similarities with the UK's future should current economic and demographic trends continue (Chan, 2017)*. This study looks at how Tokyo chose to solve the problem of its housing shortage through deregulation, and compares that with our approach in London where house prices have increased in value by over 10 times that of Tokyo's over the same twenty year time period* (Robin Hatin, 2016)*. To understand how to influence the housing industry, it is suggested here, is to understand the economics behind it.*

"In Tokyo alone, 140,000 new homes are delivered each year through off-site manufacturing." ((London Assembly Planning Committee, 2017, p. 32))

Comparing the housing markets in the UK and Japan is of interest because of what it shows can be incorrectly assumed based on some superficial similarities. There may well be lessons to be learnt from Japan's experiences due to those similarities and their social and economic trends that appear to be a decade ahead of our own (Farmer 2016, p.47), but without understanding the many cultural differences that lie behind this, this case study shows how wrong conclusions can easily be drawn.

At the outset, when deciding how to define the scope of the literature search, it was said that geographically, there was more likely to be a synergy between the UK and northern European countries than elsewhere because of our similar cultures and climates, but that it would be wrong to rule out the experiences of any country before first making a preliminary assessment. Japan, at that stage, was used as an example of such a country because of those more obvious similarities – our size, density of population, climate, aging population, and a move away from social provision towards a more market led business model. This trend in the 1980s resulted in rampant land speculation and an increase in property values, followed by the inevitable 'realignment' from which Japan is still recovering (). It is the methods used by their government to recover from this crash over the past twenty years that are potentially of interest here alongside their attitude towards innovation, but not without first getting a full understanding of our cultural differences, and how they impacted on the decisions that were made.

At the height of Japan's post war economic boom, which saw its 'bubble economy' grow over twenty years to become the second largest in the world, the value of the country's real estate was estimated to be four times that of the entire USA, with prime locations in Tokyo being worth 350 times that of Manhattan (Colombo, 2012). When the property crash came, therefore, it was sudden and severe, wiping out over 50% of that peak value, and in some extreme cases leaving property valued at 1% of

its previous valuation only a year earlier. That was in 1991, and has been followed by a period, originally referred to as the lost decade, but now looking for a new name, during which property prices remained stagnant along with the rest of the economy, whilst the government tried various policies to reinvigorate their country.

The lessons that they learnt, and which many tried to use to forewarn western economies, did not prevent the growth and collapse of the sub prime market, and there is little reason to believe that the way in which they have now controlled the rapid growth of their major cities without creating a new property bubble will be learnt from them either. But the intention here is to decide whether their experiences and their solutions are relevant, or whether, given that broader knowledge of how we differ, it would be wrong to make such comparisons. As with many of these case studies, therefore, there are two objectives. To learn from the study itself, but also to assess the process being developed, in this case by drawing attention to the danger of a little knowledge leading to flawed decision making.

The process is basically one of listing all the similarities and all the differences and then assessing their relevance to the question being asked. In some respects this is an extension to the process of weighing up the benefits and the barriers relating to a new innovation to assess its chances of success. Before learning from the experiences of innovative solutions elsewhere, it is necessary to establish whether they are relevant to our culture, society or economy. Also similar is the way in which a single defining factor might make any comparison invalid, and negate the need for any further investigation (Barlow et al. 2003, p.143).

Japan does in fact differ from the UK in multiple ways, many of which stem from the seismic activity they have always had to consider. The need to build light, prior to the development of modern earthquake resistant measures, led to a temporary approach to their housing, which has become a cultural norm, with many timber housing solutions still only expected to last for twenty years. White footed ants are also recognised as being behind the growth of this mentality, which means it is now quite unusual to buy second hand housing – 13% of sales against the UK's 84% (Lucas, 2014). That is a substantial difference, and one that is also reflected in the way mortgages now operate, inheritance tax is calculated, and also how houses are designed and laid out. To show how much this has now become a cultural norm rather than a practical necessity, concrete houses, of which there are many, are only seen as viable for slightly longer. "Houses themselves are a rapidly depreciating asset; after 20 years the value resides only in the land" (Lucas, 2014).

Returning to the country's state of stagflation, what the Japanese government finally resorted to in an attempt to reboot their economy was to deregulate their planning system, and it is this policy that some in the UK think we should be emulating now. The comparisons being drawn to justify this are between Tokyo's house prices and those in London. With similar growth rates over a twenty year period, whilst our house prices have increased by over 440%, Tokyo has absorbed its population boom with price rises of only 45%, and this despite there being no available building plots. For Tokyo, deregulation has meant individuals being able to re-designate land use, reduce living space standards, and build as high as is practically possible. As a result of this policy shift, a building boom ensued that very quickly satisfied the pent up demand for housing in Tokyo, and greatly reduced the speculative purchasing of land. In 2014 there were actually more house starts in the city of Tokyo than in the

whole of England (Harding, 2016). The aesthetics of what this has delivered is debateable, but as the protagonists of such a policy like to point out, the cityscapes we love the most and go to great lengths to both protect and emulate, mostly evolved during periods where there was no regulation whatsoever. It is also true that Tokyo boasts a procession of Pritzker prize winners, but is this a policy that would have the same impact, for better or worse, if implemented in the UK?

For better might mean rescuing London's working population from crippling property price hikes that are in danger of making London itself untenable as a functioning city. For worse would mean presiding over the wholesale destruction of much of what makes London London. Tokyo has seen its past eradicated as single storey plots have been redeveloped as 'pencil buildings', with neighbours having no recourse to the law to protect their rights to light or to limit any nuisance that such a development might bring. It can very quickly be seen how such a policy would struggle to be adopted in the UK, with our heightened sense of self over that of the common good. But as a consequence of our inaction, we see London becoming increasingly unaffordable as did Tokyo before Japan's bubble so spectacularly burst.

Figure A: 13 Typical 'Pencil House', Tokyo, Japan.

Perhaps the lesson to learn from Tokyo is more generic than that of any specific solution. The rise in house prices in London, driven through speculation is unsustainable, and will in some way find its correct level. Whilst Japan's rise and fall were an extreme example of how this can become an unstoppable phenomenon, the basic ingredients are all here for the UK to suffer a similar fate. Our national banking system might be better rehearsed than Japan's was at regulating an overheating or underperforming economy (Colombo, 2012), but the UK is still failing to deal with the underlying issue of property speculation. If deregulation is so unpalatable to our national psyche on an individual level that it would never be allowed to perform as it would have to, what are the alternatives available to us other than to restrict speculation?

The conclusion to be drawn from this case study, therefore, is that direct comparisons can be dangerous, in the same way that following any analogy too far will always lead to a flawed interpretation of the problem being addressed. Japan's story has much to teach those countries now facing a similar need for readjustment brought about by an overheated economy, an aging demographic and falling productivity. But how that translates into government policy, methods of construction or public reaction will depend on far more than national economic trends. Japan's solution to what might appear to be a very similar set of conditions to our own is equally influenced by their national psyche, seismic activity, inheritance tax laws and even white footed ants. The methodology being proposed for assessing these alternatives, and trialled in the next section, 6.2.5, is one whereby each factor, no matter how seemingly peripheral, is considered in turn as a specific choice between two solutions. In this way, false comparisons can be shown up for what they are, before being recognised as key factors in the decision making process.

"The Japanese model presumes that the physical house will be replaced every generation, with the mortgage mechanism concentrated on site value. This is being realistic about the longevity and flexibility of offsite constructions, but of course it is also culturally appropriate. The British prefer to constantly repair and remodel, valuing patina and historic character." (Richard Saxon CBE, 2007.)

Appendix N5

Innovator sites: Dalston Lane, Hackney (Section 6.2.5)

Objective: *to define the most appropriate market for a specific material solution by direct comparison.*

The Borough of Hackney acts as a special case even within London with its decision to adopt a 'timber first' policy. How dangerous are policies like this in general, let alone to the concrete industry? Can they even be justified? CLT is undoubtedly seen as a threat by the concrete industry and this needs to be fully understood in terms of the markets, the housetypes and the clients it can be of benefit to. Going head to head with CLT is an exercise that should be done with all material solutions to define the space where there is a clear advantage for one over the other. Dalston Lane provides a case study for this and shows how these complex comparisons can be broken down into manageable decisions.

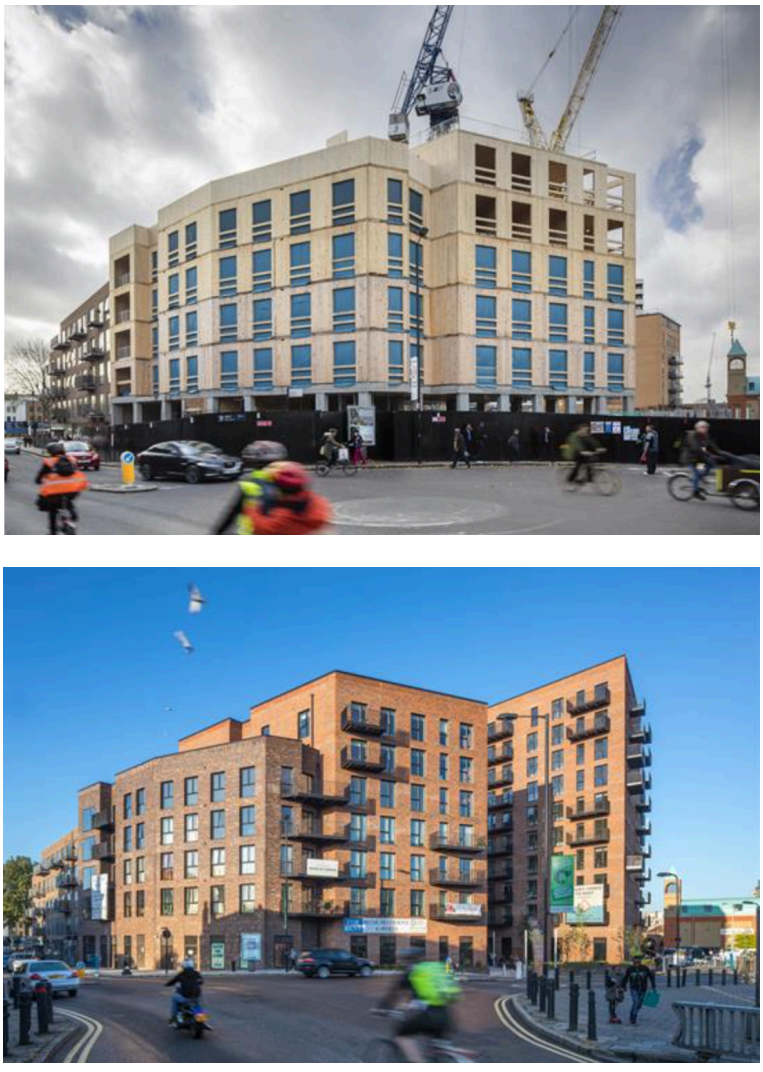


Figure A: 14 Dalston Lane development, during and after construction.

In 2012, the borough of Hackney introduced a 'timber first' policy. The reasoning behind this decision and the impact it has had on the choice of materials used is certainly relevant to this research, but the initial purpose of this case study was to investigate the decision making process behind the choice of CLT as a building material specific to a site. Not surprisingly, the majority of major CLT developments in the UK are currently in the borough of Hackney (Mathews, 2016) but the one chosen here was developed in CLT for a completely unrelated and unexpected reason.

As is also true for central government, Hackney Borough Council (HBC) soon found that promoting any particular industry does not come without its problems. After being advised that they could be opening themselves up to legal challenges from the brick, steel and concrete industries if they made planning decisions based on a pro-timber policy, this was quickly clarified with the statement "*Although the Council is keen to promote the benefits of building with wood, it is not considering a policy that would exclude locally sourced building materials or prevent the use of other sustainable building materials in future developments."* (Chartered Institute of Building, 2012) HBC then goes on to say that its main reason for promoting wood is to assist in the council's aims to reduce its carbon footprint. What line any legal challenge would have taken is unclear, beyond refuting the fundamental assumption that wood does have a smaller carbon footprint than all other building materials, something that has already been discussed in section 6.1.3. By a careful rewording of its policy, however, Hackney has now established itself as the testbed for CLT construction in the UK, the results of which will be carefully monitored by other councils and other industries, including, one would hope, the concrete industry.

Turning to Dalston Lane, this site was chosen because of its size – at the time of writing, the largest CLT residential development in the world – and the fact that the developers were snagging the project at the time of asking. The interview aimed to discover if there was any fundamental reason behind the choice of CLT, although this appeared to be self-evident, and also to compare the whole experience against the contractor's knowledge of comparable concrete constructions. The choice of CLT was in fact due to CrossRail, and had little to do with the borough's now rebranded 'timber first equal' policy. The full explanation stems from a moratorium on any piling in the area until it had been decided on the route that the tunnel would take (Davies, 2018). As it happens the decision was taken later to route the tunnel two miles away, but at that time the developers were faced with having to postpone their start date by two years, or find an alternative to piling. The chosen solution was to pour a 1m thick raft across the whole site off which they could then build – providing the total load was kept to the required minimum. The only way in which this could be achieved was to build using CLT, thereby reducing the weight of the final build by an impressive 30% over an equivalent concrete construction, and also allowing for an additional two stories to be added (The actual material weight of CLT is 80% lighter than concrete).

Reduced weight is however only one of the many benefits that CLT can offer when compared to a panelized concrete solution, although this alone is responsible for a saving on foundation costs, transport costs and crane costs. It also requires less labour on site and reduces time on site. It is quieter, safer, more accurate and more flexible, allowing for easy integration of services and on site changes without incurring major cost penalties. It can be used on site all year round at all temperatures – it's even better at dissipating seismic forces. All these factors impact on the

comparative build cost and make CLT a tempting proposition. But the factor that is used the most in promoting and selling the concept to the general public is its sustainability credentials.

How then should the concrete industry deal with CLT, the young pretender? The purpose of this case study is to show how, if direct comparisons are made rather than multiple choices with an open ended set of disparate comparators, the arguments become clearer, and the decision making process becomes a manageable exercise. This forms the basis of conjoint analysis, or discrete choice modelling, as discussed in Chapter 2 and begins to show how this approach can help the decision making process by focusing attention on those factors that really matter.

The proposition made at the outset was that assessing any innovation in order to gauge its chances of success involves looking first at the benefits it would bring for all those involved, and then any barriers that stand in the way of its adoption. Once these have been considered, and assuming the benefits outweigh the barriers to be overcome, the path of least resistance – the most appropriate market, partners, promotional campaign - can be defined through a series of staged decisions that represent the evolution of a typical project from inception to completion.

The first step is therefore to couch the question in the right terms for the answers being sought. In this instance, the actual question being asked is 'in what situations does concrete offer a better solution than CLT?' This goes beyond a comparison of their material credentials, and encompasses the entire gamut of factors that need to be considered before making that choice. The interesting dimension here is that concrete, rather than being in the position of the innovation trying to establish a foothold in the housing market, is now defending its territory against the newcomer.

1 The benefits:

Starting with the benefits of CLT, the approach taken is to assess the benefits firstly for those supplying the product, those using the product, and then in terms of society as a whole (Section 2.3.3). CLT is currently an imported product, which means there are a limited number of European suppliers who have made their own assessment of the UK market and how beneficial that could be for their business model. This represents a substantial unknown at the outset of this process, as none of the suppliers in Germany, Austria or Switzerland have been interviewed on this matter, but it is nonetheless one that cannot be left out of the equation. There is the promise of a Scottish supplier coming on line in the near future (Confederation of Timber Industries, 2015), although this is dependent on securing substantial private investment, and therefore another unknown, together with the implications of using C16 grade supplies rather than C24 and the limited resource that the UK can provide (At the time of writing this proposal appeared to be on hold). In the meantime it can be assumed those businesses looking to import to the UK will have considered the current size of the UK market, it's potential, how fragmented it is, how economically stable, how accessible. They will have considered what impact this expansion might have on their existing markets, and how to prioritise one over the other should the need arise. Do they continue to export, open new plants in the UK or franchise their operation to UK based businesses? These are all unknowns and all represent an element of risk for the supplier, against which the potential benefits of a new market must be balanced.

For the developer, the material benefits have already been listed, and the case for CLT at this point would seem undeniable, as does the sustainability argument used to promote CLT to the public as the solution to climate change and a benefit to society. But those unknowns that must be considered by the suppliers are also pertinent to the developer choosing to use the product, as security of supply is a critical factor, and it is at this level that the reasons why innovations sometimes struggle to gain acceptance becomes more apparent.

2 The Barriers:

There are in fact many barriers to adoption that beset any new innovation, plus some more that are specific to CLT. These general barriers go beyond the practicalities of the product in use, and include those associated with disrupting an existing market, how that product is perceived, and the potential unknowns yet to be discovered. These are the risk escalators that can prevent seemingly unassailable solutions from getting a foothold, let alone a percentage of the market.

Before looking at these barriers, however, it would be wrong to assume that CLT as a material has all the answers. CLT behaves constructionally very much like concrete but with the many advantages discussed above, but it also falls short of concrete in that it is less durable, and has inferior thermal mass and acoustic properties. Whilst thermal mass and acoustics are measureable properties that can be dealt with in other ways, durability constitutes a variable risk that is harder to factor in, both for the insurers and the financiers. How well will CLT perform in our climate? Will it survive flood events, both external and internal? Are the adhesives used elsewhere appropriate here if we are to start working with a lower grade Scottish timber? Are they sustainable adhesives with low VOC levels or a public health concern to be managed? Many of these concerns still remain unanswered, and thereby constitute 'future unknowns' that create barriers for those looking to adopt. And for the public, in the same way that CLT's environmental image has become seen as its main benefit promotionally, its potential to burn has become its main barrier to overcome.

The unknowns regarding CLT's performance in fires fall into the two categories of science and perception, both of which are equally important from a marketing perspective. What is of no doubt is that whilst the science can be proven, one way or another, it is by no means certain that the public can be persuaded to either trust or believe in it. The recent Grenfell Tower fire, whilst having no connection with wood products beyond possibly some timber battens, has proved two things - that even concrete tower blocks can burn catastrophically, and that our system of assessment, regulation and certification cannot be relied upon to keep us safe. The preferred solution for achieving the appropriate levels of insulation in CLT constructions is external insulation and rainscreens, potentially similar to those used and certified at Grenfell. In the wake of events such as this, the public's faith in 'the facts' is compromised, and a reliance on gut instincts becomes more prominent. Gut instincts, as the concrete industry knowns only too well, can make for very effective barriers.

Any unknown fact, future uncertainty, or misplaced perception can therefore be very detrimental to an industry competing for a foothold against an established alternative, where demand needs to be proven before investment is forthcoming, with the demand in turn requiring the 'lower cost incentive' that invariably only becomes apparent through economies of scale once the industry has become established.

In conclusion, there are many benefits to CLT but many barriers to those benefits being realized, some due to a lack of knowledge, some due to the trials of breaking into an existing market, and some due to limitations of the material itself. So before any meaningful assessment can be made of CLT's potential position in the market compared with concrete's, these three categories of barriers need to be better defined, because eventually only the limitations of the material will be of any consequence: The unknowns due to a lack of knowledge will become either known positives or negatives, and barriers to adoption, due mainly to these unknowns, will either fall away as confidence grows and perceptions change, or they will grow until CLT's position in the market becomes untenable.

Benefits of CLT over Concrete			
credential	known **benefits**	unkowns: **disputed** (lack of knowledge)	known **barriers**
adoption (early)	timber first policies		not a UK product investment costs OSM barriers public perception of fire risk public perception of rot MMC warranties supply chain risk
material (current)	80% lighter safer, cleaner quieter on site faster on site (inc. second fix) more accurate (CNC cutting) flexibility of design error correction routing of services airtightness exposed finishes breathable construction weather independent	carbon emissions fire resistance glue / VOC	maximum height of build (less thermal mass) (acoustic performance) needs external insulation (Grenfell) above ground only structural span of 8m 3m panel width
potential (future)	UK production economies of scale	longevity proximity security of supply	catestrophic event reassessment of environmental impact.

Table 0:4 Comparative benefits of CLT over concrete

Seeing the facts set out in this format helps to focus attention on the barriers than can be challenged (disputed) and the benefits that need to be accepted and worked around. What is noticeable is the degree to which the major barriers are potentially temporary whilst the benefits are unlikely to change, with the added concern that CLT's greatest material barrier, height of build, is already being challenged, most often with hybrid steel frame constructions.

The key areas of investigation should therefore be regarding CLT's performance, focusing on those areas that are seen as the most contentious. This is not the material's thermal or acoustic performance, or even its durability, which are ultimately part of a wider financial cost benefit analysis, but the emotional factors of environmental and fire performance. These are not areas for detailed analysis here, but both are areas where the facts can be contested. CLT buildings have burnt out of

control, albeit mostly during construction or due to procedures not being followed, but the claim that CLT can only char is only true in the right conditions. Similarly, the claim that CLT is environmentally superior to concrete is only true under the current accreditation system (section 6.1.4) and this is, by the BRE's own admission, no more than a guide based on a set of basic assumptions (Henderson, 2017).

3 The Path of Least Resistance:

The third and final stage of this analysis looks at the path of least resistance for the products being considered. In this instance, that means looking for where panelized concrete can offer a more appropriate solution than that offered by CLT. This goes beyond a comparison the materials' physical properties, and looks at the six stages in the decision making process first introduced in Section 2.3.6 and asks 'where do the barriers to CLT outweigh the benefits making it less preferable than concrete?'

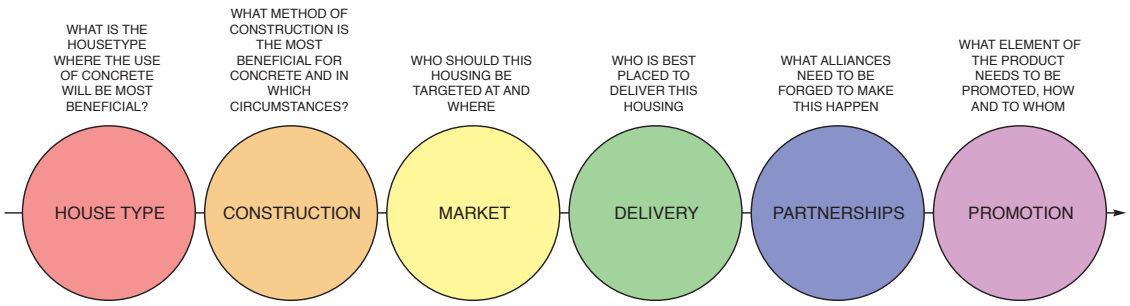


Figure A: 15 six stages of the decision making process

The linear process adopted here is for practical purposes rather than a strict linear progression of decisions that need to be taken. In reality there are multiple interrelated factors to consider within each of these stages, and which one is central in the decision making process will vary from project to project – sometimes the requirement for a specific housing solution will be fixed, with all other considerations being variables, whilst on other occasions site constraints might dictate the method of construction, such as at Dalston Lane, making this the fixed condition around which all other considerations are discussed. The aim here however is to break all these factors down into separate binary choices wherever possible to simplify the decisions being made. The following examples within each of these six stages, and based on this CLT case study, demonstrate the process by showing just how many different criteria there are to consider. How they are actually compared against each other is dealt with in Chapter 7.

Housetype:

The decision of which housetype would be most appropriate for a panelized concrete solution has already been defined by the practicalities of concrete construction as one over 4 stories high, due to the redundancy in reinforced concrete panels required for handling on site (P.16.1, p.15). On this one condition alone, this rules out all residential construction below five story apartment blocks and high rise as areas where concrete might have a clear advantage over its competitors. This is not to say other factors might intervene, but initially this is about making binary choices based on appropriateness within each of these six categories when comparing two material solutions. In this case CLT does not suffer from similar limitations at low levels of construction, but cannot currently be used structurally above 10 stories unless in a hybrid form, making high rise residential the only house type where panelized concrete could be said to have no direct competition from CLT. With the advances in hybrid solutions, however, this does not provide concrete with a clear advantage over CLT for any house type.

Construction:

There are some key constructional benefits that concrete has over CLT: Ground floor construction in many high-rise developments is often constructed in concrete as an extension of the foundation and ground floor slab contract, resulting in a first floor platform on which the superstructure is built. This can be due to ground floor differences with the rest of the design - especially with mixed use developments, greater height or wider span requirements, flood risk, security, durability, etc. Beyond these specifically ground floor benefits however, safety and durability during prolonged construction programmes possibly provide the main reasons for choosing a concrete solution over CLT from a purely material perspective, CLT structures being far more vulnerable to fire and weather damage during construction than concrete structures.

Methods of construction, however, can be defined in many ways; by on-site / off-site - although this is far from binary - by materials used, or by component (foundation, wall, floors, etc.), which in the case of concrete can all be constructed either in situ or precast. The area of competition between concrete and CLT as materials is within the panelized, component, and possibly volumetric offsite sector, but primarily walls and floor components, where material benefits such as manufactured panel sizes can be compared: Both CLT and concrete panels are ultimately limited by the size of delivery possible, but CLT is currently limited by the manufacturing process to 2.95m wide panels up to 13m long. CLT is further limited to 8m clear spans, whilst concrete can span up to 9m even with a flat slab and twice as far as CLT if pre-stressed, although for residential construction these may not be key issues.

If similar comparisons were to be made based on weight, durability, thermal insulation, speed of construction, and all the other criteria listed in Table 0:5 they would provide a set of comparative benefits all independent of each other. The variable is these factors' relative importance, and that will depend on the choices made in the following two sections, Market and Delivery.

Market:

Whether there is a choice to be made of which housing market to target or a predefined market for which the most appropriate solution must be chosen, the same criteria apply. The housing 'market' has been defined here by 'people' and 'place', both of which have needs and preferences: The question 'for which market is panelized concrete more appropriate than CLT?' encompasses two conditions, 'place', or geographic location, (site related issues, proximity of supply, land values, availability of labour, climate) and 'people', or end user requirements from a social, environmental and economic perspective. To again make this a truly binary comparative process each of these must be considered in turn, and if necessary broken down even further until they can be treated as such.

Understanding the needs and preferences of the public end users was the purpose of the public survey discussed in sections 6.1.2. Issues as broad as environmental awareness, wellbeing, mortgageability and perceptions of fire risk are all binary comparisons when making a material choice, to be balanced against those already collected. Quantifying how seriously some of these perceptual barriers should be taken is discussed later, but for now the task is to recognize what they are and how and why alternative solutions might score differently under this direct comparison.

Turning to 'place' and taking geographical location as an example, both CLT and panelized concrete as off-site manufacturing (OSM) solutions are more financially viable where labour costs are high, such as in the South East. The geographical location of OSM factories is therefore relevant as transport costs will begin to reduce these benefits. Concrete's source aggregates are well distributed throughout the UK making a viable case for a national distribution of smaller OSM factories catering for all regions, including London via ports. CLT on the other hand is currently all imported from Europe, making the London market and potentially other port towns more accessible than elsewhere for delivery of its products. But with the possible introduction of Scottish manufacturing from locally grown timber, the logistics for CLT will change, possibly making Manchester and the north a more viable location for home produced CLT than London. For the CLT industry, these are currently unknowns that add to the degree of risk both for those delivering and those using the product, discussed next.

Delivery:

As with markets, delivery mechanisms too – who is best placed to act as the housing provider - might not be an open choice, but again, the same criteria apply regardless of whether this is a fixed condition or a variable to be balanced against other considerations. Also, as with markets, there are many ways to define the sectors within this category beyond the basic 'private economic enterprise' and 'social state funded' definition, with some providers increasingly finding themselves bridging this cultural divide. Some European models have now introduced a third sector definition to sit alongside that of 'private economy' and 'social state', the 'social economy' (Minister of the Brussels-Capital Region for the Environment Energy Urban Renewal and Welfare., 2016) to cater for the growth in co-housing as a grass roots delivery mechanism, a definition which has been incorporated here to reflect the potential for this option to take root here in the UK.

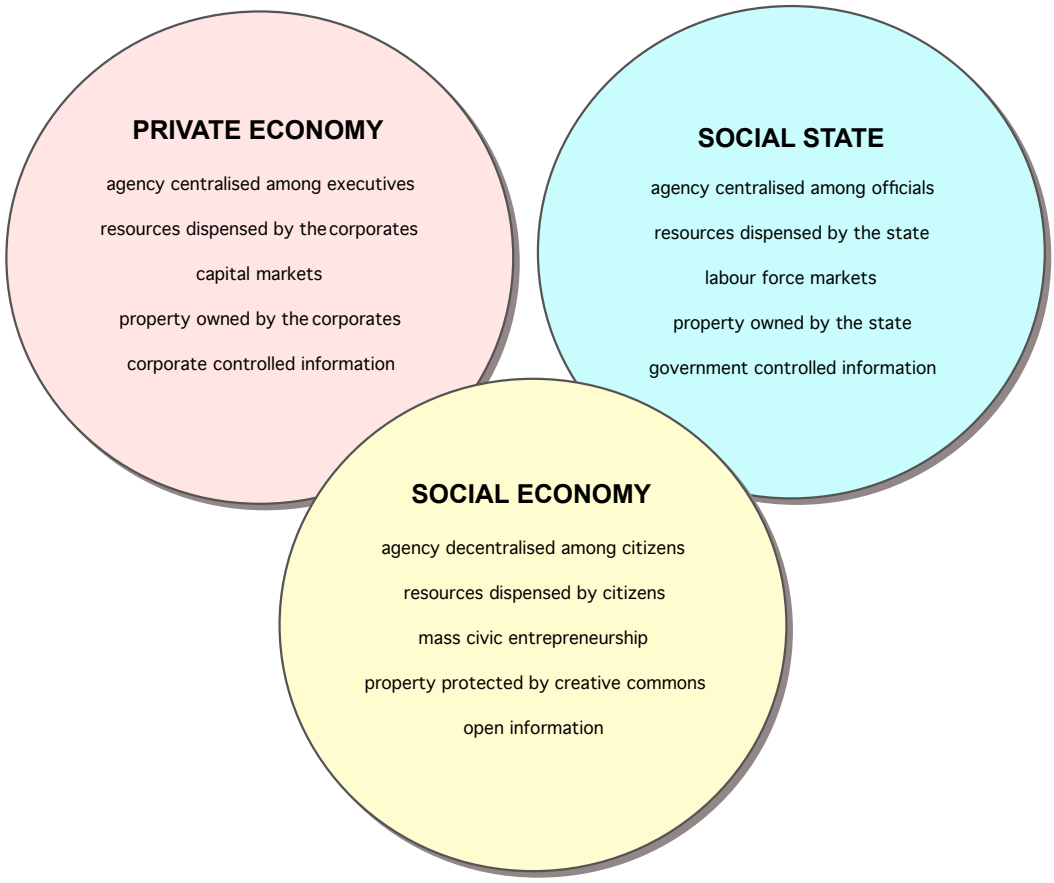


Figure A: 16 the alternative European 'social economy' model

The question being asked though, given a straight choice of CLT or concrete is what would drive the decision of these different sectors to use one material over the other? Referring back to the table of comparative benefits, would those decisions be driven by, for instance, short term onsite cost benefits (CLT) or the degree of security offered by the chosen material in terms of longevity, durability, resilience, and the degree to which these factors might be beneficial in terms of warranties and mortgagability (concrete). To this end, concrete would perhaps be a more preferable option to long term investors rather than speculative house builders, ie, the new entrants / build to rent developers and the providers of social housing.

The final two criteria, partnerships and promotion, differ from the first four in that they are unlikely to be fixed conditions around which all other choices must be made – although section 6.4.4 does look at the issue of collaboration becoming a powerful driver in the decision making process.

Partnerships:

The drive towards more collaboration within the housing industry provides an opportunity and a threat to innovation in equal measure. Once partnerships have been formed and alliances made, the task of promoting an alternative solution to that closed set becomes even more imbalanced. It is for

that reason that policies like Hackney Borough Council's Timber First (Equal) policy can become even more damaging if left unchallenged. The choices to be made here are less binary and more strategic. What are the key factors that have emerged from the first four categories of comparators that need to be addressed and who is best placed to assist in that process? If the Timber First policy is to be challenged, for instance, that will not only require evidence of how the timber industry's measure of carbon sequestration is flawed (Section 6.1.3), but also of the benefits of thermal mass in reducing carbon emissions (Section 6.1.4). That evidence then needs to be used to convince those in a position to change policy, before then addressing the Standard Assessment Procedure, before finally attempting to convince the housing industry of the benefits from their perspective. That is a long process requiring many partners, all of whom will need to have a reason for participating in such an undertaking.

This is just one example of the many complex arguments regarding the benefits of concrete that cannot be tackled alone. If the fundamental barrier that concrete needs to confront is its perceived inferior environmental performance compared to that of CLT, even if SAP were to be addressed, a consensus would also need to be reached on the measurement procedure for whole life costing. The current situation where cradle to gate is seen as an acceptable compromise is detrimental to concrete and just feeds into the narrative that timber is a more sustainable solution. How to create these partnerships is the focus of the forth section of case studies, together with what language to use to promote the solutions being proposed.

Promotion:

The final stage of promotion becomes the process through which those partnerships are galvanized. Not just between the concrete industry and the public end user, but between all the necessary parties that will need to understand the problem, and be motivated to participate in solving it. That promotional message will be different for all involved as it will be based on each participant's own drivers. Many of these case studies have shown how the promotional message used has little connection with the initial decisions made, which is not a measure of dishonesty but more of a recognition of relevance. Governments have a remit to reduce carbon emissions to tackle climate change. The public may or may not be driven by their role in that process, but they will be driven by their individual remit to provide a home for themselves and their families. That is why resilience to climate change may be a more powerful message to the individual than preventing climate change, especially if it impacts on the likelihood of obtaining a mortgage. Finding the right language for the right market is the critical last step in promoting an innovation.

Conclusion

By focusing on one client's decision to use CLT over a concrete construction, this case study has set out the scope of the task at hand in countering such decisions. It is not enough to spell out the benefits of concrete, nor is it enough to point out the disadvantages of CLT. By making direct comparisons across a whole range of factors, however, the 'sweet spot' for concrete can be defined, in terms of a housing solution, a method of construction, a market for that product and the delivery system most appropriate for providing it. But even that level of assessment will not ensure a positive outcome

without there also being a collaborative effort by all the parties involved in delivering that solution, and understanding how to promote that solution is where the task begins.

The process that evolved out of this analysis was one whereby the benefits and barriers relating to each binary choice between two options could be recorded in turn (Figure A: 17), and where necessary breaking these questions down to consider each one from the different perspectives of the sectors involved.

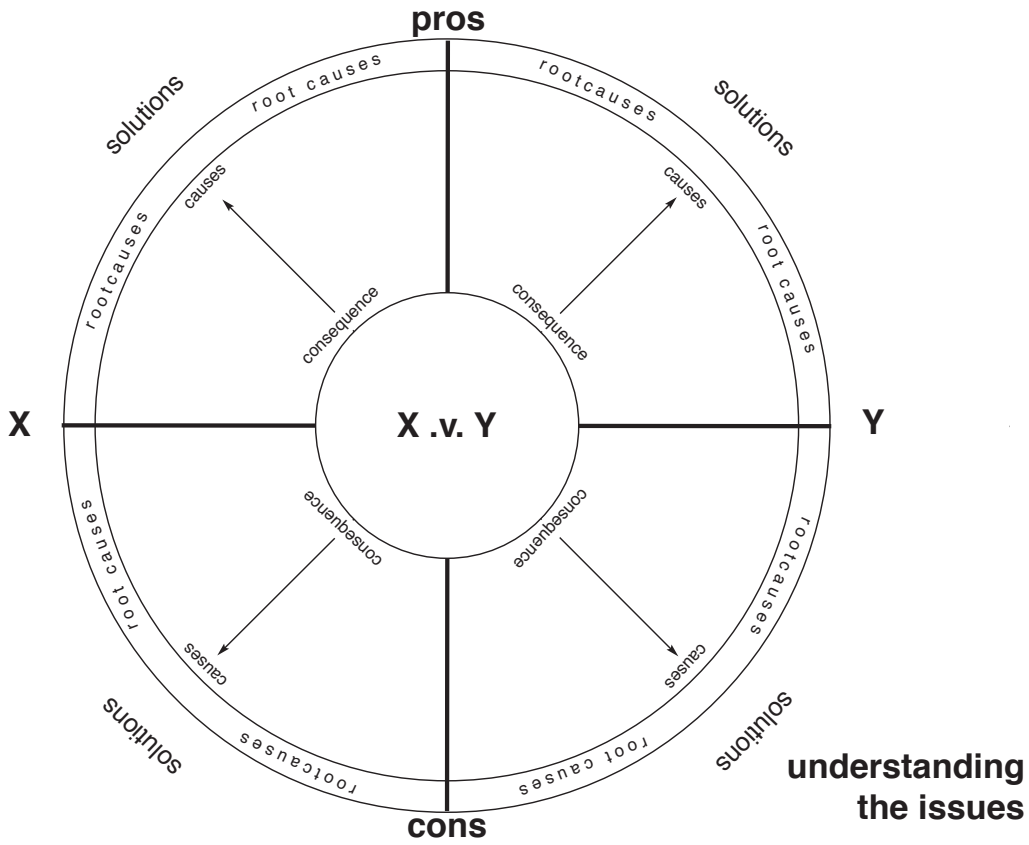


Figure A: 17 diagram of the binary choices and how they can be assessed

Appendix O1

European models (Section 6.3.1)

Objective: *to show what can be learnt from overseas models that are importing products to our markets.*

This case study looks at three European companies that are exporting their products to the UK housing market – concrete block components, panelized cladding solutions and complete kit houses. Each of these industries has a history particular to its own country of origin, and each has had different experiences in trying to influence our housing market. It would seem reasonable to assume that replicating these products in the UK would be more profitable than importing them, but a deeper understanding of their business models would suggest otherwise.

Much is made of the European housing market and how we should emulate their models, in much the same way as we praise the affordability of the French railway system without fully appreciating how much it is subsidised by the state. What might appear an appealing alternative to our system might in reality be problematic in other ways or incompatible with our society or economy for reasons beyond the housing industry's gift to change. Before proposing to adopt European solutions, therefore, a holistic assessment should be made of how and why those solutions have been successful in their country of origin.

Many of Europe's generic housing solutions appear to be almost painfully preferable to our own, such as the German policy of building housing with useable cellars and attics for easy, affordable expansion when a family's needs increase. Others, such as the reliance upon apartment living to create higher densities of accommodation in the city centres is increasingly seen by us as only acceptable as a solution for a young urban elite prior to them starting a family. For most other demographics this style of living can be tainted with a degree of financial necessity over aspiration. But it is on a materials and methods of construction level that the differences that have evolved between our housing industries here and on the Continent are the hardest to understand. Why is it that Belgium, once wedded to brick even more so than ourselves, has not only now embraced precast concrete construction, but is successfully exporting its concrete panels into London on a regular basis? How is it that Germany has developed a housing industry where 30% of its housing is prefabricated and is seen as a high quality, affordable - even an individualised solution – the complete opposite of our own perceptions born of our post war housing boom when we adopted similar methods?

The history behind these European successes needs to be understood before importing, let alone trying to emulate these solutions, because just as our generic housing solution has evolved over a period of many decades, so have theirs, and similar as our cultures and climates may appear to be at a superficial level, there are as many differences that could render their solutions completely incompatible with our markets.

The Kit House, Wuppertal, Germany.

Off-site manufacturing has been a constant in Germany since the Second World War, and currently supplies about 30% of the country's housing needs (Venables and Courtney, 2004), compared with the UK's 7% niche market (). Unlike here, where our post war prefabrication industry petered out as the supply of labour and materials became more plentiful again, Germany has honed its kit housing solution from a base of family run businesses that continue to compete productively with each other, and have evolved a pattern book of housetypes that can be customised to suit every need – financially, practically and aesthetically. About 80% of these businesses supply timber frame based housing solutions, with the remaining being mainly concrete framed, this depending more on the location within Germany than any other factor.

Figure A: 18 Typical concrete panelised kit house design, Wuppertal, Germany

Show home villages such as this one in Wuppertal (Figure 6-24) are a common marketing method, with a variety of fully furnished house types open to the public with sales representatives on hand to answer questions and take orders. The Huff House is the creation of one of the many family owned businesses, well known here because 40% of their entire production is built for the UK market, although that only totals 80 houses per year. The fact that this is a viable business model, even with a 30% uplift to cover export costs, has as much to do with the state of our industry as it does with their production process, which would suggest there is much that can be learnt from how the German model has evolved. But for kit housing to break out of its current niche market in the UK, the barriers are not so much design related as price related. The model currently works for those who can afford

to pay a premium for an exclusive housing solution, whereas in Germany it is also one of the most affordable options available. This is due to factors that cannot easily be replicated here in the UK. The kit house model is a mainstream solution and therefore benefits from economies of scale. The German land market works to entirely different mechanisms to ours, with their government controlling the allocation and price paid for land on a needs related basis, so that buying a plot of land becomes a separate operation to purchasing a house type.

Proposals to replicate this industry in the UK fail to recognise these fundamental differences and also underestimate the strength of a business model that has evolved over generations to create a vernacular that is appropriate for their society, their climate, their business culture, their regulatory requirements – all those factors that are equally apparent in the UK and equally responsible for the generic solution that we have evolved. But perhaps the most debilitating barrier that would have to be overcome is still the investment needed to set up an off-site manufacturing plant that could finance itself through good times and bad (section 6.4.3). Again, the continent benefits from being able to diversify its markets during recessions, as it is unusual for two neighbouring countries to be on the same economic cycle, but for the UK to become an exporter of kit housing would be a very different proposition. Current government policy is nevertheless promoting off-site manufacturing as the panacea to our housing needs, and notwithstanding the arguments made above, it is in the government's gift to make the policy changes necessary to ensure its success. The question that has to be asked, however, is whether or not the government is fully committed to seeing the housing industry revolutionised in this way (section 6.4.5). If it were, there are many successful organic business models that could be emulated (section 6.3.4) rather than promoting the large start up models promising to provide 5000+ houses a year from a standing start.

Kerkstoel's twinwall market.

Kerkstoel also began as a family business, over forty years ago. They are based in Antwerp, Belgium, and make concrete twin wall panels in what is now a highly automated factory bringing in sand, aggregate, cement and coiled reinforcement bar. They can produce 1500m2 of panel per day in one centralised factory and now export to the UK. The UK market appealed because construction in London is booming, our home grown market for twinwall is small, and there is little competition from other overseas manufacturers – mainly because the UK is a notoriously difficult market to break in to. Kerkstoel is the company that Laing O'Rourke attempted to buy before deciding to set up their own factory in Worksop, Nottinghamshire to produce a similar product. It is too early to say whether LOR will be successful in their bid to grow a concrete based off-site manufacturing business providing housing for the UK market, and probably too late for them to benefit from this research into the reasons why it might be more difficult than just competing with an overseas supplier. (Laing O'Rourke, for reasons unknown to the author have now moved away from Twinwall as a solution for their offsite manufactured housing and are looking at light gauge steel frame instead).

As in the previous example, Kerkstoel have the benefit of an established home market on which they can rely should the UK market fail to expand, plus neighbouring countries into which they currently export. In addition, they have focused on the London market only, where the land distances are less,

for instance, than for Laing O'Rourke from Worksop in Nottinghamshire. It should also be noted that were this market to expand, there are many more similar businesses on the continent poised to intervene, potentially driving prices even lower. From Kerkstoel's perspective however, the UK currently represents an opportunity, but also a market with little knowledge or understanding of the principles involved in off-site, which means a higher degree of 'hand holding' than would otherwise be necessary. There are also numerous other downsides; a lower level of BIM development, seen as a necessary building block for any pre-manufactured solution that requires early design decisions to be made and adhered to; the UK accreditation system requiring an additional level of compliance above existing European standards, introducing cost, delays and uncertainty; and the exchange rate, on which all profits depend for an overseas investor could fluctuate wildly in the run up to Brexit. All these factors, in addition to the 20% surcharge that importing their product adds to their bottom line, means that interventions from overseas remain a minority interest for those supplying their products as much as it is for those developers here considering their adoption. But despite all these barriers, Kerkstoel have found a niche market where they can be competitive for the time being.

What is of more interest, looking at the wider market penetration that LOR was hoping to achieve, is the history of Belgium's move to concrete panelised construction from a similarly brick based housing industry to our own. Belgian housing did not transform itself overnight, but evolved over many decades and most importantly, through intermediate solutions:

Xella Calcium Silicate blocks

Xella, based in Duisburg, Germany, is one of the world's largest manufacturers of aerated concrete and calcium silicate products. They are currently promoting their thin joint Calcium Silicate blocks and larger aircrete wall panels – technologies that have a 30 year history on the continent but have consistently failed to make an impression in the UK. The products' UK representative, despite his enthusiasm for these products, is baffled as to why they are not being more widely adopted here.

Belgium was first exposed to them as an alternative to brick twenty years ago, when they began to be imported from plants in Holland and later from Germany. Because the technology was relatively traditional, allowing small contractors to continue to work in a similar way, the cost benefits that came from reduced time on site was enough to see the product adopted. The benefits came primarily from the fact that calcium silicate is lighter than clay, so the blocks can be larger without becoming too heavy to handle, hence the time reduction on site with a two man team laying 100m2 of wall in a day. Once the break from brick and the move to a new supplier had been established, the change to an even larger block, precut to size and delivered to site by Xella was less contentious. Even the need for a small crane on site was not outside the conventional equipment hire procedures already established. The barrier presented by the need for more pre-planning and an earlier cut off point in the design process was lessened by Xella's in house design team who would translate the developer's drawings into a template for the require block sizes to be delivered, thereby reducing the need for their clients to be fully BIM compliant. A further sweetener came from the fact that the unreinforced monolithic blocks could be easily cut on site with a hand saw should last minute changes still need to be incorporated on site Figure A: 19.

Figure A: 19 Precut aircrete blocks on site.

The next transition came in the form of full height floor to ceiling calcium silicate blocks, reinforced for transporting but still 'cutable' on site. The crane had already been introduced so the benefits of this variation far outweighed any barriers around change. With regards to the need for BIM compliance, the norm has become for smaller developers to continue to rely upon the services of the suppliers' design teams, whilst larger concerns take the operations in house. By this stage, the introduction of a fully pre-designed, reinforced twin wall solution, already in use on major developments, was a far more palatable proposition for the housing industry than it would have been twenty years previously.

The lesson to be taken from this is that if the UK wants to introduce a new technology without taking part in the transitionary processes that paved its way elsewhere, there needs to at least be an awareness of that process so that the barriers that will inevitably result can be dealt with. The differences between an off-site manufactured panelised building solution and our traditional on site construction methods are currently so extreme that the New Entrants' solution of controlling the entire process from beginning to end is possibly the most realistic way that this transition could ever take place within the timeframes being proposed.

Revolutionary changes are where small builders, heavily invested in their own solutions find it difficult to participate, as incremental evolution is all they can afford to consider (Pan, Gibb and Dainty, 2005, p. 11). This barrier goes beyond the need to retrain, increase the accuracy of the workforce, possibly change the order of construction and introduce cranes; it also includes the added risks involved. Changing suppliers, especially to overseas suppliers means having to invest heavily in a solution that will inevitably mean more to that developer than that single developer, or even the whole UK market would mean to an overseas supplier. For confidence to be high enough for this to happen, not only do the cost savings have to be significant, but the material supply has to be guaranteed, even if this means the product being stockpiled in the UK. Were that to be considered, however, in this particular instance a further problem in the form of block sizes comes into play. At 1000mm x 645mm, Xella's large format blocks are designed to be lifted mechanically, and also cut to size prior to delivery, but these blocks bear no relation to the standard 900mm module that all houses in the UK are designed to – for brick dimensions, door and window dimensions, and consequently whole house dimensions. To redesign an entire range of standard house types to incorporate a block that may not prove to be successful for a multitude of other reasons, is just not viable, let alone necessary.

So the question is, who in the UK will risk using these new products that are so prevalent on the continent? Taylor Wimpey, one of the UK's major volume house builders are certainly investigating Xella's blockwork solutions, including the full height panels, and have found very little to criticise about them as an internal wall solution for traditional housing (). But despite recent government announcements regarding the need to adopt modern methods of construction, a clear need from the public's perspective and some over publicised manoeuvring from the 'new entrants', that pressure to change has still not reached the tipping point that will see any shift in how the established industry operates. This is as predicted in the Farmer Review, and the place to watch is very much the arena of the new entrants, such as Laing O'Rourke, who are following their own alternative trajectory, creating their own independent alliances with suppliers of new materials at a scale that will provide reassurance on both sides that this is a market worth pursuing.

The term New Entrants in itself covers a range of business operations from the small start ups to the panacea status companies who the government turns to when needing to provide up front proof to the general public that their policies are being enacted. In reality, there is a sweet spot in between these two extremes, where companies are growing their market share organically within proven sectors where growth is at least secure if not guaranteed. One example is McCarthy and Stone, the care home operators, highlighted by Xella as a company who have trialled and adopted their large format block solution. They have the scale and the autonomy – and the guaranteed market – to allow a new innovative solution to be trialled effectively over a period of time that will allow it to become embedded. They are what are referred to as the 'early majority' players (section 6.4.1) that take innovation from demonstrator site status to proven mass market appeal status, where the likes of the volume housebuilders will then capitalise on the security of supply they have created.

Conclusion

What might appear to be very appealing European alternatives to our housing industry's solutions have invariably evolved over many decades and cannot easily be 'transplanted' into our markets, even as imports, let alone be replicated by our own providers. An established import business does however act as a barometer for a product's potential to succeed, whilst recognising the additional factors that can still provide the importer with the advantage – alternative markets to alleviate the impact of downturns, an established network that can cope with a slow UK market growth, embedded knowledge of the product from decades of evolution. Allowing European providers to prime the market whilst waiting for the right moment to intervene can be a wise strategy, as in this case with UK manufactured kit housing:

"Until now, Dutch and German makers such as Huf Haus have dominated the UK kit-home market. But a new breed of British start-ups such as Facit Homes is now challenging them with individually designed and digitally manufactured homes made in an east London factory, helped by the fall in the pound since the EU referendum, which has effectively priced out European rivals." (Collinson, 2018)

Appendix O2

Established .v. disrupter business models (Section 6.3.2)

Objective: *to highlight the differences between established and emerging business methodologies and their roles in promoting new innovations*

This study is based on the interviews held with both established, traditional developers and 'new entrant' innovating developers. The picture that emerges is far more complex than normally perceived, with both having important roles to play in bringing innovation to the mainstream market. The level of risk associated with an innovation will dictate which market is the most receptive, but risk takers are not necessarily more acute at reading the potential for a new product. They can just be less aware of the risks they are taking, and it is worth noting that failure can be just as damaging to the innovator's reputation as it is to the start-up company's finances.

There is a tendency in many business environments to oversimplify the role played by mainstream established companies and be dismissive of their contribution to innovation in comparison to that of the plucky start-up companies, and this is no different in the UK housing market.

"It is often said that start-ups are better at creating new things. They are not; they are better at exploiting them. Successful start-ups almost always begin with an idea that has ripened in the research organization of a large company. Lose the large companies, or research organizations of large companies, and start-ups disappear." (Lazonick & Mazzucato 2013)

Whether or not this is more pronounced in the UK due to a cultural tendency to stand up for the underdog, the voice of the establishment is often considered less trustworthy than that of the newcomer, despite their almost inevitable lack of comparable experience. Whilst this would suggest that in the UK we welcome innovation, the case studies so far paint a picture of overwhelming conservatism to the point of indifference towards change.

Defining the psyche of an entire country is complex in the best of cases, but for the UK, with its melting pot of cultural references, and a demographic range that spans such disparate experiences as world wars and the twittersphere, there seems little point in even trying. What is needed however is a better understanding of what roles different businesses fulfil regarding the uptake of innovations, so that correlations can start to be made between products, the markets they are aimed at and the businesses best placed to deliver them.

Through a series of interviews undertaken with directors of the major volume housebuilders and the innovative start-ups, a picture begins to emerge that suggests that each sector has its role to play in encouraging innovation that goes against the default position often portrayed. The purpose of this case study therefore, is to show how a better understanding of those roles can help define a strategy for deciding where to promote new innovations within the housing industry as a whole.

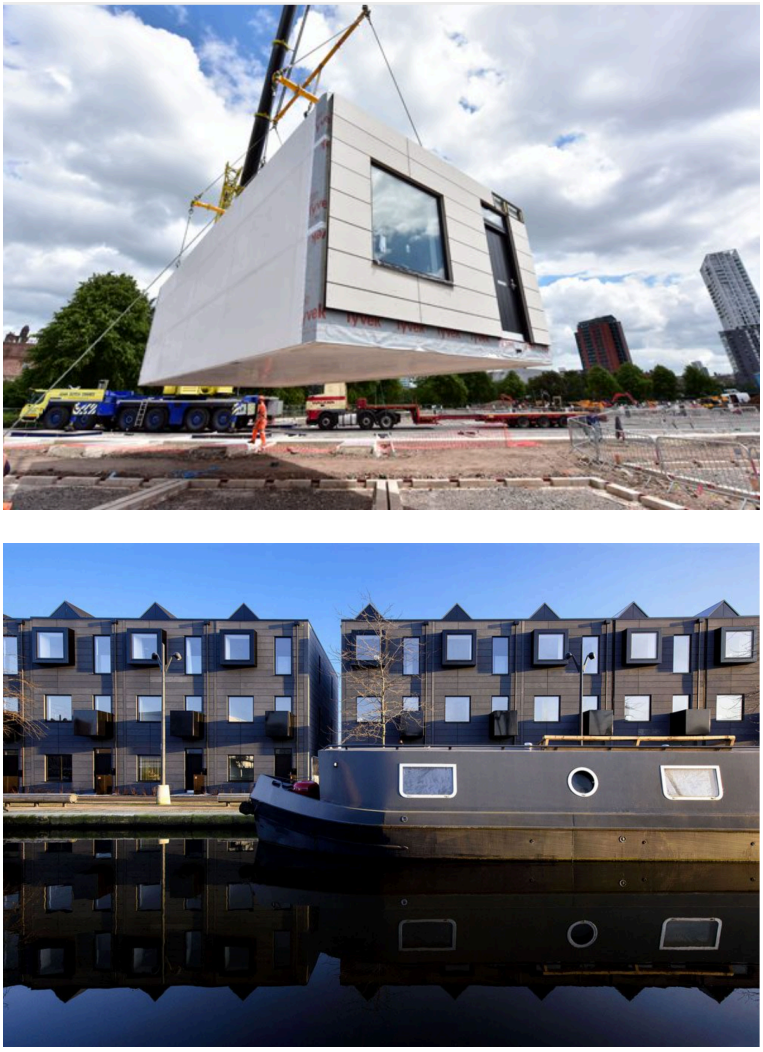


Figure A: 20 Urban Splash volumetric house, Manchester.

Urban Splash, Manchester's award winning property developers now have residential properties to buy and rent throughout the UK. They are a success story that the government often refers to when promoting the concept of off-site manufacturing as the panacea for our housing crisis. Their iconic offering on the canal side in their home town, referred to as the Urban Splash 'House', is a package of good ideas brought together as a volumetric shell to be pre-designed internally by the prospective owners prior to delivery to site. It is a prototype for a 'mass customised' housing solution, with a pattern book of permutations available in the show home for clients to choose from. There is little that is truly revolutionary about this concept, but it has been well promoted within a niche market where people are prepared to pay a premium for something beyond the standard speculative house offering. In Germany, it would sit towards the budget end of kit housing.

Digging a little deeper, however, exposes a level of inexperience that often defines many young and entrepreneurial companies. House Mk 1 was not without its flaws, perhaps the most unexpected being the width of the volumetric modules being too large to transport without the expense of a police escort. There were other issues, now ironed out in later models, but the underlying concern

was with the level of research that went into such a high spec, attention grabbing end product. From the volume house builders' perspective the high risk levels associated with new innovations has less to do with the products being promoted and more to do with the naïve optimism of those prepared to experiment with them.

In contrast, the established volume house builders project a very different image – more considered experience than naïve optimism. Their business model, tried and tested over many decades, delivers a product that satisfies their market as well as their shareholders and has also developed coping strategies for riding out recessions. Their role, although not one consciously undertaken, is to provide the financial benchmark by which new innovations are measured. By benefitting from a perpetuation of the status quo, they have adopted a position that resists anything that is not immediately viable to undermine their position.

Taylor Wimpey, like many other volume house builders, has a budget and a department charged with investigating alternative solutions. To what extent this is a 'watching brief' to keep themselves informed should the need arise to make changes is unclear, but their business model would suggest that changes will only occur when there is a less expensive option available, or they are pushed into action either by government legislation, public pressure or competition from their own sector. Until that time, they will continue to follow the most financially beneficial path available, which is their current, well honed solution.

The outcome of this flawed scenario, the reasons for which are discussed in the final section, 6.4.5, is that whilst these established companies are able to carry out the research these innovations require, they have no intention of being the guinea pigs, and those willing to take that risk, are doing so without the necessary knowledge to ensure their success. As a consequence, many start-ups fail, and many good innovations get abandoned either through the bad publicity that follows, or their inability to stay in business for long enough to reach the security of the established markets. This apparent stalemate is a reversal of a well recognised phenomenon discussed in section 6.4.1 whereby early adopters of a new idea are reluctant to promote that idea to the mainstream market for fear of losing their competitive advantage. In this scenario, however, it is the mainstream market that is holding back the uptake of the innovation by failing to assist their own guinea pigs with the research and experience that they have gained. Whether reversed or not, the end result is the same, in that innovation is stifled to the detriment of both parties. Yet again, it is the New Entrants who benefit from this dysfunction, as they have both the knowledge and experience from being established players in other markets, and the zeal for innovation in their quest to enter the housing market with alternative solutions.

What does this mean for the innovator, trying to establish a foothold in the housing industry? Firstly, not to be overly optimistic about trials being carried out by established developers, unless there is an immediate cost advantage to the product being trialed or there is good reason to believe that government policy will be forcing them to change their practices in the foreseeable future. Secondly, not to over-estimate the impact of small young innovative companies who are overly willing to invest time and money in solutions that may have limited viability. When the product is right for the market, it will 'cross the chasm' from early adopter to mainstream status. If it cannot make that leap, there

will be a good reason why not, which suggests why understanding the barriers to innovation is more important than understanding the benefits.

The Farmer Report also puts a lot of its faith in the New Entrants, and for similar reasons, but it is still faith, rather than proven ability. The trials that innovative solutions have to undergo to make that leap and topple the status quo may seem harsh, but there is an analogy here with natural selection that would suggest that these trials are for a reason. It may be that, by forging their own path and taking the entire build process in-house, which effectively by-passes many of the checks and measures that other businesses have to deal with, the New Entrants will still fail, but further down the road than would have otherwise been the case. (Laing O'Rourke have recently changed tack after many years of investment in their concrete twinwall housing solution and are now looking at light gauge steel frame, suggesting just such a lack of up front research into the viability of this imported solution).

The conclusion to draw from this case study is that innovations need to be matched to delivery models. If an innovation presents a simple cost saving alternative that requires little or no change to their existing systems of delivery, the mainstream market suppliers will be receptive. The same applies if it answers a need that is being mandated upon them by new legislation. Otherwise, it falls into the category of 'change that needs change', requiring more complex longer term arguments to be invoked. In this scenario, it is either the New Entrants who are prepared to, and can financially afford to take the longer term view, or the younger innovative companies who are prepared to take the greater risks. Which of these two options presents the greater certainty of success depends on the validity of their business models and the potential of the markets they are attempting to break in to, discussed in the next section.

Appendix O3

Alternative market models – mainstream .v. minority (Section 6.3.3)

Objective: *to show how smaller more fragmented markets might prove more fertile for innovative solutions than the large, more homogeneous but less receptive mainstream markets*

The speculative housing market may represent almost 80% of the entire housing delivery system, but size of market is only one of many factors to consider when promoting an alternative solution. Appropriateness, receptiveness, potential for growth, as well as governmental needs and public appeal are all equally important considerations. This study looks at group custom build, a relatively small and unrecognized sector and shows how it could be far more beneficial to the concrete industry due to the combined impact of these other factors.

"In the UK, speculative production of new housing is dominant, with about 79% of new homes being provided by developers. Some 13% of homes are built for non or limited-profit organisations, and about 8% are self procured" (Venables and Courtney, 2004)

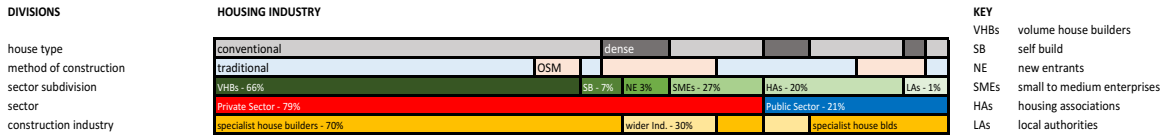


Figure A: 21 approximate breakdown of housing delivery in the UK.

The major volume house builders are responsible for 50% of our housing output, making them an appealing sector for any marketing campaign. They are consistent in their methodology, they have honed their product over decades to appeal to a majority market, and they have buying power. The reasons why this is not enough in itself to justify focusing on this market alone were discussed in section 6.2.2 from the perspective of Housing Associations, one of the many alternative sectors making up the remaining 50% of the market. Their needs differ from those of the VHBs, and despite representing a far smaller market share, the closer synergy between their needs and the concrete industry's products means that as a sector, they could potentially represent a more profitable proposition.

Figure 6-27 shows that housing associations form one of many sectors that need to be considered in their own right, and also that these sector subdivisions are only one of many ways in which the housing market can be viewed. Whilst an approximation has been made here of each sector's size, what is even harder to define is their growth potential, which will clearly have an influence over any one sector's appeal. The purpose of this case study is to look at some of these minority sectors and

examine how they need to be assessed before deciding on their potential worth as markets. The markets chosen are the somewhat related communal living (co-housing) and self-build markets. What, if anything is their appeal to suppliers? Why do they continue to be such minority interests in the UK whilst efficiently providing much needed affordable housing elsewhere in Europe? And to bring this back to the case study that is the concrete industry, what relevance could these markets have for the solutions that the concrete industry has to offer?

Having looked at the decision making process from numerous angles now, these case studies, whilst all focusing on different aspects of the detailed analysis that is necessary but so often missing, begin to overlap as the interconnectedness of these issues grows. This is especially true of this case study as both communal living and self-build are attempts to address our housing crisis from a more holistic vantage point. Both camps recognize that building more housing is in itself not going to solve the problems we face if those most in need of housing still can't afford to live in what is being built (The Resolution Foundation, 2018, p. 55). These are solutions that look to radically reduce the cost of housing whilst maintaining a quality of living both socially and sustainably, something that recent governments seem unable or unwilling to demand or deliver.

What should be of interest to the concrete industry and to innovators in general is the substantial difference between the size of this 'social economy' market if measured by its physical presence, about 8%, or by its general appeal, put at 53% (Brown *et al.*, 2013) (Communities and Local Government Committee, 2016). That is one measure to be considered. Another is the degree to which government policy has been affected by the lobby groups promoting these solutions (), and a third, the degree to which this market is appropriate for the concrete industry's solutions. In broad terms; the questions to be asked are; what are the benefits to the supplier, the market being supplied, and society as a whole? Are there any substantive barriers preventing this sector's growth, and if not; what are the products and solutions that present the best fit with this sector's needs? The following review takes those questions in order and shows how this market, despite its current size, could be very beneficial to the concrete industry.

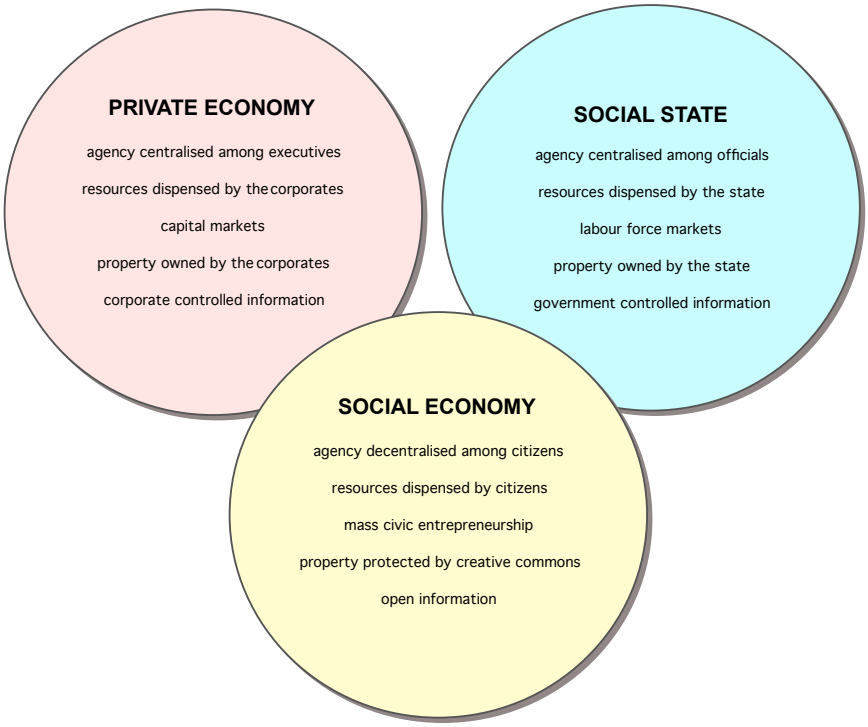


Figure A: 22 the alternative European 'social economy' model

To be of 'benefit to the supplier' basically requires that market to be appropriate, accessible and of a size or potential size to justify the effort. The volume housebuilder sector certainly has scale and accessibility due to its uniformity and small number of players, but has little to align it with the credentials that concrete can offer above ground level. As a market, it has a marginal interest in longevity and durability, and is driven by an aesthetic 'middle ground' ethos that does not like change or the risk it entails. This is not to dismiss an entire sector, but the marketing strategy used should be very much dictated by these factors. In comparison, the communal and self build markets are smaller, more disparate and harder to access, but for many reasons, more appropriate, as concrete can offer them the qualities they need. It is the supplier's role to recognize these benefits to the market - and to the wider society, and package them accordingly.

The benefits concrete can offer may not be immediately recognized by this market, and may still need to be explained, but the holistic language used by the social economy sector is far more conducive to a conversation than the closed, bottom line driven discussions more associated with the volume housebuilders. This holistic mindset may also be more amenable to packaged solutions rather than specific products, as there are less embedded processes for them to overcome. There is also a desire for these markets to differentiate themselves from the accepted norm, which could be capitalized upon. Matching the many benefits concrete can offer to the many needs that these markets have is therefore an essential part of the process.

In an ideal world, the benefits to society as a whole should be apparent by the level of government support for any particular sector, although the degree to which government policy leads or is led by

public opinion can influence this. In the case of the self-build market, a strong lobby group fronted by NaCSBA (National Custom & Self Build Association) has pressured the government to commit to supplying enough land to satisfy the self-build market's demand. In 2011, as part of its Housing Strategy for England, the government announced plans to double the output of self-build housing from 100,000 units to 200,000 over the next decade. Since then, they have launched a three-year £30m Revolving Loan Fund, agreed to a CIL exemption and in 2016 enacted the Right to Build legislation whereby councils have to supply enough serviced plots to satisfy the local demand (Brown *et al.*, 2013). None of this has happened without strong representation, but the fact that there is a recognized social benefit for all those involved is what eventually brings about the changes needed to enable a market to grow.

Communal living, under the new banner of 'co-housing' is undergoing a similar public led promotional campaign to engage the government in this sector's potential to alleviate the housing crisis, by providing a combination of private and shared facilities at more affordable levels. The rise in loneliness amongst both young and old in our society is also targeted by this movement and will no doubt be picked up by the government's new appointment of a Minister for Loneliness in January 2018. The potential for co-housing solutions to minimize the demands on social care for the elderly should be enough on its own to attract the attention of the government and will undoubtedly attract similar levels of support amongst those facing unaffordable care costs as the movement grows.

As is often the case both these movements are more advanced on the continent, where self build constitutes 38% of France's housing market and an incredible 80% of Austria's (Crosby, 2014). Co-housing is a mainstream option for the elderly in Denmark, The Netherlands and Sweden, where it is actively supported by government funding and proven to be beneficial both financially and societally (Tummers, 2016). Structural changes are needed in the UK before these sectors can flourish here, but there is are two important factors that suggest this will happen. There is a financial need driving the public to consider these options, and a financial benefit to be gained for a government in encouraging them to do so.

On that basis, this would appear to be a market that is small but with potential to grow, has the right ethos to embrace new ideas, and is promoting new solutions that are beneficial to both those who are supporting it and to society as a whole. The movement has a strong voice that is successfully lobbying a government that is equally motivated to see the sector succeed, encouraged by its evidenced success elsewhere in Europe. The question that remains for the concrete industry, or any other innovator that might see this as an emerging market, is what is it that can be offered by them that is more appropriate for this sector's needs than any alternative solution?

The centre ground where co-housing and self-build share many of the same values is in the concept of Group Custom Build, the collective approach to self build where a group of people pool their resources to find land, acquire finance and build out a small site of housing in which they often live as a community, sometimes with a degree of shared space. Group Custom Build (GCB) is a different level of self building, where the group will invariably contract out the building of the shell which individual members can then complete to their own design, budget and timescales. In many ways GCB is the financially viable route for those who want to either build their own home or live communally – or

both. The ideal of the individual self-build, as perpetuated by Grand Designs and many other reality shows is unaffordable for all but a small percentage of the 53% of the UK public who purport to want to one day build their own home (Brown *et al.*, 2013). Land values alone, certainly in cities where the most need is for affordable housing, prevent most self builders from realizing their dreams, whereas a GCB project can maximise the most difficult of inner city brownfield sites because of the collective flexibility of the co-housing group's individual needs.

Figure A: 23 Example of crosswall custom build development, Almere, Netherlands

Following this process, the solution that possibly lends itself best to this need would be a concrete in-situ or panelized cross wall development that provides the compartmented shell for a variety of apartment and house sizes designed to maximize the site's potential within planning constraints. Being concrete, it could be built quickly and cheaply providing a weather resistant shell by a contractor who could then depart and leave the group's individuals to take over the build from that point on. No other solution can compete with this on cost, flexibility, fire and acoustic partitioning and also allow for a slow build out without any damage occurring due to weather.

On a psychological level, there is a further reason why this kind of semi-communal living favours a concrete solution. If the desire to own property persists amongst the public due to its role as an accumulating asset, and also for the government as a guarantee of its property owning voting base, current trends would suggest that getting onto the housing ladder will mean having to start at an increasingly low entry point, or spend over half a lifetime saving up for that first purchase. It is this reality that ought to drive a reappraisal of communal living and a realization of the benefits it could bring. A possible outcome of this would be a part ownership, part rental solution, where the private element is purchased within a rented, shared environment. The smaller that owned element becomes, the greater the sense of financial security that will come from its solidity. Any sense of temporariness would be unlikely to command the same value in this situation.

This represents one solution for one market condition, but acts as a good example for how a market can be defined by its appropriateness for one built solution over any other, and as such increases the likelihood of that solution becoming adopted.

"The deal done was to develop the land under one unified style, with Wood himself designing the famous frontages of Queen Square. Sites were then divided into individual plots to be sold to different local builders and masons, who were given a two-year limit to complete their plot before being hit by a substantial rent increase (to incentivise fast and unified development and reduce risk to Wood). He thus pioneered a form of early custom build while strongly influencing the architectural style of those who came after him. The City of Bath is now a UNESCO World Heritage Site." (Jefferys and Lloyd, 2017)

Figure A: 24 Early Custom Build at Queen's Square, Bath.

Appendix O4

Off-site innovation Evolution .v. Revolution (Section 6.3.4)

Objective: *to question the merits of OSM for the concrete industry, the dangers of not participating, and what model would be most beneficial if it were to engage.*

There is a strong argument for the concrete industry not engaging with the off-site manufacturing (OSM) revolution, as it may not benefit from OSM's success to the same degree as its competition stands to. But if OSM's time has now finally come, not engaging is not an option. This study looks at two companies' very different approaches to the same solution, Laing O'Rourke, with their as yet unproven, but headline grabbing answer to the nations' housing shortage, and LoCal Homes, interviewed by the author, who have spent the past 20 years evolving a sustainable housing model that has already survived two recessions. The concrete industry needs a policy on how they will engage or not engage with this unpredictable market, and should be basing this on the experience of others.

"recent developments suggest that industry confidence is growing and major investment decisions are being made"

"It is clear that the level of housing and infrastructure required in the capital cannot be delivered through local resources alone and a strategic approach to creating national interconnected supply chains must be a priority." (London Assembly Planning Committee, 2017)

The government's agenda for promoting off-site manufacturing is not straight forward, but it is increasingly being seen by many as the only way for the housing industry to significantly increase its output. Historical attempts by the off-site manufacturing industry to break into the volume housing market have followed a now familiar cycle, whereby off-site businesses flourish as the economy recovers from a recession when skilled labour and traditional material supplies are low, only to falter towards the end of a boom when supplies of both recover, the need for speed on site reduces, and developers revert to traditional on-site methods. The investment needed to set up these offsite factories and the subsequent need for a continuous throughput means that many businesses then fail as the next recession takes hold.

Whilst no iteration of this cycle is identical, there are still fears of a repeat performance come the next recession, despite there now being far more awareness of the barriers to overcome. Confidence in a positive outcome comes more from the desperate state of our existing industry, with the imminent collapse in our labour force due in part to the low public image that has grown out of this cyclical failure, the low investment in training, poor working conditions and the lack of job security it can offer. Despite there being some new funding initiatives behind this current wave of offsite manufacturing, the concern is that many of the underlying issues that have made this transition from conventional to off-site working practices so hard to embed are still present.

A more cynical view of the government's role in promoting OSM as a solution to our housing crisis would look at the other recent panaceas that have been used to placate a public who are portrayed as demanding action, whilst in reality are still, albeit by a narrowing margin, content to benefit from the rising house prices that this shortage of housing has brought about. There is much to unpick behind that statement – 'the public' referred to, increasingly belong to one of these two camps, and the home owning camp's contentment is becoming increasingly short sighted, especially for those having to help house their aging children. There is also the contention over the actual need to provide more housing when we already have more unoccupied housing than there is demand (Dorling, 2014), and whether this 'housing shortage' is in fact the root cause of our housing crisis. Furthermore, there is the government's genuine inability to promote any one sector of the industry over another without having to justify its actions to the injured party; and the most cynical of all, the view that the government's main objective is not to solve the housing crisis but to prop up its own support by continuing to balance a need to maintain a majority of home owners on the electoral register whilst ensuring that property prices do not fall.

Were these statements to paint a true picture of the government's objectives, they would explain those other recent panaceas, New Towns, Garden Cities, the Localism Bill, support for self build, council housing programmes, reduced planning requirements, the abolition of the Code for Sustainable Homes - all of which have been heralded in their time as the route to unblocking a dysfunctional housing system that, despite all these policy announcements, remains comfortably intact. The many white papers that have drawn attention to this impending crisis (section 6.1.5) and the government's inability to respond or make the housing industry respond to their calls to action, would also suggest a lack of ability or genuine belief in the need to interfere with the status quo.

"One of the Coalition's first acts when coming to power in 2010 was to abolish regional housing targets, leaving the decision up to individual local authorities in their Local Plans. But the widespread failure of councils – most of them Tory-controlled – to designate new housing areas, or even to have a plan that's up-and-running has been a signature feature of recent 'localism'. (Ryan, 2015)

Other recently promoted solutions have received equally cynical responses:

"locally-led garden cities' at Ebbsfleet and Bicester, on land already earmarked for many thousands of dwellings. And the pressing need to provide housing in London will be addressed through a new Land Commission, which will designate up to 95,000 new homes on surplus public sector brownfield sites. Effectively, then, it's a recipe for procrastination, tinkering round the edges and delegating responsibility (and ultimately, blame) to others." (Ryan, 2015)

The reason for pointing out this alternative reality is that the housing industry is now genuinely at the point of collapse, and to blindly believe in another cycle of offsite manufacturing being its saviour could be to risk all.

"This review suggests there is a tipping point that is likely to be reached in the next 10 years where industry will see all of the symptoms highlighted in section 1 getting worse to the point where decline possibly becomes irreversible." (Farmer, 2016)

If there are some underlying structural issues with off-site manufacturing that the government for whatever reason refuses to address, this cycle will be no more than a displacement exercise with very little impact on housing numbers, and more importantly, even less impact on house prices. The fast track, major impact solutions favoured by governments wanting to see returns on their political investment within a 5 year cycle are therefore compared here to an organically grown business model that is far less likely to perpetuate the cycle of OSM collapse that has been this country's legacy.

This is particularly pertinent to the concrete industry who need to decide how or even if it should be engaging with this market. Unlike many suppliers, they have a foot in both camps, on site and off-site, and potentially far less to gain from seeing OSM grow. If Germany's experience is of any relevance, where OSM supplies about 30% of their housing supply, only 20% of that is not timber construction. Despite Laing O"Rourke's massive, government backed investment in their plant at Streetley, their capacity to produce 10 000 homes a year is aspirational and far from proven with no guaranteed market for their product. The company's prediction that it will be delivering "quality homes a third cheaper in half the time, with a 50% saving in emissions while also closing the import export gap" (Morby, 2015), whilst sounding impressive, is based on nothing other than the Government's equally aspirational and identical targets set out in their Construction 2025 White Paper (HM Government 2013, p.5). The comparison made here is with the many smaller OSM operations, who, below the radar, have evolved sustainable business models that grow in response to the markets they have created. Can the concrete industry emulate this more organic business model or is concrete a material that requires larger scale operations to be viable? And if that is so, is it better to wait for those smaller, predominantly timber frame companies to secure the transition to OSM before investing in risky asset building operations at the scale that concrete requires? Knowing when to enter a market is an important part of the decision making process.

Figure A: 25 LoCal Homes timber frame factory providing for the local community (Local Homes, 2018)

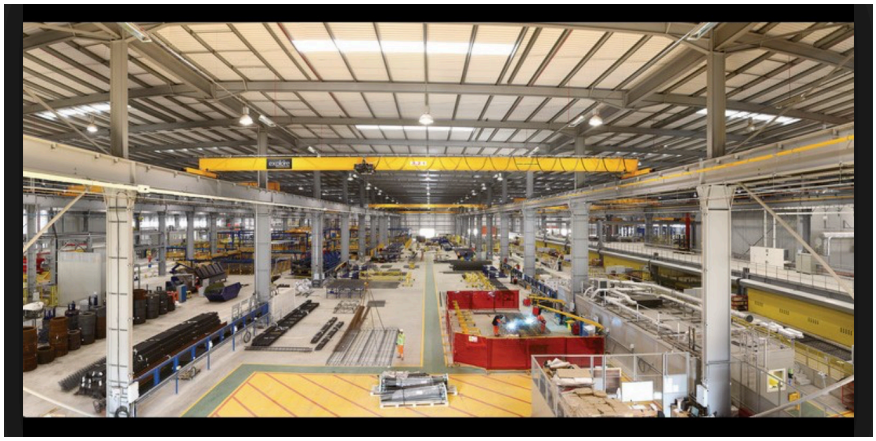


Figure A: 26 Laing O'Rourke's DfMA manufacturing facility, Explore Industrial Park (Ray O'Rourke et.al, 2013, p. 27)

LoCal Homes

The Accord Group in Warsall, Birmingham set up a small timber frame production business in 2005 after having studied overseas models and purchasing some housing from a Norwegian company that had been honing their solution for 50 years. After testing and monitoring these houses, they geared up for producing Code 3 compliant homes as the BRE launched the Code for Sustainable Homes in 2007. From then on they have grown their capacity based on local authority collaboration and local need. They have trained up a gender blind workforce from the local area and with little fanfare, developed a sustainable business model both environmentally and economically. When John Prescott MP came to visit the site he commented that he didn't know of anyone else who has done what he had called for in his report, namely the housing solution for £60k initiative, now over 10 years ago (Hankinson, 2005).

In the Accord Group's opinion, their success is down to not being greedy. Their factory is sized to support the local need for housing and operates with a local workforce. They are now in a position where many other local authorities want to replicate their model, which they are helping to set up around the country as franchise operations. The company name, LoCal Homes, represents low carbon local homes built by local people for local people, and that is the model they want to see replicated.

Not being greedy has seen them ride the last recession without making any redundancies. In good times they work double shifts, and double their throughput, but have no intention to grow their output beyond what the local economy can support. By working collaboratively with franchised operations in neighbouring counties, they have created the kind of 'factory sharing' solution espoused in the Farmer Review (Farmer, 2016). A network of provision gives them the flexibility to maintain a regular supply of work, split between local authority requirements working on four year funding cycles and speculative developers, with even some self-build filling any troughs.

There is nothing revolutionary about this business model. It is evolutionary, and a reflection of a previous era where time was taken to grow solutions, rather than attempting to insert solutions into

unprepared business environments. The Accord Group liken their approach to the more recent return to local shopping by the supermarket chains, who have now recognized the benefits of locality whilst still maintaining their economies of scale. If the government were serious about increasing this market and truly diversifying our housing delivery system, perhaps it is these low key solutions that would secure the future for OSM, not the headline grabbing big name operations promising to turn around our housing deficit in year one.

Turning to those 5000+ houses per year operations, the faith in their ability to succeed where previous OSM businesses have failed comes from their packaged solution whereby they are proposing to supply units for their own build for rent market, from which they will get returns over a 50 year period, supporting pension funds – a form of 'patient finance' seeking reliable, long-term yields that track inflation (Jefferys and Lloyd, 2017). The appeal here for the government is that this is a market that does not interfere directly with the volume house builder's market, and is relatively recession proof, so should in theory increase the supply of housing rather than just replacing one supplier with another. And if it should be too successful and result in too much rented accommodation, that housing could theoretically be sold to its tenants at some future date. This synopsis only works, however, if the housing provided by this new stream is less expensive than the volume house builders' supply, so as not to compete with their market, and to provide more affordable housing to meet this currently unmet demand.

That is the state of play that the concrete industry must now consider when deciding how to engage with the OSM market. It is not just a case of what can concrete offer to OSM, but about the comparative benefits of concrete over all other materials, the gains that this might bring to the concrete industry itself, and the risks associated with investing in this market. To what extent is the timing critical to this being successful, and how serious is the government in supporting such initiatives, especially when the next downturn inevitably arrives.

To some extent, both of the extreme cases discussed above have protected themselves from government intervention and the threat of recessions, either by growing a sustainable organic network, or by creating a vertically integrated market that limits the impact of any outside influences and removes the variability of purchasers. Both these approaches avoid one of the many risks historically associated with OSM and perhaps the largest of these going forwards – that of security of supply. Whichever of these options the concrete industry chooses, however, perhaps their greatest dilemma will be how to define a market for off-site manufactured concrete solutions where concrete is the most appropriate solution, something that is picked up in the next section, 6.3.5.

Appendix O5

Whole package solutions Holistic solution .v. Piecemeal products (Section 6.3.5)

Objective: to consider the merits of developing a solution rather than a product, based around a package of measures, not all of which are necessarily about concrete.

*An alternative to the idealised Laing O'Rourke model of totally controlling an internal vertical market is to gain a full understanding of that market by forming a chain of collaborative partnerships. Promoting packaged solutions by this method, both in terms of products and services, allows for multiple benefits to be brought together to make a more convincing case, and also reduces the risk levels by securing consensus throughout the delivery chain. Bill Dunster's Zero Bills House (*Figure 6-32*) is an example of this approach and shows how a concrete solution might not need to be promoted through the use of concrete alone, but through a package of benefits where concrete plays an essential but not necessarily a primary role.*

Figure A: 27 Bill Dunster's Zero Bills House, BRE site,Watford

Bill Dunster's solution to mass market eco housing shows how successfully taking on the status quo requires a holistic approach to the issues that need to be resolved. The Zero Bills House is innovative in many ways, but the partnerships and delivery mechanisms that have been formed are equally radical. Dunster's broad understanding of material solutions has led to a logical but eclectic construction system and his approach to land procurement shows the same level of free thinking, not bound by convention.

The main consequence of trying to gain a more complete picture of the housing industry and how it operates is a realization of how interconnected all the factors are that need to be considered. Trying to balance so many different and often conflicting requirements can become an overly complicated and inconclusive exercise. An alternative and far easier approach is to let the positives for, in this case, concrete, define the options for which this is the most appropriate product, and then grow a packaged solution from that solid foundation. Packaged solutions are in themselves a positive, as they reduce the risks associated with our fragmented industry by consolidating suppliers and lessening the number of adversarial relationships needed to deliver the end product.

In some respects this approach is not dissimilar to the vertically integrated market philosophy of the New Entrants, who aim to control the entire process by bringing all operations under one roof, whereas providing a packaged solution only requires those businesses and their motivations to be understood rather than owned. In this scenario, it is the concept of shared goals that is important, because it brings together many small positives to make an irrefutable case for the whole, where the individual pieces of the jigsaw on their own could be less convincing.

This is of particular significance for the concrete industry who have a product that performs many different roles, none of which in isolation are often seen as 'key motivating factors'. It is only by combining these to define more appropriate, if smaller markets that the case for concrete becomes strong enough to dictate the outcome. But the concept of the packaged solution does not have to stop at the sector of the market defined by its material solutions. How that end product is promoted and who it is promoted to can then be used to grow what may appear to be a niche market into a financially viable business proposition.

Bill Dunster has been used in this case study to exemplify this because of how he has successfully managed to grow a brand around a house type, his Zero Bills House, that he developed to answer the many complex questions that were being asked of sustainable housing. It is no co-incidence that this depth of understanding about how to market an energy saving house comes from a man who has been engrossed in his vocation for over 30 years. His solutions span far wider than just choosing the correct materials, and extend, for instance, to making the right finance deals to secure land at values that allow him to compete on price with the land banked assets of the volume house builders.

There are in fact elements of the last four case studies in Dunster's solution. It is less about technical innovation, and more about making a financially viable package that can be rolled out, even to volume house builders, on terms that are appropriate to that market. When Bill Dunster talks about this project, he skims over the eco credentials and focuses on why it is viable, which is all about simplifying the delivery system, utilizing off site manufacturing, making the construction idiot proof, and allowing

for a degree of mass customisation so that the model can be made to work for any location, any planning authority's whims, any house size.

It is a combination of good ideas which he has tried and tested, all brought together with an offer to anyone with land to approach the Zed Factory rather than the volume house builders because he will only take 1% of the value of the land uplift value to get a development to full planning approval rather than the 20% the volume house builders will expect to take. How can he do that? By not being greedy, by not having to cover the cost of drawn out or failed development attempts and by instead proposing developments that the planners want to see succeed.

The construction itself appears quite eclectic. A heavyweight breathable timber frame with lime rendering and thermal mass in the floors by way of a polished screed, and a PV roof, two thirds south facing with half of it over a sunspace on the 3rd floor. Log burners and MVHR as standard. The choice of materials is, however, well thought through, with each element constructed in a way that is dictated by sustainability first and foremost, but so much more as well. What it is not is a solution driven by any particular ideology or superior knowledge of one material solution over any other.

He has patented a system of lightweight steel frame sections that act as a guide for putting together a stick built timber frame on site. This is not an obvious solution, but for Dunster it is driven by some obvious benefits. To appeal to the conventional housing market the components need to be available from the builders' merchant as and when they are required. Rather than risking timber frame companies creating delays, pushing the price up, going bust, he can now provide his own timber frame template as a kit of parts that means the loose fit timbers just slotted get into place. It's faster, cheaper, and with enough control to guarantee the accuracy that standardization demands, whilst still using relatively unskilled on site labour.

The other requirement that Dunster recognizes as an essential part of the packaged solution is flexibility. To appeal to any developer, the solution needs to work for all eventualities, and not result in a return to conventional methods to finish off awkward corner plots or deal with overlooking issues. For this reason the steel frame has been designed to act as a continuous ring beam lintel allowing the windows to go where the windows want to be, depending on location, orientation, or user preference. The light gauge steel framing template allows for enough variation within a modular system to provide a degree of 'controlled customisation' either at the design stage or at a later date. The standard design includes a garage designed to be convertible into a granny annex at minimal cost because of an understanding of the environmental benefits that such pre planning can deliver.

As a solution, the Zero Bills House has clearly been designed to appeal to as many markets as possible. It recognizes the barriers that need to be overcome to appeal to the volume house builders by avoiding the usual OSM issues of supply and demand and the need for flexibility. It also appeals to housing associations who want to maintain their local on site labour commitments, and has immediate appeal to the self build market. It is also a Code Level 6 solution, coming out at £1350/m2 before factoring in efficiencies of scale, but only as a complete package, appealing to different markets through different motivators can this make the impact on the housing market that Dunster is determined that it should. But to be sure, he's also set up his own RSL (Registered Social Landlord) company and got his own lawyers to make sure it all progresses as intended.

This is not a lesson in optimizing the use of concrete, as this solution only has concrete foundations and a screeded floor, but in how focusing on the material alone may not be the best solution. How this same packaged solution approach can be used to define and then grow secure markets for housing that incorporate more concrete than a conventional build is possibly what the concrete industry needs to address by adopting a similar approach.

Appendix P1

The role of the New Entrants - crossing the chasm (Section 6.4.1)

Objective: *to highlight the need for innovations to be 'managed' as they move from the early adopter market into the mainstream market*

Choosing the right market for promoting a product based on a market's attitude to risk was discussed in section 6.3.2 (Urban Splash), where a differentiation was made between those innovations that require changes in policy and those that will be adopted on the basis of a simple financial benefit. The point being made was that those innovations that require structural regulatory changes – that need the ground to be prepared – also cannot just be seeded and left to grow. They need to be nurtured throughout this process and that requires a knowledge of how innovations are promoted by the industry itself – or not, in the case of 'crossing the chasm', a term familiar in other disciplines and applied here to the housing industry.

The Farmer Review goes into great detail about the ten symptoms of our ailing housing industry and how these need to be addressed, whilst at the same time implying that the 'New Entrants,' having set themselves aside from this dysfunction, offer our best hope for seeing the innovations that we so desperately need being adopted (Farmer, 2016).

The government is keen to see these newcomers succeed, if only to diversify the industry and bring another building stream online, but if their success means that they eventually supplant the existing industry rather than influencing it with their modern manufacturing based business model, little will have been gained in terms of output. So the question becomes 'what is the New Entrants' 'early adopter' model and what is in there that can be copied by the 'mainstreamers' to ensure that the innovations they are promoting follow through to the mass market?'

From the concrete industry's perspective, these insurgent businesses represent a far more appropriate market in terms of their openness to new technologies, their existing knowledge of concrete construction from the non-residential markets they have travelled from, and their subsequent preference for larger more standardised building solutions. In that respect, whether they transform the existing housing industry or supplant it has little impact on the concrete industry's decision whether or not to pursue this sector, as long as they grow their own market share and become a viable proposition. The real concern is more likely to be the alternative CLT option, to which the New Entrants are equally amenable.

The purpose of this case study is therefore more about how to make that leap from demonstrator site status to mainstream acceptability than it is about the fate of either of the business models currently occupying those sectors, because it is this stage of the innovation process that is critical to any business trying to influence an existing market. Much has been written about this phenomenon in other market sectors, with the term 'crossing the chasm' often used to define the point at which many innovative solutions fail (Gladwell, 2000). The principles and findings from this research have a strong resonance with the plight of both the OSM and the sustainability industry and have been used here to suggest how the chance of success for alternative delivery models might be improved.

The principle of Malcolm Gladwell's book 'The Tipping Point' was based on the work of Geoffrey Moore, Crossing the Chasm (Linowes, 1991), around the substantial difference between the people who originate trends and ideas and the people in the majority marketplace who eventually take them up. Moore's work was in the field of business consultancy, but the principles used, Gladwell has shown, are equally applicable across a much broader spectrum of what he calls 'social epidemics'.

In business terminology, the term 'crossing the chasm' is used to describe the point at which many innovations fail in the marketplace due to the disconnect between the 'early adopters', the risk takers, and the 'majority' for whom "*the word risk is a negative - it does not connote opportunity or excitement but rather the chance to waste money and time"*. There is in fact a continuum right up to the late adopters or 'laggards' which on the whole works to promote new ideas due to the way in which each sector informs the next until eventually everybody has adopted the new technology, or 'caught the contagion'(Figure 6-34). The only point at which this process fails is the chasm, because at this point, the early adopters, who strive to be different, have nothing to gain by promoting their 'new find' to a mainstream audience.

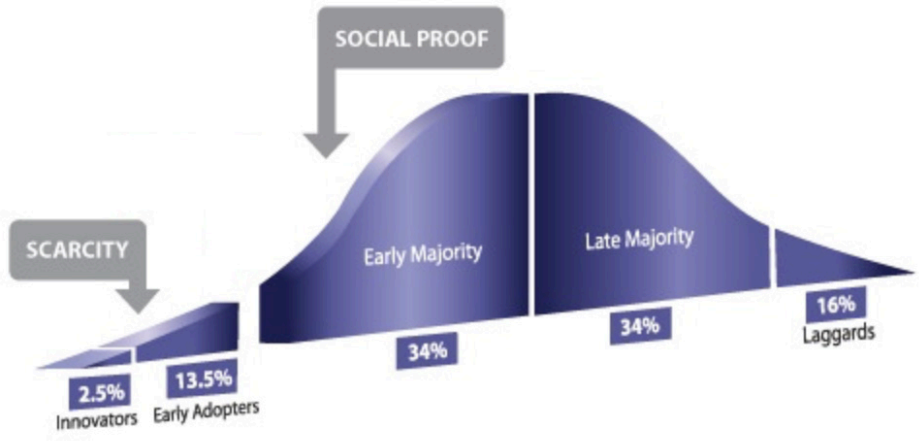


Figure A: 28 Malcolm Gladwell's adoption model

Malcolm Gladwell's work focuses on crossing this chasm, and specifically the personality types that are required to make this happen. The aim here is to interpret these principles for the housing industry to see if they correlate with findings from this sector, and if so, see whether the same principles can be applied to help drive innovation across the chasm from demonstrator site to mainstream acceptability.

The first step is to relate the different sectors within the housing industry to the roles of innovator, early adopter, early and late majority and laggard, based on their known characteristics when confronted with modern methods of construction. The same process can be carried out for the general public, as they too are complicit in this decision of whether or not to adopt new ideas in house building. Partnering these two models together is in itself a valuable exercise, but recognising where

the chasm lies is what this case study is really trying to achieve, so that we can try to understand the characteristics of those on either side.

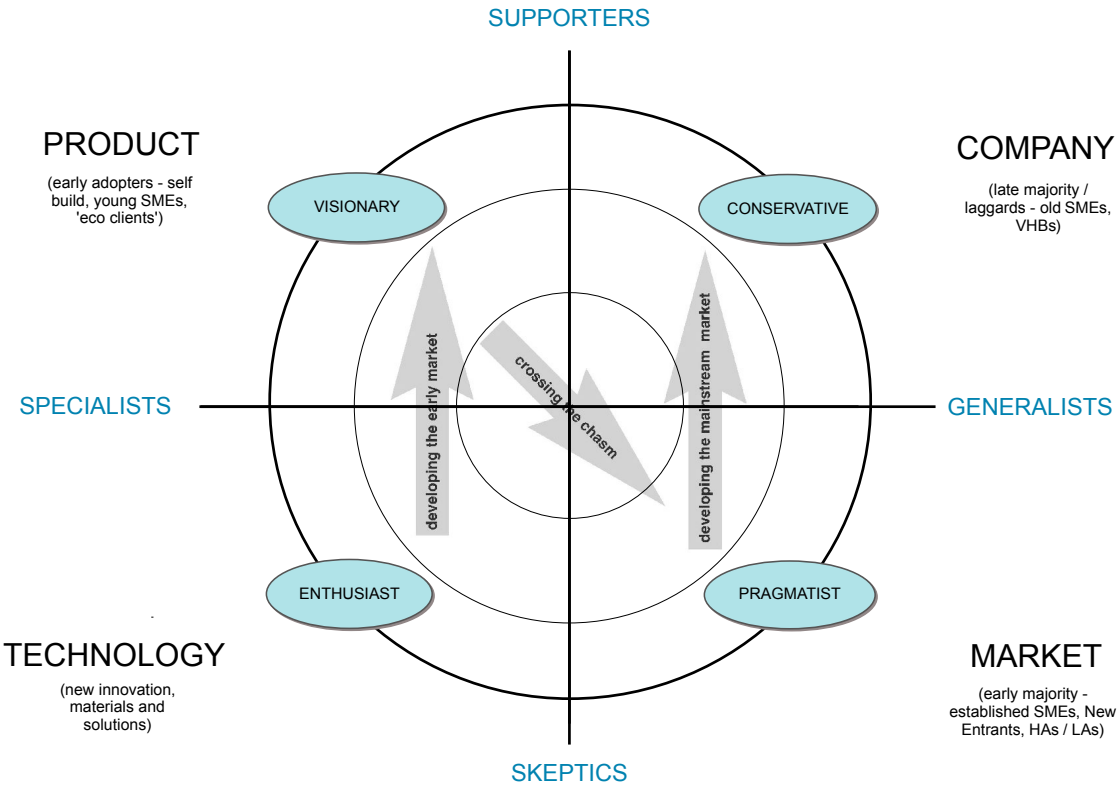


Figure A: 29 defining the character types responsible for the adoption of innovations

The first observation is that, as with individuals, it is the age of businesses that tends to define their position on the curve rather than their size, which would suggest that wisdom plays a large part in defining outlook. This is not to undermine the role of the early adopter, but recognises that risk taking is more associated with impetuous youth than it is with age and experience. The early majority, those just across the divide, therefore have an important role to play in that they need to remain open to suggestion, and willing to change, once that change has been proven to be beneficial. But this is about what else has to happen above and beyond this state of readiness to create 'the tipping point', which is where Malcolm Gladwell's three characters get introduced into the equation. The enthusiast, the connector and the salesman.

The enthusiast is the one who has the genuine thirst for knowledge for knowledge's sake, the one who will absorb the new ideas and understand them. The connector is the one who generates the networks that allow these ideas to be disseminated across the whole spectrum of the industry, not just within a close circle of like minded individuals. And the salesman is the one who makes it make sense, adapting the message until it fits with the audience. These need not necessarily be three

separate bodies or individuals, but they are three distinct skills, all of which have to be present before a fledgling idea can become a mainstream solution.

If this is a reasonable model to define the process of innovating within the housing industry, and if we accept that there is – and has been for some time – a chasm between the innovations that we are now, on the whole familiar with, and the industry's ability to adopt them as standard practices, which of these roles are we missing? To answer that, we have to decide who it is within the housing industry that should be fulfilling these roles.

The enthusiast - the inventor - is not necessarily the role of the material or product supplier alone, but this would be the sector most dependent on innovation to survive. The capacity for original thought is a characteristic of the individual, but 'the enthusiast' is also a term used to cover those who thrive on seeking out and understanding innovation, as well as the original act of invention itself. These people can be found in any role, and any sector of the industry, but will inevitably gravitate to those places where their capacity to either generate or absorb new ideas can be satiated. At a company level, this would suggest small, young and nimble, perhaps with a degree of naivety driving the agenda, or, alternatively, large and established enough to fund a division of 'blue sky thinkers' to keep them in touch with a changing world. Least likely to fit the bill would be the vast majority of middle sized, middle aged operations working to turn a profit with little time to invest in anything else. From the public's perspective, these 'enthusiastic' individuals would be most likely found within the alternative sector, where individuality and original thought are rated higher than materialistic measures, but may also reappear at the other end of the spectrum where there is enough disposable income to allow innovation and free thought to re-emerge. Again, the middling majority would be least likely to exhibit these trends and most likely to conform, either through lack of interest or a lack of time and money to dedicate to these indulgencies.

Moving on to the connectors, those who spread the word, our definition of where the enthusiasts might be found would suggest that their role would be to launch a two pronged attack on the middle ground. Connectors are by definition people who have many loose acquaintances rather than a few close friends. Social media has become our breeding ground for loose acquaintances, and despite being derided for its superficiality, has a valuable role to play, as these looser connections tend to encompass a far more varied make up, demographically, sociographically and psychographically. Close friends tend to be 'people like us' who are far less effective at spreading ideas and opinions outside that immediate circle. Digital media – twitter in particular - may therefore be the most effective connector at our disposal, and capable of replicating the role of many real life connectors if used effectively. But this still requires there to be an understanding of which sectors need to be making these connections, and with whom, for an innovation to take off.

Lastly, the salesmen. Their job is not just to sell the concept, but to reinvent it if necessary to make the message compatible with their audience. This is a crucial stage in the process and perhaps the one that needs the most consideration, because it is this operation that this research has found to be failing. There is often a clear disconnect between how a product is being promoted to the mainstream audience and what motivates that audience to consider it as an alternative to their existing solution. This is not to say the innovation is of no interest, but that the supplier is failing to understand how it

will be of benefit to their customer. What is usually missing in these circumstances is an in-depth knowledge of the customer's business model and their motivations, but maybe also an inability to see the bigger picture rather than just the enthusiast's vision of what that innovation is about. Put bluntly, the salesman's job at this stage of crossing the chasm, when moving from demonstrator site status to mainstream acceptability, is to translate the message from exciting and revolutionary to safe and profitable.

Finally, if these are the roles, who is playing them? Our initial breakdown of the housing delivery system was into the suppliers, the legislators, the providers and the end users, which could be subsequently broken down into further subsets as we define these markets more precisely. But spanning those sectors, we can also subdivide the individuals within this model psychograhically into the seven recognised categories used in the public survey. These can be overlaid onto the bell curve of adoption (Figure A: 30) giving us the characteristics of those either side of the chasm – the explorer – first to try new brands (early adopter / enthusiast / visionary) and the succeeder – supports the status quo (early majority / pragmatist).

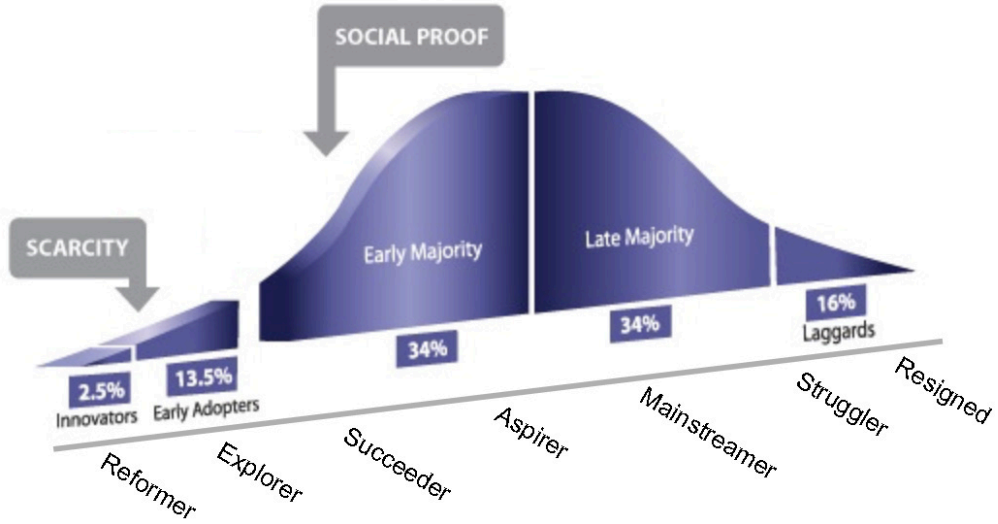


Figure A: 30 personality types associated with the adoption model

We have suggested where these two types might be found within the industry and the general public, but what of the government? What role do they play, either as enthusiasts, connectors or salesmen? It could be argued that as enthusiasts they need to create the political vision, as connectors they need to provide the infrastructure and stability from which innovations can emerge, and as salesmen they need to guide industry in the right direction. They need, in other words, to be creating the bridge across the chasm. It could also be argued, however, that they are sometimes positioned on the wrong side of the chasm to perform this role, waiting for the private sector to invest, take risks, experiment, and provide them with solutions that they can then package as panaceas, safe to promote to the mainstream at no risk to themselves.

Overlaying these theories onto the housing delivery system as it has been defined here helps to explain one of the fundamental barriers to be overcome, and it is one typical to any business environment - what motivation have the New Entrants, or the early adopters got, to promote their business model to the mainstream market? The answer, as in any other business environment is 'none'. The role they play as early adopters is, nevertheless, invaluable, as it is they that have, at considerable personal risk, proved the concept for the innovator. To follow Gladwell's proposition, it is now the innovator's role, not the early adopters', to then take that proof and sell it on to the mainstream market. And to do this, the innovator has to know when the time is right to change the language from 'risk seeking' to 'risk averse', and rebrand the innovation as 'the solution everyone is using'. The innovator also has to know which businesses are in the early mainstream sector to take this message to – possibly those companies large enough to fund a watching brief so as to be ready to benefit from those innovations that make the grade (P.03.4).

In conclusion, the role of the innovator spans many skills, far beyond that of product development. That product not only has to be marketed and launched, it has to be guided every step of the way, which requires if not full collaboration, at least a full understanding of what each sector is set to gain from deciding to adopt. So, to answer the earlier question of which sector needs to be making these connections, and with whom, for an innovation to take off, that is clearly the role of the innovator plus any other party that stands to gain from its adoption. Bearing that in mind, the broader the benefit, the easier the task will be of finding collaborators to help promote an innovation. The next case study takes this theory and applies it to the sustainability agenda.

Appendix P2

Driving innovation and the sustainability agenda (Section 6.4.2)

***Objective**: to ask who is now driving sustainability, and whether this could be the concrete industry. If so, how should they go about such a task?*

Many of the innovative solutions currently being promoted within the house building industry are predicated on a need for the industry to become more sustainable, and the concrete industry's agenda is no exception. The government's long term objectives on this front are therefore central to knowing how to proceed on this front. Will a 'stair casing' of sustainability requirements be written into legislation or does the housing industry need new drivers to ensure there is a commitment to a zero carbon future. If so, could that be the task of the concrete industry and what would they need to do to further that cause?

For the ten years following the launch of the Code for Sustainable Homes in 2007, the sustainability agenda was driven by the requirement for all government funded housing to meet regularly increasing targets for compliance. The long term agenda was for the private sector to eventually be coaxed into at least matching these standards either through competition amongst themselves or pressure from a public becoming increasing aware of the comparatively high quality of more affordable social housing. Whilst this effect was taking far longer to materialise than expected, it was beginning to impact on the quality of housing in the private sector. In 2017 however, the government decided to abandon the targets for zero carbon homes and replace the Code for Sustainable Homes with a voluntary system of assessment geared around the current Code 4 levels, the Home Quality Mark (HQM).

This abrupt policy change had a number of detrimental effects, beyond the obvious loss of a driver for the sustainability agenda. This case study looks at those effects, the reasons why the government felt it necessary to take such drastic action, and what steps the housing industry will need to take if sustainability is to continue to influence the design process. This is again of particular interest to the concrete industry as concrete's sustainability credentials are central to how it is currently being promoted as a building solution.

Firstly, the effect on the housing industry of removing the steady ratcheting up of the targets for compliance: Innovation involves risk, but that risk can be lessened by reducing complexity and uncertainty. Knowing that government policy is working towards a target and to a specific date is critical for planning a growth strategy, and the sudden removal of tariffs or of the targets themselves can damage a fledging industry. It can also damage confidence in any government backed schemes for fear of similar U-turns in the future, and once that trust has been lost, it becomes even more difficult to coax an already cautious industry into adopting new technologies dependent on that support. New supply chains that fail to establish themselves are equally detrimental to the developers choosing to invest in those new products. A further, less well recognised impact of this reversal in government policy has been an increase in land values. The additional build costs accredited to higher environmental standards had begun to impact on the price developers were prepared to pay for land

in order to protect their profit margins. This effect has now been lost and land values have reverted to their previous trajectory:

"It would have driven down land prices, absolutely. Any on cost drives down land prices because of the way you calculate the land value, it's all done on residual land calculations" (P.03.3)

Also lost is the space in the market for innovative SMEs whose alternative higher code housing solutions were helping to diversify the housing delivery system. With the loss of any additional value associated with their homes for being future proofed, their task has now become far harder, and their prospective market far smaller.

In all, it therefore seems difficult to contemplate what is was that drove the government into what appears to be such a counter-productive move, but understanding that decision is key to knowing how best to resolve the hiatus this has caused in the sustainability industry. Were the government to be asked this question outright and compelled to give an answer, the 2008 recession would no doubt feature highly as a justification for this policy decision. Faced with a non-compliant speculative housing industry, a continuing decline in the numbers of houses being built, and this whilst trying to implement an austerity programme, the government no doubt felt unable to do anything other than acquiesce to the volume house builders' demands: To take all zero carbon targets off the agenda, remove all local council powers to cherry pick their requirements and instead allow them to build the same housing as they were currently doing, throughout the whole country. It was certainly true that the 2016 target for zero carbon had for some time seemed unachievable, and the fragmentation due to many councils' different interpretations of what constituted compliance was impacting on the national companies' profit margins, but the wholesale removal of these measures was universally resisted by all but the one lobby group who had fought for this outcome (Glover, 2015). In return there was an implied duty on behalf of the volume house builders to increase the volume of housing being delivered, with no demands made of them on either price or quality – it was now just a plea for volume at any cost.

Whether this was even a worthwhile short term strategy is debateable, as it is widely recognised what the business model is within the speculative housing market, and it does not include building either excessive volumes or at excessive speed (Jefferys and Lloyd, 2017, p. 2). Neither will it do anything to broaden the range of businesses supplying our housing, or in any way drive the sustainability agenda. Since 2008, two thirds of all SME builders have gone out of business (Communities and Local Government Committee, 2016, p. 13). The question now therefore is, what is the solution going forwards, either for a reputationally damaged government, or for the housing industry, to resurrect those far reaching objectives to achieve what is still a statutorily required carbon emissions target (Harper, 2016)?

Whether the government no longer feels obliged to foster this objective, or will no longer be trusted in any future stated aims to do so is almost immaterial. The future for sustainability from here on needs to be financially viable in its own right, with any government involvement limited to defining the true cost of viability. That means having to look at all markets to establish which ones will offer the most fertile ground for sustainable innovation rather than relying on government to supply the 'fertilizer'.

The public survey discussed in section 6.1.2 addressed this question by trying to establish where the support for sustainability lies within the public, broken down by as many parameters as a short survey would allow. The same exercise has been carried out from a material perspective looking at what credentials concrete can offer and how they can be used to support this agenda (6.1.3, 4), and what should and what does motivate governments were both discussed in section 6.1.5. Armed with these insights, it should therefore be possible to define a series of markets where a sustainable agenda will be of mutual benefit to all three of these parties and subsequently stand a far better chance of success.

Hockerton Housing Project.

Figure A: 31 Hockerton Housing Project, Leicestershire.

Hockerton encapsulates many of the issues covered in this debate because it spans a period of time from before the government's drive to promote sustainability to after its demise, and whilst still being seen as the beacon for sustainable living, has seen very little uptake of its ideals. The project, a row of five earth sheltered houses with a shared south facing glazed patio area to collect solar gain was self funded in the early 1990s and now holds a wealth of anecdotal evidence to its own success. But it has very little empirical evidence beyond that to validate these claims – including its constant all year round indoor temperature of 22˚C. The 'chasm' between demonstrator sites and mainstream marketable solutions has been discussed already (section 6.3.2, 6.4.1), but the issue here is more about the conditions needed on the mainstream side of that chasm to ensure that these thermal benefits can be measured and assessed. If they cannot be measured in any recognised way by those operating in the mainstream whose main driver is compliance, how can Hockerton expect to convince anyone that this is a route worth taking?

The problem that Hockerton faces, now even more so than before, is that earth sheltered houses are not seen as a volume housing solution. For the speculative builder, even an orientation dependent

design is not seen as a viable solution, since their developments could never be built out as efficiently with that restriction on a site layout. Hockerton have over the past twenty years, effectively cornered an evangelical market that is too small to be viable. Based on the discussion in section 6.3.5 about the benefits of holistic solutions however, there is the potential to define this small evangelical market by the benefits it can offer – for all parties, including the government - and then grow it as a packaged solution for a wider audience. This is what this case study sets out to do, bearing in mind the need to find new market leaders to drive the sustainability agenda, if for no other reason than because sustainability is a major driver of innovation (Nidumolu, Prahalad and Rangaswami, 2009).

Hockerton appeals on many levels. It has become synonymous with both sustainability and communal living, and being built into the ground, has a very strong visual image. But it is this feature that has also made Hockerton such a niche solution, best suited for those who not only want to live sustainably and communally, but have access to south facing land, preferably on a hillside. This niche sector would also have to be well financed, as south facing hillsides represent some of the most expensive real estate in the UK (Davidson, 2015). People who want to live both sustainably and communally could be said to fall into one of two indistinct camps. Those who are younger, poorer and pragmatic, and those who are older, richer and idealistic. Both groups will tend to be well informed and have strongly held environmental and social consciences, but the younger group will see this as a route to affordable living whilst the older group will more likely see this as a life they can now afford – one where they can live out their ideals amongst like-minded people. Which of these groups defines the market most appropriate for the Hockerton model will depend upon affordability, in terms of the build cost, and of course the land value, something that varies across the UK far more than material and labour costs.

What both of these markets do have in common, however, is the ability to act as a promotional voice for an alternative way of living – one that goes beyond low energy and encompasses all the benefits that Hockerton portrays. The ‘packaging’ comes in how that way of living is defined to appeal to different sectors of the public, and also to the housing industry and to the government.

The bullet point benefits here are sustainability, communal living, and, depending on location and the age group concerned, affordability, within which are held the many hooks that are needed to gather the necessary support. For the government, for instance, any form of co-housing is seen as a way to improve self reliance in old age and reduce dependence on the state. Similarly, any form of self build, or more likely, group custom build is seen as a way of increasing our house building potential by diversifying the housing delivery system. Affordability is very much tied into the method of delivery, and the government’s commitment to supplying enough developable land to satisfy the self build market (Department for Communities and Local Government (DCLG), 2015) is a key instrument in selling this concept to the public.

Under the banner of sustainability also comes resilience, although more accurately, a necessary consequence of our failure to adequately address the former initiative. Either way, for the concrete industry this is where the interest in Hockerton begins. This is a thermal mass solution that is best suited to a monolithic concrete construction. If similar housing could be excavated into a sloping plots of land it represents an affordable low tech solution using viable quantities of locally sourced mass concrete. As a shell construction, it is well suited to group custom build (section 6.3.3), and if the

sustainability argument can be won (section 6.1.3), the government's assessment procedure addressed (section 6.1.4) and whole life costing fully adopted as a measure of performance (section 6.4.3) there is no reason why this should not be adopted as the most appropriate solution for this market.

That makes four barriers to be addressed before then looking at the size of the market created, but these are all issues that can and should be addressed for the benefit of the sustainability industry as a whole, not just for the benefit of concrete. The market, however, still needs to be large enough to justify the effort, and land value lies at the heart of how those markets are defined. For sites where land costs represent less than a third of the final property value, there may still be a competitive edge for this solution. For a conventional build, the rule of thumb is that every 1˚ slope on a site adds 1% to the build cost. A 20˚ slope therefore produces a useful advantage to compensate for the additional costs associated with a zero carbon development. For sites where land value pushes development costs outside the grasp of those wanting to live communally and share resources – still associated for many with a failure to support a self-sufficient lifestyle – there may need to be some form of legislative support.

Rural exception sites, those sites on the boundaries of existing development, are currently earmarked for affordable housing, and represent an opportunity for those who are part of or want to build for that market. Competition is still high, however, and would require the support of housing associations and local councils for such a project. Making a case for CIL exemption would be a useful bargaining chip in this instance, since an off grid community should have no additional impact on the local infrastructure. But taking this concept a stage further, there is an argument for allowing the development of a completely off grid community, connected by nothing other than a road and a wifi connection, within the green belt. Were this to be adopted as a policy for both containing the pressure to build within the green belt, and bringing people back into the countryside to manage and live off the land rather than using it as part of the commuter belt, this would represent a viable market for the sustainability industry and a new driving force for its innovative solutions.

In conclusion, what started out as a need for Hockerton to prove the seasonal thermal mass benefits of an earth sheltered construction by carrying out some much needed empirical research, has grown into a need to make a case for the markets that will support such an approach to housing. Without those markets, the interest in Hockerton will remain peripheral, but equally, making the case for those markets must begin with the supporting evidence. Once that has been established, it will be necessary to form partnerships with those who have a voice and will also benefit from proposals being advanced. Would the Countryside Alliance for instance see the benefits in managing the green belt through such a policy? Asking such questions at the outset can not only highlight potential barriers further down the road, but will create collaborative partnerships and help in formulating a policy that will garner the greatest support for the market being grown.

As an addendum, the need to then grow the market once it has been defined can perversely involve the addition of further limitations, as long as they fit within the same mindset already established. The easiest solution to making a house more sustainable in terms of the materials used for instance, is to reduce its size.

"According to the United States Census Bureau, the average size of new single-family houses completed in 2014 was 2,657 square feet [1]. A tiny house, which is a home of 400 square feet or less [2], may significantly reduce the ecological footprint and alleviate financial burdens of housing" (Wu and Hyatt, 2016)

Proponents of this approach to living will have strong synergies with the Hockerton story and can become part of the voice promoting the broader principles of sustainability.

As a vehicle for demonstrating the need to approach these questions regarding innovation from a holistic vantage point, this exercise has encapsulated almost all of the issues already addressed in the previous case studies. In contrast with earlier concerns that the addition of an increasing number of factors to consider would only serve to further confuse the argument, it can now be seen how these factors can also be used to narrow down the options available until the most appropriate solution emerges almost by default.

Appendix P3

BIM, EPDs and OSM – creating the right environment (Section 6.4.3)

Objective: *to show the importance of establishing an appropriate framework for change as a prerequisite for adoption.*

Taking over the wheel from legislative enforcement and driving home an agenda such as sustainability requires far more involvement than just providing the solution to a problem. Collaboration between all those with similar objectives is a necessary prerequisite, and creating the right environment for collaboration the prerequisite for that. BIM (Building Information Modeling) is the key to this change of gear in that it both requires communication between the sectors to enforce, and also paves the way for the further collaboration needed to adopt the changes the sustainability agenda needs to progress, like EPDs (Environmental Product Declarations) and off-site manufacturing.

Various references have been made throughout these case studies to the role of government - either what it has done or what it needs to do, to encourage the uptake of new technologies and working practices. The consensus opinion, certainly reflected in the Farmer Review, is that whilst any new intervention into the housing industry has to be financially viable in its own right, there is a role that governments have to play in creating the right environment for those interventions to at least make their case against the status quo (Farmer 2016, p.51).

When establishing the hierarchy of barriers that stand in the way of any innovation it soon becomes clear that no matter where the problems begin – whether that be in honing the product, overcoming public perceptions, educating the construction industry of the longer term benefits, or any number of other conditions that have to be met – the ultimate barrier or the way to remove that ultimate barrier, will be political. It is a misconception that innovation is entirely the domain of the plucky entrepreneur, risking all to make a difference (Lazonick and Mazzucato, 2013a). Without the right conditions, put in place by governments, often paid for by the tax payer, even nurtured on occasion by those large PLCs portrayed as defenders of the status quo, there would be no wave of progress for the entrepreneurs to ride. It is therefore critical to the process of innovation that the government plays its part and that the housing industry at least understands what innovation needs, whether that be financial incentives, a level playing field, a stable economy or just consistency of policies.

The 'ultimate barrier' has been defined by the fact that, unlike all other barriers, it cannot be sidestepped. It must either be accepted or dealt with, no matter how long this might take, how much support it might require or how much effort that might entail. This case study therefore looks at three fundamental but very much related issues that confront the housing industry, all of which will require strong political intervention if they are to be progressed. They all require full industry collaboration, and the question for government is whether it intends to either encourage or enforce this collaborative state into existence or whether it expects our broken, adversarial industry to get there alone. And for the concrete industry, how critical are these decisions for its own policy making? Does

it need to spend time and effort influencing these decisions, or are they too far removed to be of any immediate concern?

There is a hierarchy to these three issues in that both OSM and life cycle analysis, and the EPDs that will measure these outcomes, all require BIM to be an established protocol before they can function as intended. It is therefore interesting to look at how BIM was introduced into the construction industry. Paul Morrell, the government's then chief construction advisor, in his 2015 report, 'Collaborating for Change', looked to tackle the inefficiencies within the construction industry due to a lack of collaboration. This report followed on from the Egan Report and the Latham Report before that, neither of which had the impact intended, but Morrell recognised the need for the big stick. In his opinion, if change was going to be introduced, especially something as integrated as BIM, it needed to happen with conviction, with deadlines, and with consequences for missing them.

> *"The recommendations in the report highlight that change is almost impossible without industry-wide collaboration, cooperation and consensus and the professions and other key institutions can lead the way in ensuring that this collaboration is in the public interest." - Chris Blythe, Chief Executive CIOB.* (The Edge, 2015)

It was only by legislating for the use of BIM to be mandatory on all government led projects by 2016 that Morrell was able to start the shift across to a new and collaborative way of working. The fact that it was known to be of almost immediate financial benefit to do so was not in itself enough to guarantee that this new methodology would be adopted, because that benefit could only be realised if all parties agreed to change, and change at the same time. This fear of 'jumping too soon' and failing to see any immediate benefit from that decision is what was holding back the adoption of BIM, and why its use had to be enforced at a governmental level.

BIM can therefore be seen as both a metaphor for the barriers to change and at the same time an essential element of the change that is needed across the whole construction industry. BIM only benefits the individuals involved when all those individuals adopt it, because the procurement chain it represents has to be complete before it can have any real beneficial impact. But the very act of demanding a collaborative approach strengthens the construction industry where it is at its weakest – in its inherent fragmentation due to the cumulative impact of high levels of self employment and consequentially low levels of investment. By using the threat of isolation to force a large sector of the industry into adopting – and benefitting - from BIM, this one act seeded the industry with the co-operative framework that it needed to face the many other changes that it also needs to confront collaboratively.

In theory, that is the argument for the 'big stick' approach, although the argument in favour of the threat element is independent of the argument that recognizes the need for a framework for its implementation to be dictated from outside the industry, but not necessarily by government. As the adversarial norm makes way for a more collaborative working environment, the need to enforce changes that are for the benefit of all those involved should become less necessary, but collective benefit is still very different from individual benefit. Understanding that difference helps explain the inertia that is sometimes misdiagnosed as complacency within the construction industry as a whole,

and given that understanding, suggests how to progress changes that might be seen as necessary by all those involved, but still virtually impossible to enact.

OSM and the use of EPDs both fall into this definition of changes that are seen as necessary for the industry as a whole, require the participation of the industry as a whole, but unlike BIM, are of selective benefit to any one sector for reasons of internal competition. This would suggest that, unless the adoption of BIM can create the pockets of collaboration needed to progress these changes, these changes will also need to be enforced from outside the existing industry structure. The reason for pursuing this line of argument is that the concrete industry needs EPDs to be fully adopted before they will be beneficial to their cause (Section 6.1.3). A partial 'cradle to gate' adoption, whilst easier to police, will only serve to place timber in a better light, with no attention being paid to the growth cycle, the performance figures, longevity or the end of life methods of disposal. It is unrealistic to expect government to enforce these protocols up front and across the board. There will far more likely be a gradual, public sector based introduction of the principles that will attempt to recognize the need for whole life costing, but will in reality skew the argument in favour of timber until lobbying from the aggrieved party forces a reassessment.

In this scenario, seeing the speed of change that has dogged the zero carbon agenda as a whole, pockets of collaboration can be seen as the most appealing prospect for defining functional markets in the short term where positive changes can be made for the benefit of the concrete industry.

Not for the first time, this takes the argument back to the model of the New Entrants, who have entered the market with solutions that control the whole operation from concept design though to sale or rental. In this environment BIM can be made to work, along with any of the other policy decisions that elsewhere struggle to find the co-operative air to establish themselves, and which, even when they do, still struggle to hold the parties involved together for long enough to justify the effort.

It is also true that in this environment, OSM should stand a far better chance of establishing a foothold. Off site manufacturing requires a radical change to the way in which projects are run, with more supply chain management, pre-planning and sharing of information. Previous attempts to infiltrate the established delivery systems with off site manufactured components have floundered at some point, usually towards the end of a boom period, when one of the parties, usually a volume house builder, decides the benefit to them is waning as on site labour costs come down and the need for speed is replaced with the need to pace completions. Without the continuing steady demand for the OSM components, the OSM model collapses due to its unsustainable overheads, and the construction industry as a whole is forced to revert to conventional methods.

To use an unlikely analogy, it is as though any collaborative enterprise, no matter how beneficial it may be to all those involved at the time, acts like an atom in its excited state, with its electrons boosted into a higher more energetic orbit. At some point an electron escapes and the whole collaborative system collapses back down to its stable state, the status quo, where it's business as usual. Unless the government is going to continuously beat the construction industry into an excited state of collaboration, it would seem the status quo will always prevail. Collaboration is just not the industry's natural state.

The conclusion drawn from the cases of BIM, OSM and EPDs therefore, is that conducive environments are important, and that BIM holds a special status in that it both needs and delivers that level of collaboration which makes other changes in the housing delivery system easier to implement. That effectively puts BIM higher up in the hierarchy of barriers to be overcome. Its partial adoption has come about through a combination of government insistence for participation in public sector works, and the ability of the New Entrants to dictate to their own supply chains. In both these scenarios, this has opened up the possibility of a viable OSM solution, potentially delivering more sustainable buildings which in turn drive the EPD agenda. If a slow and partial roll out of EPDs represents a threat to the concrete industry, there is therefore a way in which this problem can be tackled, involving those sectors that are driving these agendas forwards at pace, and focusing initially on the adoption of BIM as the necessary catalyst for change (Figure A: 32).

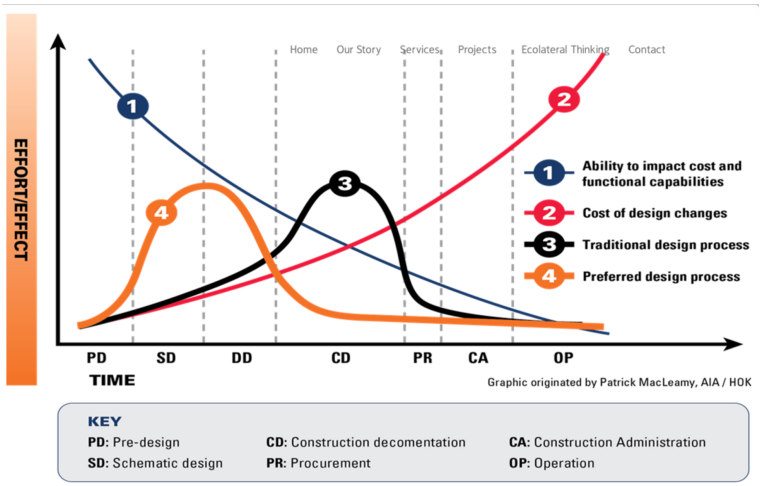


Figure A: 32 the value of early information as delivered by BIM. (www. ecolateral.com)

To this end, the Construction Leadership Council's (CLC) objectives in promoting the benefits of Smart Construction to the UK construction Industry are worth noting, as they encapsulate these three objectives:

- DIGITAL – delivering better, more certain outcomes by using **BIM** enabled ways of working
- MANUFACTURING – increasing the proportion of **off-site manufacture** to improve productivity, quality and safety
- **WHOLE-LIFE PERFORMANCE** – getting more out of new and existing assets through the use of smart technologies.

Alignment with a government backed scheme that is promoting objectives that are beneficial to the concrete industry would provide a useful platform for the further lobbying needed to progress EPDs, something that will find limited support across the rest of the suppliers' sector. This concern, of how to progress agendas that require broader support than can be found within the industry is the subject of the next case study, and proves the case for broadening the argument until a solution appears.

Appendix P4

Collaborative concerns – promoting the solution (Section 6.4.4)

Objective: *to consider the implications of collaboration, how that might need to be managed, and what impact that might have on the partnerships the concrete industry should make.*

If these policy changes are integral to the success of the concrete industry's objectives – the use of EPDs, the acceptance of thermal mass benefits, the environmental case for concrete – the concrete industry might have to be at the forefront of these campaigns. Not all industries require such fundamental changes at a governmental level to further their cause. Leading change at this level can be a costly and time consuming exercise, making the choice of the right partners even more critical. This study looks at some of the issues around collaboration taken from the housing industry's recent history, and suggests a way forwards based on shared objectives.

More collaboration is the overriding message to be taken from the government's latest drive to improve productivity within the housing industry. This follows calls from numerous white papers for the adversarial nature of procurement practices to be reassessed:

The construction industry's 'collaboration problem' is at the root of its change inertia. It prevents itself scaling up, sharing risk more appropriately and creating more business plan certainty. The industry is currently conditioned to using adversarial margin protection and expansion tactics. (Farmer, 2016)

The argument in favour of more collaboration is convincing in terms of greater productivity and encouraging innovation because of the increased opportunities these partnerships provide for developing a better understanding of the new innovative solutions being promoted. Anything that reduces the complexities and uncertainties that lie at the root of the industry's risk averse nature must be good for encouraging change, but change, even in the form of more collaboration can still carry associated risks. In order to further the case for understanding the barriers to be overcome, this section looks at the implications of this policy and shows how a deeper understanding can help formulate a better strategy that could also be beneficial for the promotion of concrete.

In 2006 the CIOB (Chartered Institute of Building) released their findings from a survey carried out to investigate levels of corruption in the UK construction industry. This was in response to the OFT's (Office of Fair Trading) claim that firms had been engaged in illegal anti-competitive bid-rigging activities on 199 tenders from 2000 to 2006, mostly in the form of 'cover pricing'. Cover pricing is where one or more bidders in a tender process obtains an artificially high price from a competitor. These cover bids are submitted as genuine bids, but priced so as not to win the contract, giving a misleading impression to clients as to the real extent of competition. This distorts the tender process and makes it less likely that other potentially cheaper firms are invited to tender. The report stated:

"It would seem from the results that while corruption is present to some degree in many areas of the construction industry, there is some disagreement of where networking and the development of harmonious working relationships stop, and corruption starts." (CIOB, 2006)

As an acceptable working practice, this stemmed from a situation where construction firms, contractors and sub-contractors formed close on-going working relationships based on a mutually beneficial sharing of knowledge, much like that being actively encouraged today. Whilst this practice of bid rigging was commonplace less than twenty years ago, competition law has been tightened since, and a recurrence of this activity is unlikely. But are there any other unintended consequences that the industry should be aware of?

The Section 6.2 case studies looked at the various motivating factors that could dictate the decisions made about materials and methods of construction used on any particular site. The purpose of this section was to show how varied those key motivating factors could be – location, site constraints, client's agenda, planning demands - and how incidental the actual choice of material could be in comparison. The one factor that was not considered in this section was that of embedded knowledge. To what extent is the decision maker's existing knowledge of a material, a method of construction, a company, or a supply chain, pivotal in the choices being made?

The scenario being established here is the one where the repeated use of a collaborative contractor or supplier results in an enhanced knowledge of one particular solution, or a 'familiarity factor' that then begins to mask all other decision making factors. If the principle concept of there being a most appropriate solution for any particular building, site, location at any particular time, is to be accepted, embedded knowledge should not be allowed to override that. The extent to which this could be seen as a serious concern will depend on other factors. A larger company would more likely have the capacity to span more than one preferred solution and call upon whichever department had the necessary expertise for that site, but many smaller practitioners would not necessarily have that capacity of knowledge.

For many reasons the call for collaboration is a double-edged sword and will require some degree of oversight, not only to bring it into existence, but to ensure that the thin line between mutually beneficial co-operation and anti-competitive practices or familiarity biased decision making is adequately monitored. To what extent this task falls upon the government is debatable, both in terms of its practicality and its desirability. If their role is one of facilitator only, in creating the appropriate environment for 'managed collaboration' to flourish, who is best placed to play that overseeing role?

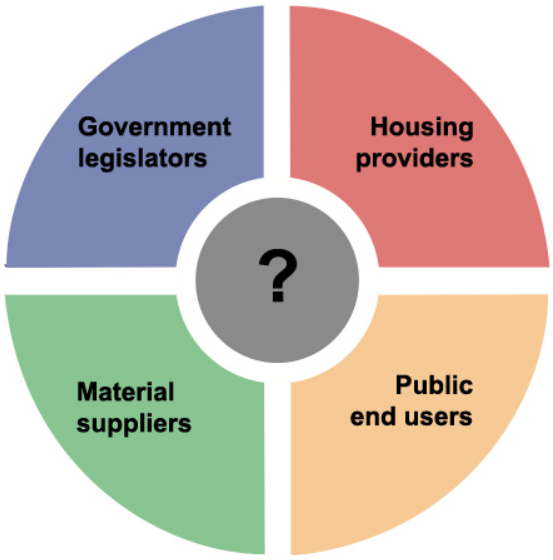


Figure A: 33 the five sectors making up our housing delivery system?

The answer suggested here is that the role, mostly by a process of elimination, should fall upon the architect, and that this, co-incidentally, could be very fortuitous for the concrete industry. So much so that supporting their cause should be a central pillar to the concrete industry's promotional campaign.

The Architect's role.

Already established is the fact that BIM has an important role to play in strengthening the communication channels within the construction industry, but still needs to be more widely adopted. The main barrier to adoption is the lack of individual benefits to be realised before the whole industry has committed, something which after a 5 year phased roll out is still far from complete. But when the question was asked of the construction industry *"do you agree that architects should be responsible for BIM co-ordination on construction projects?"*, 80% said yes (BD and Morrell, 2014). Whether this is a vote of confidence or more a passing of the BIM buck, it could be that the now widely recognised need for collaboration means the architect becomes reinstated, not so much as Master Builder, but as Master BIM co-ordinator.

There is certainly a role here that needs to be taken up, and it would seem to fall most naturally to the architect for a number of reasons. Returning to the concerns raised over the skewing of the decision making process in the new collaborative era due to embedded knowledge, most architects would like to see themselves as putting the appropriateness of materials and methods of construction above such choices. Contractors, unlike architects would quite rightly feel far less concerned with being labelled as specialists who had honed their skills and standardised their working practices around a specific solution to ensure the most profitable outcome. This alone puts the architect's role outside of that collaborative process and allows them to make that more rounded decision based on all the evidence relevant to a specific project. 'BIM co-ordinator' effectively reinforces the architect's position as the overseer and project controller from the earliest stage in the process through to on-site construction, which is what makes them of particular interest to any innovator promoting their products:

More open to innovation: Unlike developers whose default position is to stay with what they know and trust, most architects live to experiment and innovate. They do not on the whole set out to replicate the same solution for their entire career, but seek out new challenges, and new innovative solutions, if not as individuals, as a business.

Not driven by price: Part of the reason for this openness to new experiences, not to mention their loss of control over the building process, is the architect's renowned lack of business acumen. The decision to try something new is rarely the fast track route to success, if ever, and carries a high degree of uncertainty and failure.

In addition to these credentials, the Architect is potentially concrete's strongest protagonist:

A visual commitment to concrete is harder to change during later design stages: If the architect can sow the seeds of desire for visual concrete at the outset of a project, there is a far better chance of keeping this element of the design than with a concrete frame, which can become steel due to delivery issues, global prices, etc. relatively late on in the design process.

Architectural students love concrete: It may be that concrete still holds connotations of modernity, experimentalism and radicalism, or it may be for no other reason than CAD software tends to make all construction look like concrete before choosing to make it look like anything else. It is a pure form, a blank surface, which can be made to do almost anything without complex detailing, and as such, appeals to architectural students.

Open to a counter-intuitive argument: The architectural education does involve an advanced degree of analysis over a broad spectrum of disciplines, which means the comparative sustainability of building materials is understood at a level that goes beyond trees being green and concrete being grey.

Easy to get to: Unlike the general public, architects are an easy to reach sector, especially when they're still studying, which is possibly the best time to reach out to them. Playing to their 'strengths' – spoon feeding them with tabulated data and sets of downloadable CAD details for every junction makes a connection that could last for an entire career.

That represents six very strong reasons for focusing on the architectural profession, especially during their education. Currently TRADA (Timber Research and Development Association) are making their information freely available to students of architecture across the whole country. They run competitions and regularly send in representatives to make presentations. The Concrete Centre in comparison had, at the time of writing, shut down its entire student education programme budget. Recognising the need for forming partnerships to either change policy or promote products is a key element in this process. Knowing where to invest what could be a considerable amount of effort over a prolonged period of time comes from an in depth understanding of the industry as a whole, the political and economic environment, and the predicted direction of travel.

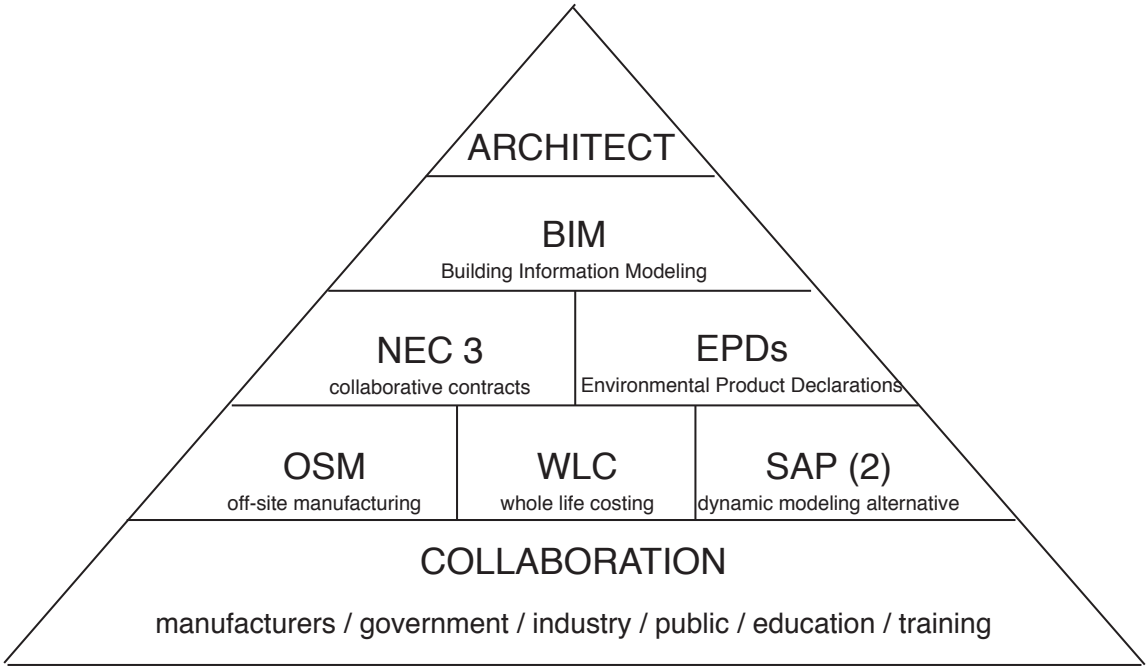


Figure A: 34 Hierarchy of factors that need to be in place for change to take place

"The impersonal government bureaucracy will never take the trouble to make a place human and livable; it can more easily just follow uncreative rules of modularity and mechanical combination. The construction group is not responsible: it wants to finish its job in the minimum time and make the least number of adjustments. The residents are not politically powerful to guarantee a livable environment. Within the realities of construction, a project requires an advocate with the power to coordinate all of these forces."

Appendix P5

The land question – the political end game (Section 6.4.5)

"Buy land, they're not making it any more." Mark Twain.

Objective: *to show how the concrete industry could play a role in removing the ultimate barrier.*

The theory that all barriers to innovation must be dealt with before any change can take place is best exemplified by the way we have collectively failed to address the issue of land valuation in the UK. Land speculation is the ultimate 'barrier at the end of the road' which is currently seen, even by governments, as immovable. If it is not dealt with, however, no level of innovation will bring about a reduction in the value of our properties, because of the residual land value calculation used to absorb any additional profit introduced into our housing delivery system (P0.03.3, p4). This last study looks at the history behind this barrier to change that sets us apart from the rest of Europe, and discusses how the concrete industry could be pivotal in its removal.

According to the VOA (Valuation Office Agency), the average price of agricultural land in England is £21,000 per hectare, while land with planning permission for housing is around £6m per hectare. To take the most extreme example,

"If a hectare of agricultural land in London's green belt was given residential planning status, with no requirement for affordable housing, then its value would increase around 1,000 times." (Jefferys and Lloyd, 2017)

This final case study brings together a number of themes already discussed in order to confront the elephant in the room, the one barrier that sits at the end of all the roads so far investigated as routes to promoting innovation. The point has already been made that many barriers can be avoided rather than tackled head on by choosing more appropriate markets in which to seed a new concept, but at some point there will usually be a barrier that cannot be sidestepped and must be dealt with (section 6.4.3). More often than not, at this level in the hierarchy, that barrier will be political either in its cause or in its solution.

There has also been a recognition that many of the policies that we aspire to already exist in continental Europe, whether that be related to community, social provision, sustainability measures, modern methods of construction or diversification of delivery mechanisms, with self build, custom build and kit housing all playing substantial roles in their housing provision (Section 6.3.1). Understanding the underlying reasons behind these different evolutionary paths over the past 50+ years is complex, and avoiding that detail can easily lead to false assumptions about what can be done here to replicate those outcomes. But there are nevertheless lessons that can be learnt that either

help to define a strategy to adopt, or at least help to explain why some of their solutions will never be ours.

Another emerging theme, unexpected at the outset, is the potentially pivotal role of the architect in any restructuring of the housing delivery system. More mediator-in-chief than commander-in-chief, the architect is possibly best placed to navigate the path ahead (Section 6.4.4). Implementing changes requires oversight, both in terms of knowledge of the entire process from beginning to end, and knowledge of the alternative solutions available, together with a vision that goes beyond bottom line profits and recognises the benefits that can stem from a more holistic outlook.

And lastly, the stunted role played by the general public in demanding a better quality of housing. Seen by the entire industry as 'not even in the room' when it comes to influencing the product that is ostensibly being built on their behalf, the public have become marginalised by an industry and successive governments that have pursued their own agendas (section 6.1.2) for many decades. Whilst the endemic shortage of housing that these policies have perpetuated continues, 'the public' has no choice other than to dutifully accept whatever housing becomes available, at whatever price it can command.

"The goal of building homes is to benefit the people who will live in them and the communities that they are part of".

""When the old neighbourhoods of houses, shops and small businesses were razed to the ground, they were replaced by monolithic single tenure estates of council flats, many in high rise or long deck access blocks. Amidst all the powerful pressures, there was little room for the choices and aspirations of tenants to be heard. The merits of industrialised housing never matched the promises made for it…"

"it is important to remember that public benefit is explicitly not the goal of speculative housebuilding. As the Callcutt Review of Housebuilding Delivery stated bluntly: 'housebuilders are not in business to serve the public interest, except incidentally. Their primary concern is to deliver profits for their investors, now and in the future'" (Jefferys and Lloyd, 2017)

Returning, as always, to the relevance of this to the concrete industry, towns and cities are where the housing revolution we need, needs to happen (The compact sustainable city, R Rogers). Sustainability in terms of the communities we live in requires it, but the solutions that will make this achievable – densification, standardization, modular off-site construction, all contentious in their own right, are still not seen as mainstream options. But they are the solutions where the concrete industry can capitalize and provide truly affordable housing by pioneering alternative visions for how we live, such as custom build communal living projects.

This case study looks at the political conundrum of land reform and shows how it is central to all these issues – the quality and affordability of our housing, the lack of diversification and the stunted role played by the public and the architectural profession in this debate. It then goes on to look at how and why these are not such contentious issues on the continent, and what changes would need to be made here to allow a European-style collaborative housebuilding movement to flourish. And to be clear on the relevance of this, whilst it can be shown that custom build communal living projects would indeed

be a solution the concrete industry could justify pursuing, without first addressing the systemic changes needed to allow this market to flourish, it is unlikely this would grow into a sustainable revenue stream. The question therefore becomes – for this and all the other scenarios so far discussed - one of whether the changes needed are achievable, what partnerships would be needed to make those changes, and whether in fact the markets these changes would open up justify the effort involved.

The Farmer Report, in its overarching assessment of our housing system has highlighted all the themes mentioned above and more. The DCLG has published its response, 'Fixing our Broken Housing Market' (DCLG (Department for Communities and Local Government), 2017)and the CLGC (Communities and Local Government Committee) has now published its response to that, 'Capacity in the Homebuilding Industry (Communities and Local Government Committee, 2016). All are in agreement as to where the problems lie and what both the industry and the government need to do to resolve these issues. These papers are not 'in-house' consultations that actively avoid confronting the real problems as they see them, but there is nonetheless a sense of them all operating within the constraints of what the government either can or is prepared to consider doing. There is, for instance, not a single mention of the sustainability agenda throughout either of these responses.

"The Tory agenda is based on economic growth, achieved through competition – themes that permeate their manifesto. But the idea of sustainable development is more nuanced. It goes well beyond the realm of market economics. Although it's stated as a 'golden thread' in the NPPF, the government consistently refuses to define what it means by sustainable development " (Ryan, 2015)

Neither is there any mention of overseas investment in our housing market by non domiciles, a policy that guarantees that much of London's new build housing is taken out the market before it arrives on the market, or, central to both of these issues, any mention of a land value tax to halt the windfall profits that go to landowners and ensure that land prices, and consequently property prices, remain high.

It is at this level that intervention is needed to have any real impact on the quantity, quality and affordability of our housing, and the only conclusion that can be drawn from these omissions is that neither the government nor the private sector are incentivized enough to resolve these endemic issues (Jefferys and Lloyd, 2017).There are, however, movements in continental Europe that recognize these shortcomings and also recognize the power of a third force in rebalancing the marketplace, which are worthy of investigation, if only to understand why there is not an equivalent movement in the UK.

The Baugruppen or 'building groups' model of housing represents the future of architect-led, collectively funded, community-based living in many cities across northern Europe, where communities are re-engaging with their own housing needs in a way that makes use of the 'social state' and the 'private economy' through what has been called the 'social economy', referred to briefly in section 6.2.5. In these countries, the role of the architect has been redefined as one of facilitator rather than purely the creator of the built form. It is an extension of their current role rather than a change, as the architect's creative abilities are no less necessary, but there is in addition a need to

listen to, understand and respond to the needs of the real client, the home user – something that the housing industry in the UK has lost sight of to the detriment of our society as a whole.

It is perhaps unexpected to find the architect as the instrument most appropriate for orchestrating the resurgence of this marginalised sector, but they are, almost by default, best placed to play the 'honest broker' and reopen the channels of communication between those whose motivations have become self-fulfilling, and a public whose motivations have been ignored to such a degree, their understanding of the game has all but gone. What makes the position of the architect unique is their central role, once at the pinnacle of the process as Master Builder, now in a position of relative subservience, but no less central for that fall in status. If anything, their decline has put them even more central within the pyramid of the housing delivery system, and even more accessible for this new role as mediator-in-chief. The architect's ulterior if reluctant role has long been no more than to reach an acceptable compromise – between client, developer, financier, legislator, and their own aesthetic sensibilities. It was perhaps no more than the displacement of the public end user as client from this equation due to the inevitable complexity of our societal structures that caused the model to falter and the current fragmented imbalance to take hold, but the situation is far from irretrievable. The cycle of industrialization that first professionalized housebuilding has taken us through mass production, to mass customization and now poised to enter an era of mass personalization, where individuals are once again in a position to reassert themselves through a new social economy, emboldened by social media, that has given them a voice and an ability to re-enter the game.

The Conservative manifesto *"hopes to massage the market through measures like extending the Right to Buy to Housing Association tenants, and Help to Buy mortgage support (the latter condemned as a Ponzi scheme, even by The Spectator). All are likely to inflate house prices in the long run and further reduce the supply of social housing"*

"The reason, and the only reason, that house prices have not collapsed in Britain as they have in, say, the US and Ireland is because the government has not allowed them to."

(Ryan, 2015)

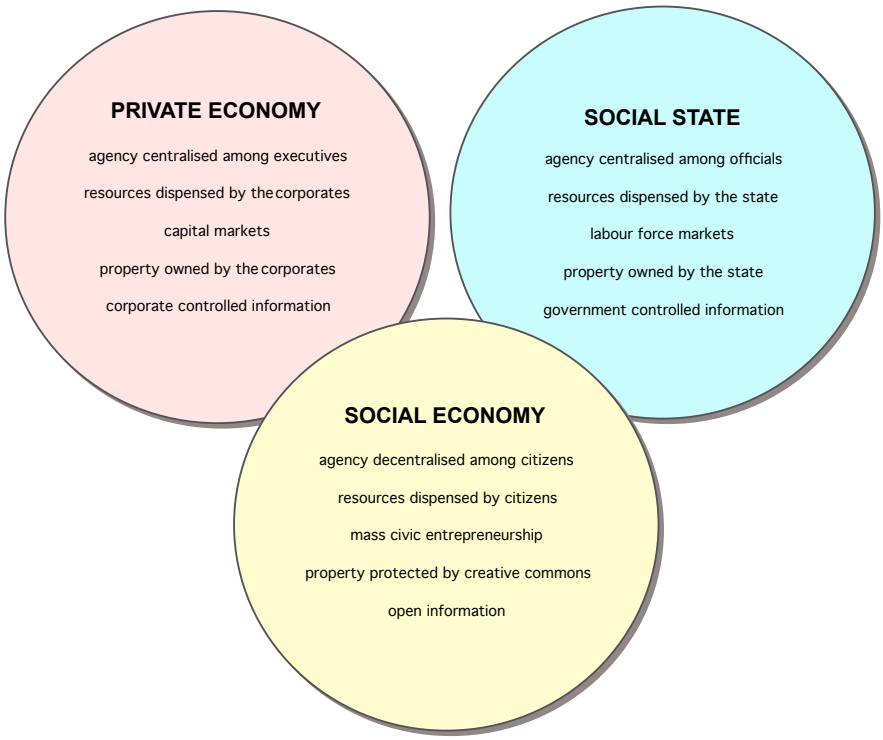


Figure A: 35 The model for 'New Civic Housebuilding'

The question this raises, however, is why this 'third way' is not as yet a recognized movement in the UK? What is the fundamental difference between here and the continent that prevents the same mass civic entrepreneurship taking hold and providing the much needed affordable housing where it is most needed, in our cities?

The answer to that and to a much broader malaise that impacts our entire housing delivery system, it has been suggested is the way in which we value our land, an issue that has dogged our attempts to provide good quality affordable housing for over 100 years.

It is admitted on all sides that the housing of the working classes both in town and country districts urgently needs improvement, and that the homes of a large proportion of the nation fall far beneath the standard of health, decency, and comfort which our level of civilization requires… Private enterprise is proved to be incapable of solving the problem by itself, where it has hitherto been left to deal with it.

The Times, 1913

'Consider what rent is. It does not arise spontaneously from land; it is due to nothing that the land owners have done. It represents a value created by the whole community. Let the land holders have, if you please, all that the possession of the land would give them in the absence of the rest of the

community. But rent, the creation of the whole community, necessarily belongs to the whole community.'

Henry George, 1879

(Bentley, 2017)

The last budget, in November 2017 announced a raft of proposals to unlock the housing crisis and pave the way for our long awaited housebuilding boom. But there are many voices warning that this boom will not happen, in the same way as it has not happened for the past 50 years. There are multiple barriers that need to be removed simultaneously before any change can take place, and whilst there have been numerous papers and reports written to this effect, government policies have systematically failed to address the holistic nature of the problem. What is less clear is the degree to which the government understands, believes or feels able to enact the policies that are needed to break this cycle.

The best that can be expected from this latest budget therefore, is an influx of capital into a wholly dysfunctional system that will result in a modest increase in housebuilding, but one that will only provide for the most wealthy of those waiting to get onto the housing ladder, not those in greatest need. This is a known consequence of landowners justifiably holding out for the highest values they can attract for their land, which inevitably results in that land being sold for the development of the most expensive properties the market can sustain. Over time, this results in an over supply of properties on the market for these wealthier sectors whilst continuing to undersupply for those sectors where the demand is greatest.

"About 80 per cent of the new homes build in London are affordable to just eight per cent of households in the capital" (Dorling, 2014)

The reason why this is a known consequence is because this is not the first time these policies have been pursued, and although all cyclical re-enactments have their differences, our recent history is still worthy of comparison.

Before the 1st WW there was a recognition that the private sector alone could not be expected to provide all the housing needed or the right mix, and policies were enacted to rectify this. The 1947 Town and Country Planning Act brought in powerful planning regulations for the first time including a limitation on landowners ability to profit from the uplift in their land value on receiving planning permission. This was achieved through a tax on *"all of the increase in value arising from planning permission, by way of a development charge set at 100 per cent of the difference between existing use value and residential use value."* (Bentley, 2017)

In hindsight, a 100% tax was recognised as unwise, as it gave landowners no incentive to part with their land, and the act was scrapped by the subsequent Conservative government in 1953, replacing it with the threat of compulsory purchase laws which were poorly written and seldom enforced. Local authorities were able to purchase land at its existing use value for a further 6 years however, before they too were forced to return to a free market policy in 1959. But in those 11 years, a third of all the post war council housing was built, including 21 new towns, now providing homes for 2.8m people.

"The unserviced land cost component of houses in Harlow and Milton Keynes has been demonstrated to have been only about one per cent of housing costs at the time." (Bentley, 2017)

Since the Land Compensation Act of 1961, landowners have been paid the value of their land plus any 'hope value', and as a consequence, land acquisition has been increasingly expensive ever since, as this led to land speculation and the withholding of developable land on the hope of future increases in value. Indeed, land acquisition costs for council housing doubled in the four years after the introduction of this Act.

Various attempts have been made by Labour governments since then to reintroduce a land value tax, but not at 100%, so as to maintain some incentive for landowners to sell, but such is the history of these failed attempts, that landowners have tended to withhold their land until these Acts have been repealed by successive Conservative governments. Section 106 agreements, introduced in the 1990s as part of the shift of affordable housing provision to the private sector, was the latest incarnation of these attempts to control land values, and has been more successful than any preceding attempts, but has nevertheless been criticised for the endless delays caused by its negotiated nature, and its inability to drive down land purchase prices because of the late stage at which it is finally agreed.

The current argument is that this is an inappropriate mechanism for delivering affordable housing on many levels – it is not only failing to influence the land purchase price, but it is delivering an increasingly inadequate supply of social housing as developers and landowners negotiate down the percentages on the basis of site viability. Councils, now almost entirely dependent on this as their main method for delivery are put in a weak bargaining position, and often settle for what they can get. But more importantly, because their stock is now almost entirely delivered by this method, the supply drops off during a recessionary period when it should be growing to compensate for the reduction in workload across the industry as a whole.

The most recent attempt to correct the shortcomings of these systems has been the Community Infrastructure Levy or CIL. This is effectively a return to a form of betterment levy which is a non negotiable fixed sum, but set locally rather than by national government. Unfortunately, its uptake has been patchy, partly because of the costs of implementing it, and possibly a desire to attract development in favour of neighbouring councils who have introduced it. But for whatever reason, the tax yield has been far lower than expected, and ultimately, it still fails to focus on the landowners' profits at source, but seeks to retrieve them indirectly through the developers and the prices they buy land at over a period of time.

The most desirable solution after 100 years of experimentation would seem to still require governments to have a degree of compulsory purchase power, even if this is rarely used. It is only this ability to purchase land at a price related to its current value when that land is deemed necessary for the provision of housing in an area, that land value speculation can be curtailed. The alternative mechanisms, of negotiated Section 106 settlements, fixed price CIL payments or a land value tax payable on all developable land have all proved too complex in their adoption or their administration – and all are liable to reversal by future governments. Clearly a compulsory purchase mechanism can also be reversed, as it was in 1959, but it cannot be avoided whilst it is in operation, and that, quite simply, is why it works on the continent, and why, given the opportunity, it could also work here. But

how do we go about making that systemic change? In this respect, the government is no different to the marketplace, and the question to ask is, does the government lack the knowledge, the motivation or the ability to make that change?

In 2013 The Joseph Rowntree Foundation commissioned an International Review of Land Supply and Planning Systems, which compared residential land supply systems in eleven countries and considered which approaches could potentially be adapted and implemented in the UK. Their first observation was that the UK was unique in its approach to land acquisition.

"There are many differences but also many similarities between countries. Only England comes from a purely planning-permission background, although South Korea is moving in this direction. All the others use zoning with varying degrees of discretion" (Monk *et al.*, 2013)

The conclusions drawn from this review highlight three areas where the UK's approach differs from many European systems – France, Germany, The Netherlands and Switzerland in particular.

• The use of local incentives, possible through a greater degree of local governance.

"Most countries have three layers of governance for land use planning, namely national, regional and local. England, outside London, is alone in having no regional strategic layer."

Local Enterprise Partnerships cover the whole of England. *"So there's plenty of scope for them to become more visible, community-focused champions for their areas, act as convenors and brokers for determining planning matters that are 'bigger than local yet smaller than national' "*

• The use of compulsory purchase powers to finance infrastructure costs and assemble small plots of land into useable sites of projects deemed to be of communal benefit.

"the operation of the land market in England needs careful review. Under the current system all the incentives are to obtain planning permission as this increases the value of the land. Expectations from landowners can therefore prevent land coming forward until the price is right." "In many countries local authorities play an active role in land assembly, often using compulsory purchase powers."

• A more holistic approach to land use that enables growth, specifically through a more strategic green belt policy.

"The evidence from other countries suggests that our green belt policy should be operated far more flexibly than has been the case over the decades. Boundaries should be revisited at regular intervals"

There is no shortage of policy papers and think tanks recommending ways in which government policy could be revised to implement these changes and bring about a more equitable housing delivery system, and they all recognise the underlying issue of land value and how 50 years of unfettered speculation has resulted in our present predicament (Aubrey, 2015, p. 4). It would seem disingenuous therefore to suggest that the government lacks a similar level of understanding, leaving only a lack of motivation or a lack of ability to explain their lack of action. As a line of research, answering questions at this level becomes increasingly difficult, as straightforward answers are hard to come by. Motivation and ability also become blurred as both are clouded by the need to be re-elected. But

whilst there is endless speculation as to what political purpose might be served by preventing the adoption of a more equitable system of land procurement, ultimately the need to be re-elected seems to prevail, which would suggest that raising public awareness might be a more effective route to pursue.

None of these options offer immediate, simple or guaranteed solutions, but this is the barrier that has consistently been put in the 'too difficult to deal with' box, and as a consequence, piecemeal policies have been pursued that stand little chance of success. The point was made at the outset of this study that the ultimate barriers were most often political and could not be sidestepped - they had to be either dealt with or accepted. Accepting a continuation of our current land value system means accepting that whilst there is a shortage of housing, no innovation will reduce its cost, as the residual land value will always rise to compensate for the savings made. It also means accepting that there may always be a shortage of housing, as without innovation our housing delivery system will probably remain under the control of the speculative house builders who have a vested interest in maintaining this undersupply (Barker, 2004, p. 25). Every attempt to disprove these assumptions over the past fifty years has failed, as they did prior to the First World War. It would seem therefore that this is a barrier that cannot be accepted and must be dealt with.

"Policy Network suggests regional authorities should be able to acquire land at 'close to use value' in dedicated housing zones, through an amendment to the 1961 Land Compensation Act, which deals with compulsory land purchases." (Evans, 2015)

"When the planning system began in 1947, we said the value of a planning permission should go to the public good. The 'uplift' from a field to a housing development was owned by the public." (Wainwright, 2017)

"A smarter use of compulsory purchase is also far from a modern idea. In the 1870's Joseph Chamberlain as Mayor of Birmingham used compulsory purchase to assemble land cheaply and to ensure profit came in the form of public benefit. He said 'we shall get our profit indirectly in the comfort of the town and in the health of the inhabitants'." (White, 2017)

"A business model that relies on keeping house prices up to recoup the high cost of land will never build enough homes to bring prices down." (Jefferys and Lloyd, 2017)

"a sensational and shocking rise in the price of land". Gaitskell blamed this rise on the Prime Minister Harold MacMillan who, as Churchill's Minister for Housing, had "[thrown] away the compensation and betterment provisions of the Town and Country Planning Act, which, at least, would have ensured that the benefit of these increased values came to the community." (Jefferys and Lloyd, 2017)

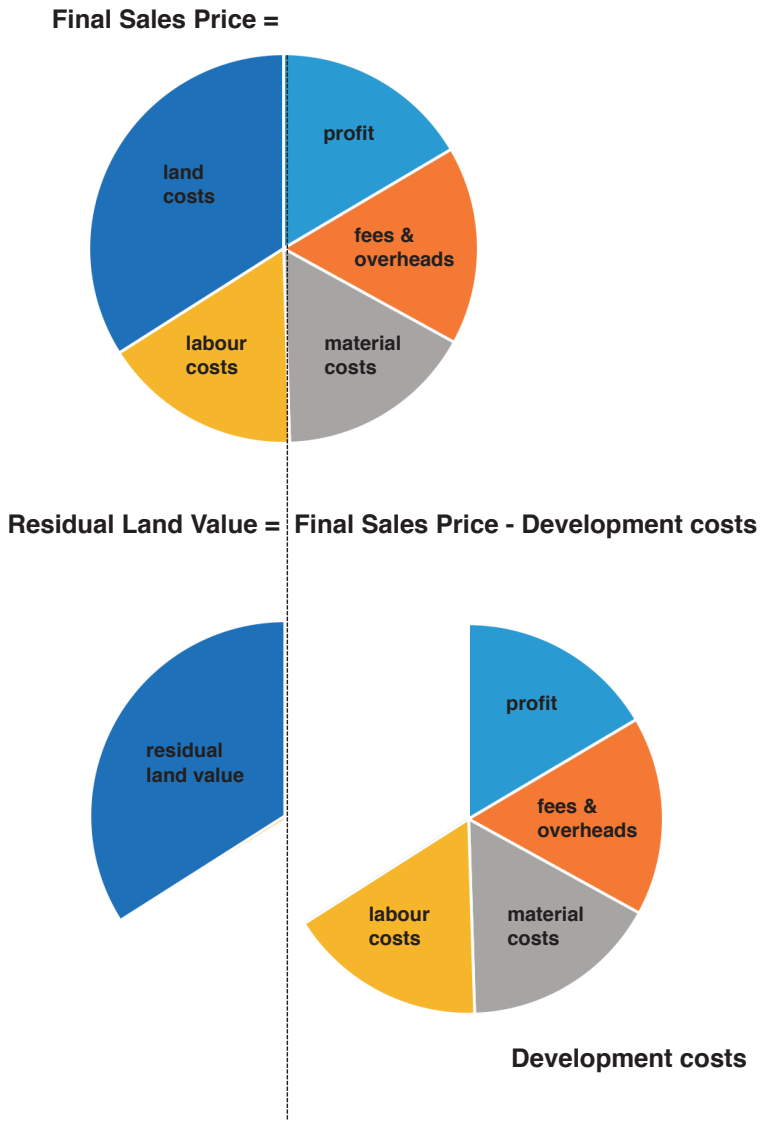


Figure A: 36 Residual Land Value calculation

To end on how the concrete industry could proceed, one option might be to lead by example. A fair purchase value for developable land has been defined as

"the existing market value of the land (it's agricultural or industrial value), plus a degree of compensation. This could be achieved by agreement with landowners as typically happens on rural exception sites." (Jefferys and Lloyd, 2017)

It has been suggested that the public sector should lead by example, using its assets to support high quality development and affordable housing, but in reality policies relating to land value need to be enacted universally and for a period of time that prevents the option of 'holding out' as has been the case on previous occasions, if they are to be truly effective. What this does not rule out however is for the concrete industry to use its own developable land to promote this policy on a scale that publicizes the impact this could have at a national level. This needn't be a wholly altruistic intervention, as the

concrete industry, like the government is in a position as a major landowner to derive their profits over longer timeframes. This kind of long term 'patient finance' where the landowner is prepared to trade some of their windfall returns for a high quality legacy and a longer term return, similar to housing associations or community land trusts, is a common or even the dominant way that homes get built in other European countries (Jefferys and Lloyd, 2017).

If the concrete industry were to adopt this policy, they could promote not only a different housing solution built using their methods and materials, but an affordable housing model capitalizing on the uplift in land value profits currently going to landowners. That is the basis of the social economy model, with windfall profits being used to substantially reduce the build cost without any consequential increase in land value, and also pay for the infrastructure costs and amenities that local communities want to see when a new housing development is proposed in their area.

In the same way as the concrete industry needs demonstrator sites to promote the use of concrete as a sustainable, resilient, affordable building material, the public also needs to see alternative ways of living at prices that are truly affordable. By using their own depleted quarry sites as a controlled land bank dispersed as they are across the whole country, the concrete industry could show by example how the almost £10billion (Bentley, 2017, p. 35) that should be put towards our nation's housing but instead goes every year to landowners as windfall profits could, with government intervention, transform our housing delivery system and end the housing crisis.