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Driving sustainability in the UK housebuilding industry around the barriers to change.

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ABSTRACT:

Sustainability's Coming of Age

For many in the UK, the sustainability agenda for housing is now ten years old, dating from the adoption of the Code for Sustainable Homes as the benchmark for the reduction of carbon emissions in all new housing. It's had a messy childhood loaded with conflicting advice and unrealistic expectations put upon it – but now, the industry that has grown up around it has been pushed out of its government protected home and is having to come of age earlier than it had prepared for. The government's dismantling of the Code for Sustainable Homes and removal of the 2016 Zero Carbon targets have meant that with little warning, the sustainability industry has had to start fending for itself without the support of targets for the housing industry to meet - the big stick approach, or the programme of tariffs, the carrots, to reduce the financial impact of adopting the changes prescribed. Without these incentives to focus the minds of the developers, the sustainability industry is looking vulnerable and the realities of now having to be financially self sufficient are coming home to roost. But our statutory requirement to reach an 80% carbon reduction by 2050 has not changed, and neither have the reasons for achieving it.

This paper looks at the barriers to adoption that now face the sustainability industry (Morrell 2010, p.5) and asks whether there is an alternative approach that might avoid hitting some of these more intractable barriers head on. It will look holistically at how the housing industry operates, how government initiatives have tried to impact on this to bring about change, and more importantly why they have, to a large extent failed. It will then put forward an alternative model that is effectively already being adopted by some within the housing industry (Farmer 2016, p.38), and backed up by findings from a series of interviews held across the sectors that need to work together to bring about the changes that all profess to want but none appear able to deliver.

Housing, Sustainable, Motivators Barriers, Risk

1. INTRODUCTION

The starting point for the sustainability industry, now that it has had independence 'thrust upon it', is to recognize that it has to sell itself into an indifferent, even hostile housing market in whatever way works best. That means understanding what its potential customers want, and what motivates them to want it, but it also means understanding who its customers are. Is it the house builders, or is it the public – or is it still to some degree the government? Working on the premise that these sectors might not even have the knowledge, let alone the motivation or the ability to implement the changes that sustainability entails, this represents a big shift from being dependent on legislation as the main marketing tool for sustainable innovation. (Figure 1)

Legislation is clearly a vital component in the initiation of change, and whilst this has not disappeared, it is no longer the driving force it previously was (Pitt 2014). But it should never have been thought of as more than just a component of that process, because as we have seen, it cannot be depended upon to provide the stability and continuity that businesses need. At some point decisions have to be taken on their merit alone, and a transition period is needed for this to occur. The problem now facing the sustainability industry is that whilst they have been waiting for the housing market to transition to a carbon based state of mind, that market has been waiting for them to transition to financial viability. Neither party is as yet ready for this coming of age, and this disconnect of expectations is now in itself a major barrier to change (Farmer 2016, p.66).

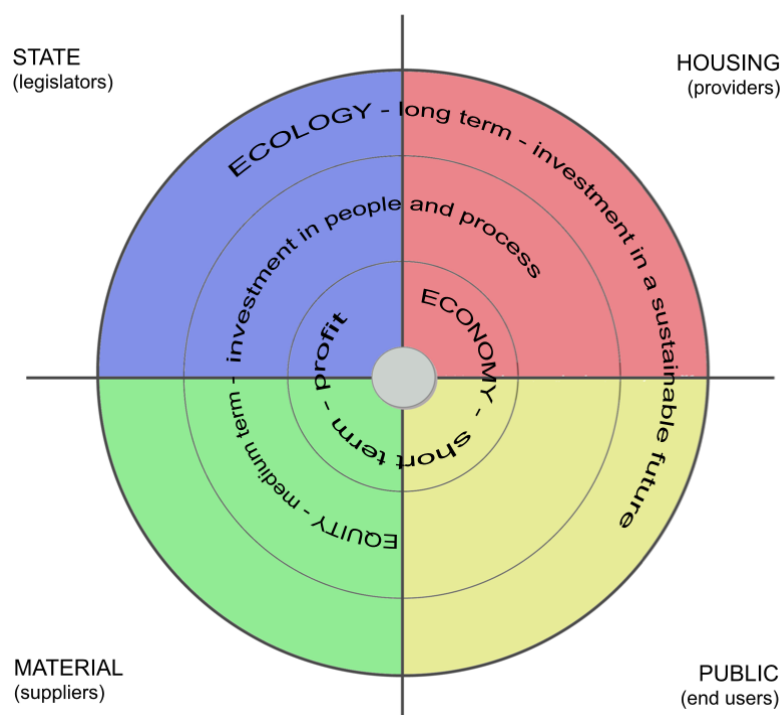


Figure 1: diagrammatic representation of the main sectors within the housing industry and the three motivating factors that drive their decision making.

2. UNMATCHED MOTIVATIONS

Unmatched motivations represent one of the fundamental barriers that stand in the way of the sustainability agenda's acceptance, and it is these barriers that the industry needs to focus on before it can begin to construct a policy for moving forwards. Understanding what motivates the housing industry to make the decisions it does, and this includes all sectors that are part of this complex chain of delivery, is the first step towards a successful dialogue, and whilst this will always include an educational role about the long term benefits of sustainability, it also requires the sustainability industry to understand the need for short term financial viability. There is an unhelpful tendency for this to be seen by the sustainability protagonists as commercial greed overriding the collective good that sustainability represents, but this presupposes that all potential customers are firstly, informed, secondly motivated and thirdly in a position to follow through with the changes being asked of them (Figure 2). All three of these are prerequisites of change and together they represent a considerable journey for any one individual or business to make within what is an extremely complex and adversarial industry (Cabinet Office 2011, p.3).

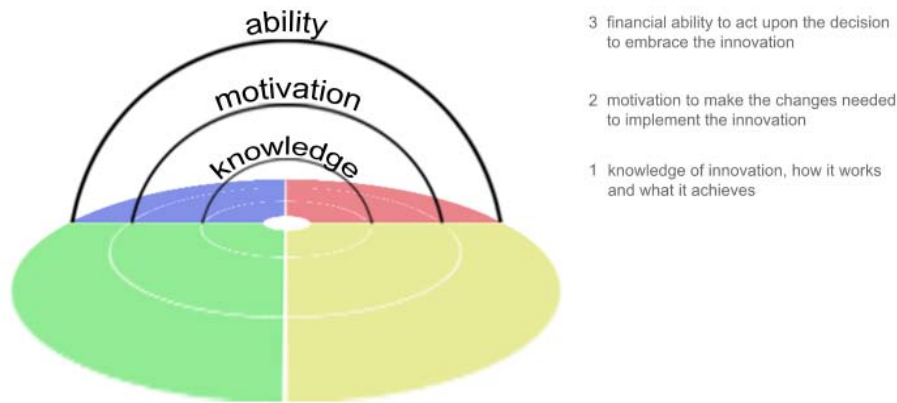


Figure 2: three prerequisites of change through innovation

3. GOVERNMENT INTERVENTION

It soon becomes clear that it is very easy to make a strong and compelling case for the status quo and why innovation in the housing industry has always struggled to find acceptance. The Farmer Review, published in October last year, and entitled ‘Modernise or Die’ recognises all of these barriers to change and defines them as the ten symptoms of a near terminally ill patient (Farmer 2016, p.6). It talks about the complexity of the housing industry’s structure and the poor communication and understanding that exists between its sectors. It talks about the uncertainty that hounds the housing industry due to government policy inconsistencies and the effect that our cyclical economy has on investment, training and ultimately on our skilled labour supply. And it also talks about the many other papers that have preceded it, making similar observations (Figure 3), but all failing to have any meaningful impact on the productivity or output that is now so desperately needed (Lyons 2014, p.6)

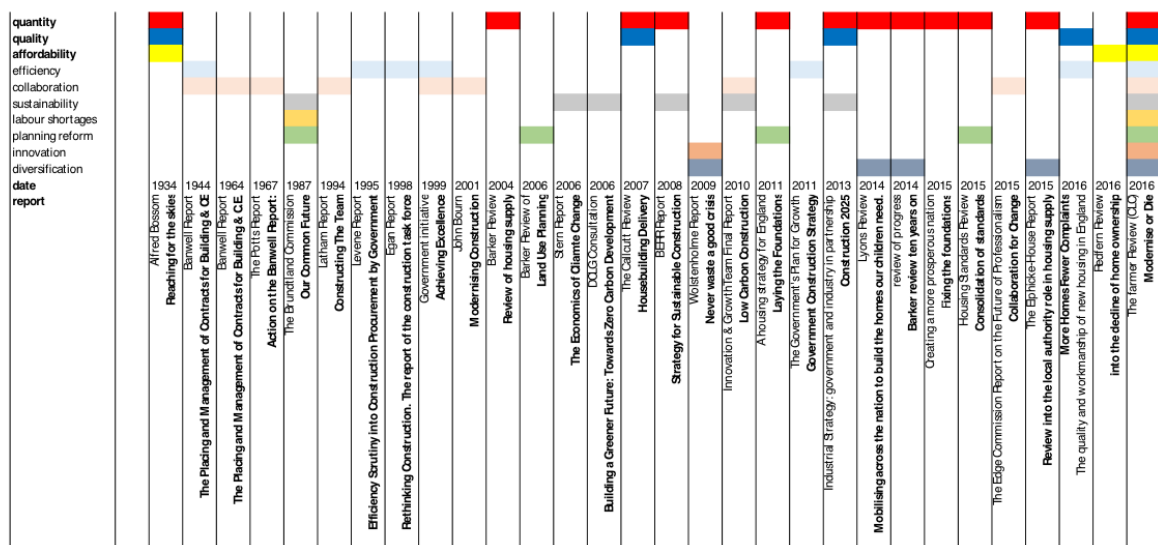


Figure 3: timeline of government white papers and the symptoms addressed

The concern that arises from studying this very thorough review however, and what has led to the question being asked by the authors, is that despite recognising all the previous papers that were also well received in their time, there is no attempt here to question why it is that they were so ineffective, which begs the question, why will this paper be treated any differently? The Farmer Review itemises and deals with the many symptoms of the inertia that has beset the housing industry, but there is still a tendency, reflected also in previous papers (Morrell 2010, pp.5, 34), (Eclipse Research Consultants 2009, p.4) to then settle on complacency as the root cause.

“I am very clear that if we do not address in short order how the construction industry operates and delivers, we will see a long-term and inexorable decline in its fortunes. 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).

As well as being an unproductive diagnosis, the authors suggest that the housing industry is not so much reluctant to consider change, as unable to, due to the levels of risk that its individual component businesses are being asked to take. They also suggest that this is central to the reason why the sustainability agenda is failing to transition from a government incentivised proposition to a business led proposition. In this respect, the sustainability agenda is no different to any other agenda in that it requires changes to be made. Any change involves an element of risk, something which many businesses are founded on, but risk has to be manageable. In the housing industry there are high levels of complexity and uncertainty, both of which are risk escalators, to a degree where the risk becomes untenable, and the status quo, no matter how discredited, becomes the safest option. The Zero Carbon Homes standard, both in its inception and its demise, exemplify the impact that enforced innovation can have on small businesses.

“The costs and complexity of running a SME house builder business have been increasing steadily over the last 25 years and have had the effect of driving many smaller firms out of the market” House Builders’ Federation, (Lyons 2014, p.106).

This is perhaps where the crux of the problem confronting the UK housing industry is to be found, and the reason why so many government initiatives, dating back over an incredible eighty years have failed to bring about the changes that were intended. And whilst sustainability is only one part of that call to action alongside increased productivity, quality and affordability, the problem confronting those making these demands lies in their refusal to recognise the role of risk as the main barrier to change (Figure 4).

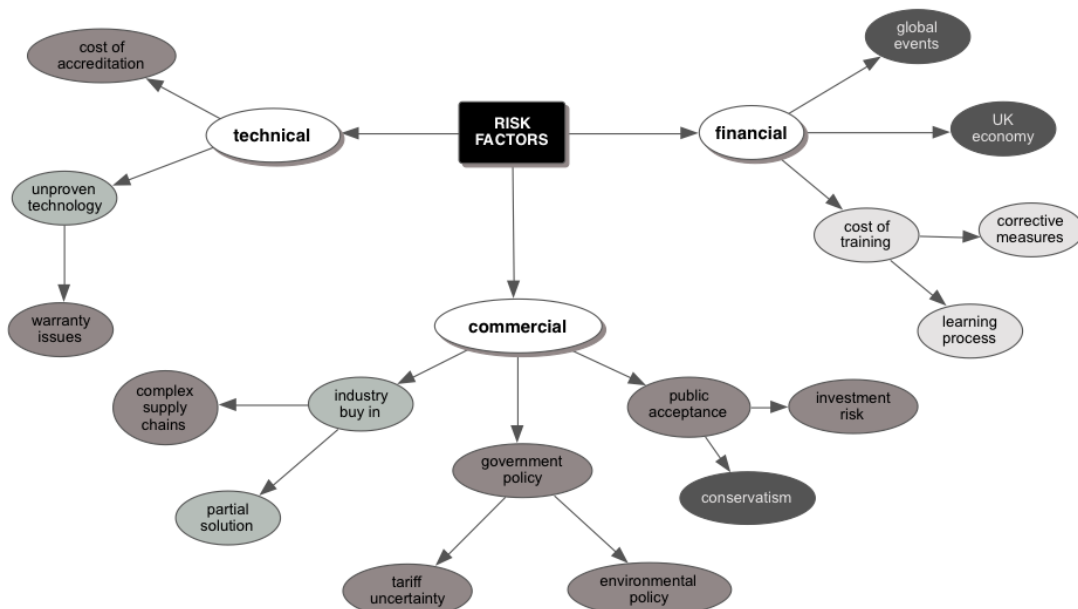


Figure 4: The risk factors confronting the housing industry. Darker shades represent less controllable risks.

Technical risk: New innovative solutions are seen as high risk because they are technically unproven, open to the threat of competition, and potentially difficult to warranty. New technologies require many bodies across all sectors to be convinced of their necessity, viability and practicality before they will be accepted.

Commercial risk: From an implementation perspective, new innovative solutions are seen as high risk because of their dependence on vacillating government policies, tariffs and regulatory targets, the need for businesses in complex industry supply chains to be willing to participate, dependent on their need to be beneficiaries in their own right, and the unknown factor of public acceptance, due to either conservatism or an unwillingness to risk their investment.

Financial risk: Once the decision has been taken to participate, there is the direct financial risk associated with costs of promotion, of training and reskilling, of possible corrective measures at the outset, plus the risk associated with unknown future political, economic and environmental events.

4. FIX OR AVOID?

There are two alternatives to consider here. The first is to limit these risks by changing the way in which the housing industry operates, and the second is to accept that the way in which the industry operates is unchangeable and to avoid those risks by taking an alternative route. As suggested at the outset, the proposal made in this research is that the alternative route might be the only realistic solution, and that eighty years of attempted intervention has proven that governments' ability to make wholesale changes that encompass our entire housing delivery system is beyond their capabilities.

So is there really an alternative route that bypasses all these substantial barriers that we could be considering? The answer to that is a conditional ‘yes’ because it is already happening, albeit not yet on any meaningful scale. The focus of the current government’s latest drive to revolutionize the house building industry is off-site manufacturing (DCLG (Department for Communities and Local Government) 2017, p.48), but whilst this is where the innovation is centred, the real revolution is in how this is being orchestrated as an independent operation. Off-site manufacturing has been paraded as the housing industry’s panacea to increased productivity before, and if we are to include its precursor, ‘prefab housing’ - the same solution in all but name - it is a solution that has been available to us since the First World War. What is different about this incarnation is the fact that the ‘New Entrants’ who are propagating this model, are not attempting to woo the existing developers or connect into their existing business models, but are instead setting up their own self contained operations, which in some cases, such as with Legal & General, includes land procurement right through to property management with a long term interest in rental returns (Farmer 2016, p.38).

In some respects, this is merely a recognition of how successful the volume house builders’ business model is, but what it is also doing is recognizing their model as a vertically integrated market solution, something that often gets missed because of the fact that it is also a very broad market, soaking up 50% of the whole (Figure 5).

“The standard UK business model is that of the volume house builders. They typically manage all the stages of housing development themselves; from land purchase through to selling the completed homes and taking development and demand risk.” (Lyons 2014, p.104)

By controlling the whole operation, no matter how narrowly defined that market becomes, the number of transactions and the risks associated with these begin to diminish, making the proposition of innovative solutions more appealing. The important message, therefore, and the reason why this is only a conditional ‘yes’ in answer to the question posed, is that the solution to confronting the barriers that are preventing progress is not off-site manufacturing per se, but in defining vertically integrated solutions that work for specific markets where that innovation is un-resisted and uncontested.

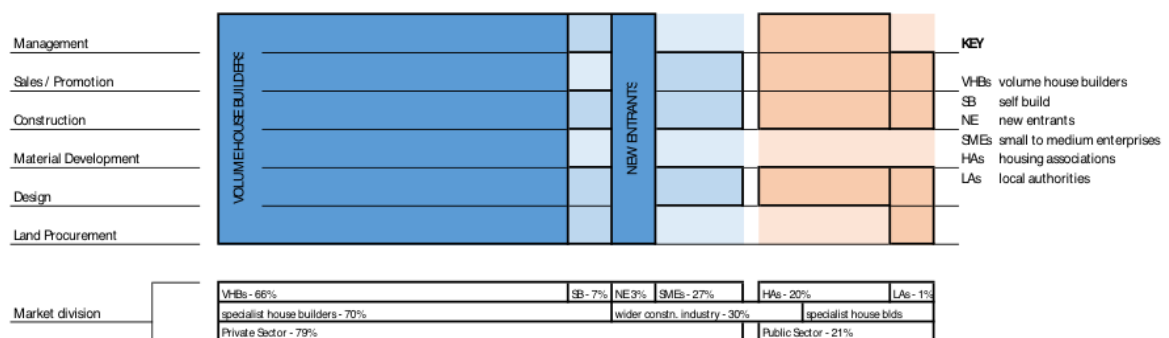


Figure 5: Market division by provider and level of control over the delivery system

It is also only a conditional yes because this model only removes the known risks – it cannot deal with the longer term unknown risks that lie in the future, although in the case of off-site manufacturing those risks are now well rehearsed: If this particular solution were allowed to grow to encompass more than the basic, modular, easy to access sites that the New Entrants’ build for rent model is currently pursuing, it would begin to run into the issues that off-site manufacturing frequently runs into, such as the limitations of a standardized solution, the limitations of tight sites, and of client inconsistency (Ross 2002, p.20).

“There’s a lot of hype around off-site construction but it’s spin - it’s not reality. The reality is the majority of housing construction takes place on relatively small sites where the adaptability of traditional masonry build is a key driver. Unless homes are being mainly built on big sites where the replication of large numbers of units and components is possible, nothing will beat the flexibility and efficiency of masonry.” Mike Leonard, CEO Building Alliance, (Gardiner 2016).

But these remain in-house decisions to be taken, whereas future events such as the onset of the next recession, are as uncontrollable as they are inevitable. And when the next downturn does come, off-site manufacturing’s relative efficiencies will begin to diminish alongside its diminishing throughput, and the investment costs will begin to bite. The risks that stem from the complexities of the housing industry can be dealt with, but the uncertainty of ‘future risk’ is still a fundamental barrier to innovation.

5. DEFINING A SPHERE OF INFLUENCE

In reality, creating a self contained bubble in which to operate is as unrealistic as attempting to correct the marketplace in which the rest of the housing industry has to survive, and the real challenge is knowing what can be brought ‘inside the bubble’ to be controlled and what must remain outside the bubble and be factored in as an accepted risk. That interface, if pushed to its extreme is arguably the interface between what is known to be true

now and what can only be expected to be true in the future. A knowledge of the current state of affairs can be researched and a level of risk associated to any strategy based upon that, but future risk is an altogether different proposition. Outside of the bubble is a whole world of financial, social and environmental unknowns that are all interrelated and influenced by political forces over which the housing industry only has occasional control. But this is not to destroy the original argument. The best route to progressing innovation is to limit that associated risk, which requires the industry to simplify its proposition until the remaining risk is tenable. The principle behind narrowly defining the market for an innovative solution is to arrive at a point where that market presents a negligible risk because the proposed innovation represents the best solution over any other. The only unknown risk left in this scenario is that of future events, and that then becomes the point of discussion. How well can future outcomes be predicted and either controlled, ie brought inside the bubble, or protected against? Environmentally, this is a familiar debate, with resilience planning being the solution to environmental unpredictability (McPhearson 2014). But the same principles need to be applied to our political environment. Any future strategy also needs a degree of political resilience if it is to survive beyond its inception (Meerow et al. 2016)

To return to the example of off-site manufacturing and what its ongoing success depends upon, the evidence provided within the Farmer Review would suggest its prospects today are looking more favourable than they have in the past (Farmer 2016, p.23,). But to project this forwards, the question has to be asked, how does this differ from any previous iteration, knowing how the industry struggles to survive economic cycles of boom and bust? Off-site manufacturing has, as discussed, now attempted to acquire a degree of autonomy so as to protect itself from the often incompatible requirements of the volume house builders, but it is still dependent on an economy delivering a constant need for housing that at the very least must take the business model beyond the point at which it recovers its investment costs. Controlling these events would mean either stabilising our boom and bust economy, or protecting against the impact of recessions, both of which require a dialogue with the government, since outcomes from future events, those outside the bubble, are by and large influenced, if not controlled by political intervention.

Irrespective of opinion regarding the role and size of government, the fundamental need is for governments to be predictable and deliver stability. Our boom and bust economy is indeed predictable, and the construction industry has over time developed its own dysfunctional coping mechanisms to deal with that, with land banking being one of those methods (Campaign to Protect Rural England, 2014, p8). If economic stability is not an option, however, the more realistic solution would be for governments to 'build a bridge' over the downturns by funding a social housing programme during these periods to maintain a level of throughput that prevents the industry from collapsing. But whilst this may be the desire of some governments, that is not always matched by an ability to deliver, leaving the off-site manufacturing industry exposed to government policies, economic downturns and a housing industry that is tied into both.

"There is a clear role here for government at the highest level in making stability an overriding objective of economic policy. But it is also sensible to make policy on the basis that, where there may be volatility, the government will try to build in stabilisers, to create greater certainty and sustainability of supply. For that reason, this review recommends that government should provide confidence that in future counter- cyclical demand side measures will be implemented when needed and focused on new build properties" (Lyons 2014, p.105).

Risk therefore, is always greater outside the bubble, and the more a solution can be defined within it, the more predictable the outcomes. In terms of the very real issues around investment and establishing a robust off-site manufacturing industry, the contained solution would be for off-site to diversify into anything other than housing during recessionary periods, which is historically how other off-site manufacturing businesses have survived. Or alternatively, look to provide the market demand as well as the product supply, so that it does not collapse along with the economy, which is what the build for rent model has effectively achieved.

L&G's 3,000-strong pipeline of rented housing, not subject to the cyclical nature of the private sale market, gives it the confidence to make a large investment in off-site construction where speculative housebuilders fear to venture (Gardiner 2016).

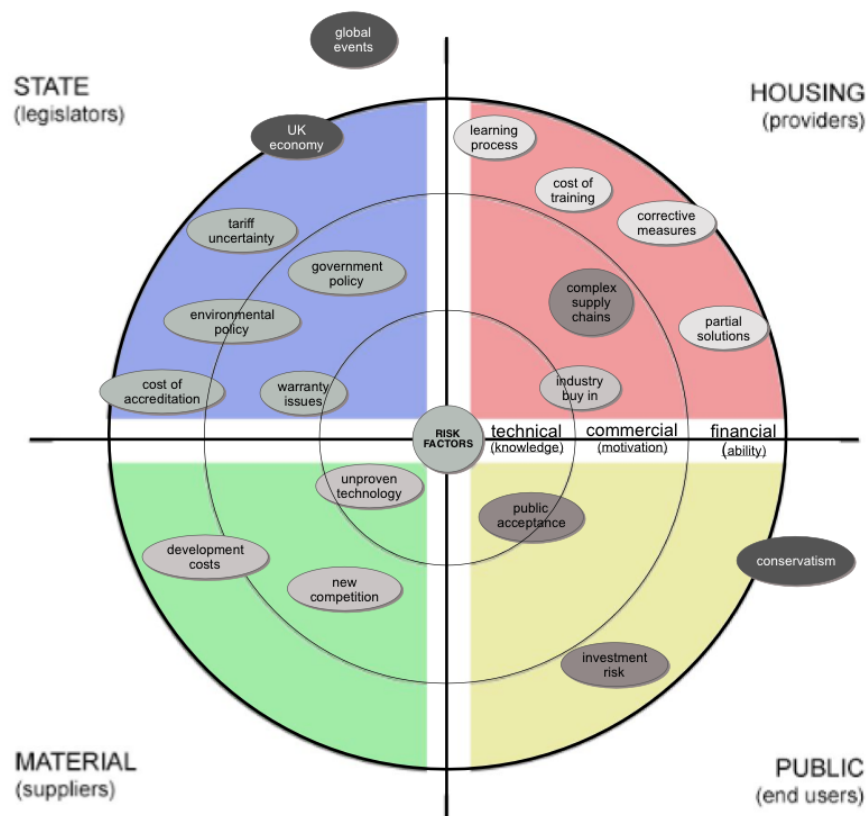


Figure 6: risk factors by sector inside and outside the sphere of influence

6. RISK REDUCTION

The question still remains however, of how the housing industry should go about simplifying the equation so as to reduce risks associated with innovation and thereby increase the likelihood of change taking place? Or in other words, how many of the variables in that equation can be removed by taking control of the factors involved in making the decision to change? Whilst the example of the New Entrants and their risk avoidance policy of taking complete control of their sector is very relevant, that option is not immediately open to all participants. The more realistic starting point is for those individual businesses that make up the housing industry to work together more co-operatively, so that they understand each others' motivations, and from that, are able to define those vertically integrated markets where there are mutual, financial benefits and the opportunities to develop collaborative ways of working that do not function on a level of adversarial in-fighting. In other words, increasing their spheres of influence by focusing on the barriers between the sectors within the industry whilst accepting what is outside of that as beyond their control (Figure 6).

The purpose of the work from which this paper has been taken was to first prove that these disconnects between the sectors within the housing industry were indeed there and in part the cause of the industry's resistance to change, but also to develop a model by which the industry could mitigate the risks associated with that change by defining markets that represented the strongest opportunities for them to pursue. This process began with a series of interviews across the whole 'housing delivery system' as defined in figure 1, to establish the levels of knowledge and understanding that existed between these sectors. This exposed a number of areas where there were clear differences of opinion about what was important with respect to their decision-making processes, but also areas where there was a growing dependency on perceptions about other sectors' behaviours in place of any clear information being available. None of these findings represented a healthy foundation for mutual co-operation, but the same interviews also unearthed a wealth of opportunities for these sectors to connect with their counterparts in ways that could be mutually beneficial and constructive for innovation.

Developing a visual representation of this model has become a central objective of this process to prevent the complexities of the industry structure, the motivations within it, the associated risks and the barriers they represent - all interacting and presenting themselves as nothing more than the manifestations of a complacent industry. The components of that model have evolved as shown throughout this paper. The housing industry itself has been defined by all those factors that impact upon it, divided into the four participating categories of Supplier, State, Provider and End User, each then further subdivided by the motivating factors that drive them, defined under Economy, Equity and Ecology (figure 1). The requirements for change to take place within this structure have been

defined as Knowledge, Motivation and Ability, all of which have to be complied with across all sectors to mitigate the risks associated with that change (figure 2). These risk factors in turn have been categorized as those relating to technical development, commercial implementation and financial commitment (figure 4). Individual businesses, operating within their own disconnected sectors have their own spheres of influence where they can control the level of risk associated with the adoption of change from their perspective (figure 6), but have little control over the industry as a whole. This represents our current housing delivery system with many small businesses that operate in silos within a very large and complex industry, with most of their risk factors existing outside their individual spheres of influence (Farmer 2016, p.33). What is needed is for these small businesses to work together collaboratively, creating larger spheres of influence, and to focus on smaller segments of the market that can be defined by their inclusion within these new larger bubbles of shared risk (Figure 7).

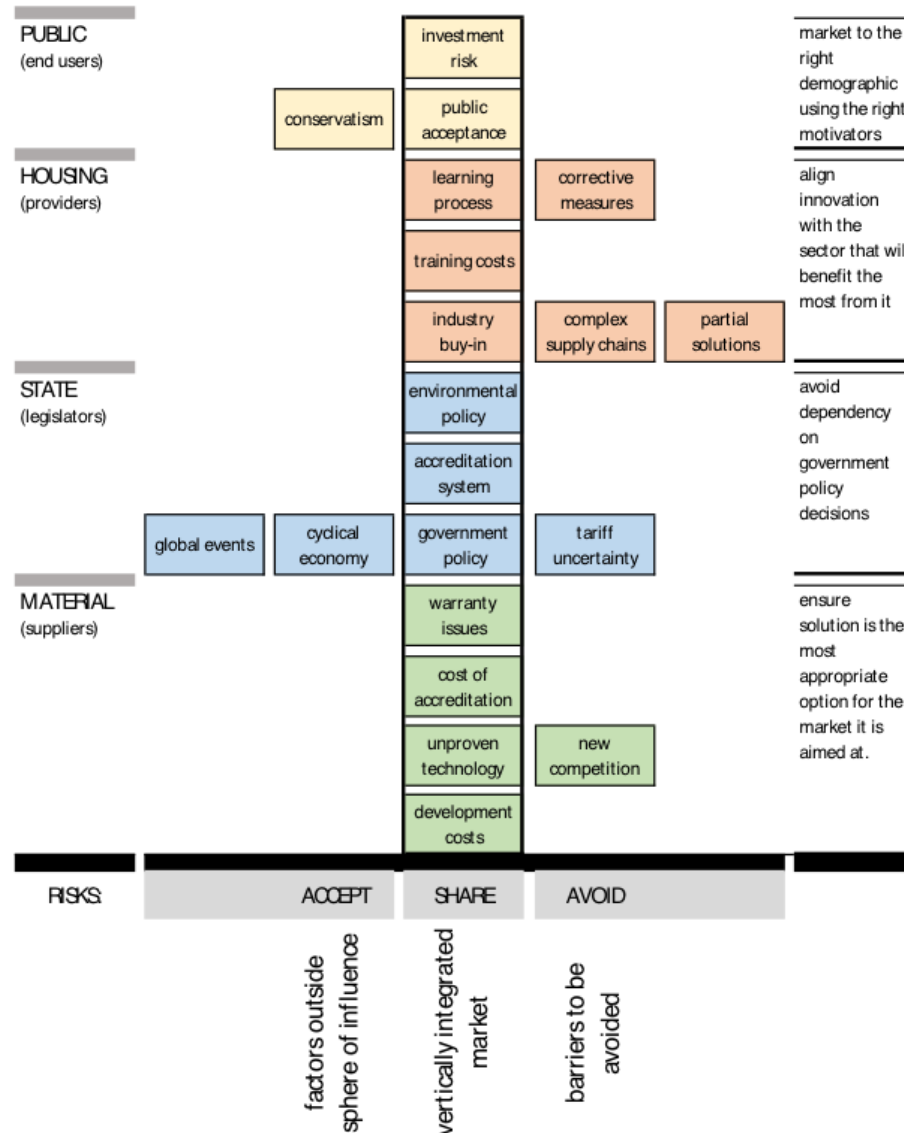


Figure 7: Vertically integrated market defined around acceptable risk

The three 'levels of attainment' required for the acceptance of innovation shown in figure 2 – knowledge, motivation and ability - in terms of risk, relate to technical risk, (how does it work or 'knowledge'), commercial risk (why do we need it or 'motivation') and financial risk, (how do we pay for it or 'ability'). All of these are key elements of the model but the chronology of events, their relative importance, the level and exposure to risk they represent - are all dependent on the role of the participant. For the innovator, the commercial risk of finding a secure market might be the greatest barrier, whereas for the developer it might be the technical risk of trialing an unproven technology. And for the end user, the financial risk of investing in that technology could be the main consideration. Whilst that might seem to represent a shared risk when looked at holistically, this is not how it appears to each individual at the time of making that decision, and individual risk for collective benefit is not a good recipe for driving change (Lazonick & Mazzucato 2013). A true sharing of risk, which is what the authors suggests is the only way in which innovation can gain consideration, let alone acceptance, comes from a close collaboration based on mutual benefit. And that requires a foundation based on a knowledge and understanding of each others' needs and motivating factors that this research has proven to be weak to non-existent.

The following three examples of the barriers to innovation are all related to the use of concrete in ways that are in competition with alternative technologies. We look at how and where the concrete industry has chosen to promote these solutions, the possible reasons why these strategies might not be successful, and the alternative approaches that could be considered based on the policy of risk sharing, risk acceptance and risk avoidance discussed above.

7. THE USE OF BEAM AND BLOCK FLOORING FOR FIRST FLOOR CONSTRUCTION WITHIN HOUSING TO INCREASE THERMAL MASS.

The offer: The volume house building market, representing about 50% of our current new housing provision, almost universally uses some form of timber joist at first floor level. The concrete industry has recognized the potential benefit to sales of convincing this market to change to using concrete beam and block flooring instead. The marketing of this solution has focused on the thermal mass benefits, and the consequent reduction in heating and cooling costs, plus the additional benefits relating to sound proofing and fire risk (The_Concrete_Centre 2009)

The outcome: The technology itself is not new, so on this occasion, it is the promotion to the market that represents the investment, but the market they are focused on is not interested for many reasons. The proposition represents a risk for them and a benefit for their customers. Their risk is entirely financial as the solution will increase costs, both in terms of materials and time, in terms of trunking for services and floors that will require a screed finish that takes time to cure. The financial reward, however is marginal, as the change represents an improvement that their customers do not prioritise over purchase price.

INT But is that viable? Doing the first floor in beam and block rather than timber joists?

PA03.03 Ground floor it is. First floor I don't think there is any need to unless you are doing apartments, so no not really.

INT So in a domestic house?

PA03.03 You don't need to. Because generally when you put a concrete floor in you've got to put a screed on in, and a screeded floor takes two or three days before you can walk on it.

It will also involve reskilling and unless the solution represents a 100% replacement of their existing method, it merely represents the addition of another process. The benefits are also seen as marginal by their clients who are not driven by running costs as much as they are by purchase price.

PA03.1 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. 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.

Because the government has now removed the zero carbon targets that concrete's thermal mass would have potentially helped developers meet, the VHBs themselves have no vested interest in these factors beyond that expressed by their customers, and whilst there remains a housing supply shortage, their customers cannot afford to be too selective. In conclusion, therefore, this particular market, whilst being potentially very lucrative due to its size, is unlikely to be persuaded to change its ways. The reasons for this lie outside the concrete industry's sphere of influence, and for that reason represent a high risk and in all likelihood, an immovable barrier to change.

The alternative: The alternative approaches would be to either grow its sphere of influence to incorporate these risks, or define an alternative market that lies within its sphere of influence and focus on that instead. The former would require the concrete industry to either become a developer of houses or provide land for developers with conditions attached as to how those houses should be constructed, both of which are worthy of consideration. The latter would require the concrete industry to define an alternative market where there is a closer fit between their needs and the sustainable message that the industry is promoting.

This market, which they are far more likely to influence, is one where the developers have more than an indirect interest that ends at the point of sale. It is also one where the benefits of concrete floors is backed up by a regulatory requirement to deliver a level of fire protection that cannot easily be provided by timber floors. Yet again, the market is that provided by the New Entrants, who are focused on high density apartment blocks which are being built for rental only with the business model being based on fifty year returns for pension fund investments. This market might not be as large, but it is well defined, under the direct control of one operation, and it is growing. And once established as a market, other more fragmented but equally appropriate markets such as student accommodation and retirement homes could be targeted in a similar manner.

8. THE USE OF OFF-SITE MANUFACTURED PANELISED CONCRETE CONSTRUCTION FOR SOCIAL HOUSING TO REDUCE BUILD COSTS.

The offer: The concrete industry is also very focused on the potential savings in construction costs to be realized from concrete panelized solutions, and has marketed the social housing market where these savings would be most beneficial, and in their mind override any negative aesthetic associations that might exist.

The outcome: The development of concrete panels has led to many off-site solutions throughout Europe, but in the UK their use in residential properties has been limited since the post war housing boom that saw their use in the guise of over fifty system build solutions that flourished for a time before traditional material and labour supplies

re-established themselves (Ross 2002, p.5). For some these memories are still strong and the negative connotations with poor quality council housing still exist. But much of what is now associated with concrete as a material was in fact due to social and structural experimentation, with concrete being the visual manifestation that remains as a perception that is often harder to counter than factual realities (Grindrod 2011). For that reason, solutions that incorporate visual concrete elements need to be treated with caution, so as not to re-establish a link between the material and social deprivation amongst a younger demographic who no longer have any direct link with that era.

The reasons given by Housing Associations and Local Authorities however for not wanting to consider concrete panelized solutions were far more prosaic. There were two main reasons, unknown to the concrete industry, as to why this solution was not currently seen as worthy of consideration: The first was that many of the sites now being developed for social housing are small brownfield sites that exist within existing communities. These sites are invariably difficult to access and also require housing types that can be modified to comply with planning requirements on a site by site basis (Gardiner 2016). No solution that provides standardized components that cannot be easily adapted, and that arrive on vehicles that cannot always gain access will be considered, as it will only provide a partial solution.

PA03.8 "But the thing that really that made us cross it off the list was the volume they required for it to be efficient in terms of what they were building and everything comes on an articulated lorry, so I can't get it in to the majority of my sites. They're just not accessible for concrete. We have to get a fire engine on all our sites so they should be looking at that as a measure."

Partial solutions mean duplication of designs, skills and organization which can easily offset any benefits gained. The second reason for this being seen as inappropriate is the remit of Housing Associations to increasingly look to provide labour from within the communities they are providing for. Any solution that reduces their ability to do this, due to the components being delivered from elsewhere is seen as a negative.

PA03.8 "I said to 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, that I wanted our joiners to put that up, and they said no."

These findings show how important it is to have communication channels that are operating on the same wavelengths. For the concrete industry, social housing appears to provide a good fit with the solutions they are offering, with resilience, durability, and low maintenance all high on their agendas, but within the hierarchy of importance, it only takes one critical factor to render all other benefits irrelevant. The essential requirement therefore is to ensure that the solution being offered works for all eventualities, not just a proportion, and that the key motivating factor on which all else hinges is understood.

The alternative: With this knowledge, therefore, what is the market that would be best placed to benefit from this solution, where the barriers to acceptance and the risk of failure would be least? To use the principle visualized in figure 7, if perceptions are so difficult to counter, they should be treated as unresolvable risks and avoided. There are many younger demographics however where concrete is seen as aspirational, or alternatively there are many ways in which concrete panels can be used without there being a visual battle to be fought.

PA04.02 there is a market for it (visual concrete) but there's no point trying to shoehorn concrete into mass-market housing.

PA03.03 The concrete in the foundations is fine - there is no misconception with the average punter there and if we're talking about concrete blocks all those sort of things again there is no negativity around concrete blocks, around masonry, no negativity whatsoever. The only negatively I hear of is when you talk about prefabrication in the industry generally, and naturally we try to avoid the term prefabrication because they put two and two together and think we're talking about the prewar houses.

Even within the volume house building market, where the end users are recognized as being at their most conservative, the use of concrete panels stamped to look like brickwork is being considered. Whilst this might not be seen as acceptable to many purists, such as myself, it does nonetheless represent a 'route in' for an innovative change which once made, would allow for panelised construction to take many other forms. The key to knowing which markets are the ones to target however is in understanding what motivates the market to consider the change in the first place. In this instance it is not driven by speed of construction, or by aesthetics or availability of materials, but by the impending shortage of skilled labour that has now been singled out as the main threat to the housing industry (Farmer 2016, p.32). The avenues once available to us as a country for correcting this situation are rapidly disappearing, with an aging workforce, a disinterest in on site labouring as a career, partly due to the working conditions and partly due to the cyclical nature of the workload, and now Brexit, meaning that a move to off-site panelised construction is looking increasingly necessary, even if not as yet widely desired (Gardiner 2016).

The aim therefore is to define the market where panelised construction is most appropriate constructionally, most acceptable socially, without recreating the links with poor quality social housing, and most necessary financially. High quality urban communal living where privately owned accommodation is mixed with shared facilities and social spaces and aimed at a young demographic with no negative preconceptions of concrete as a material would be a likely starting point. This represents a well defined, base where a packaged solution could be marketed and a

solution developed that becomes a vertically integrated business built on aligned principles and the potential for shared risk.

9. THE USE OF CONCRETE FRAME FOR HIGH RISE RESIDENTIAL TO REDUCE FLOOR HEIGHTS.

The offer: Concrete frame has long been seen as providing the most affordable solution when building residential towers as opposed to commercial or office blocks where the wider spans needed mean that steel frame becomes a better option (Irwin 2010). The calculations involved are complex and decisions can pivot on the incremental benefits that accrue from achieving thinner floor slabs, and the consequential savings that can be made in stairwells, cladding materials, and occasionally the number of floors achievable within the planning restrictions imposed.

The outcome: There are however, many other seemingly incidental considerations that can dictate the decision, sometimes at a surprisingly late stage of a building's development, resulting in alternatives being sought. Being aware of all these possible decision-making factors at the outset can help in formulating a strategy that will ensure that the preferred decision is taken, and once taken is adhered to.

The alternative: At a very basic level, the fluctuating price of steel is a variable over which even the UK has very little control, with global demand and oil prices dictating both price and availability (Matsumoto 2015). With that factor very much outside the sphere of influence, it has to be recognized as a risk to be factored in and where possible protected against. One way of ensuring that a sudden collapse in the global price of steel does not result in a concrete frame being replaced with a steel frame is to build the use of concrete into the design at either an aesthetic or an environmental level.

PA02.05 If you can get the buy-in from the architect early on and they know that they want that (the structure) to be concrete for various other reasons - performance for acoustics and for flooding and for thermal mass - and it's embedded in their M&E strategy for keeping the building warm, then it's much harder to take it out.

Any solution serving more than one purpose is more protected, especially if that purpose becomes central to meeting regulatory targets. But the size of the market where concrete could historically be said to have a clear advantage has recently been reduced by the arrival of CLT (Cross Laminated Timber) as an alternative structural solution. Currently the maximum height that can be achieved with CLT is eight stories, but already twelve has been achieved by using it in conjunction with steel (Wenlock Cross, Hackney, London). If the aim is to define a market as that where the proposed solution is the most viable of all the options available, the 'sweet spot' for concrete in residential blocks is now over twelve stories. Interestingly, at the other end of the spectrum, low rise also becomes harder to justify financially as the need to construct concrete panels with enough strength to withstand handling and transportation means that there is more redundancy in the strength than is necessary for anything under four stories.

PA02.1 Often it's just to do with transport strength and the strength of the unit to be able to crane it in and move it about. One of the drawbacks of ICF (insulated concrete formwork), is that it can only be a certain thickness, which means it can go 5, 6 stories, so why do it for a two-story home? It's just over-engineered.

For a market to be stable and free from the variable benefits of other technologies, it is therefore necessary to continue ruling out those scenarios where there are other options that could compete until eventually arriving at an optimum market for that solution. In this case, geographical location would also be a factor to consider, with proximity to supplies, access to site, availability of skilled labour all being valid factors to consider. Returning to the original emphasis put on thermal mass as one of concrete's main credentials, if this were to be employed in a high rise residential construction in conjunction with natural ventilation as a building methodology, air quality would also need to be considered. In some cities it is no longer safe to rely upon an unfiltered air intake, which shows how even what might seem to be an incidental consideration of air quality could become the one defining argument that dictates the decision to use steel frame, mechanical ventilation and a lightweight cladding system.

10. CONCLUSIONS

These are just three examples taken from a series of interviews relating to the sustainable use of concrete in housing as an example of the barriers faced by new innovative solutions, and how these barriers could be avoided by gaining a better understanding of the housing delivery system and the needs and motivations of those within it. Whilst there are multiple examples such as these within the interviews undertaken, the main purpose of this study is not to highlight these specific cases, but to develop the approach described above as a process to be followed. By drawing attention to the unrealised breadth of the issues that can play a pivotal role in the decision whether or not to adopt innovative sustainable solutions, it is hoped that the case for innovation can in future be made more productively. This paper focuses on one aspect of this – the role of risk as a barrier to change, and how that risk can be made more manageable by sharing it amongst a market defined by its mutual benefits and shared goals. This requires better communication, and a better understanding of what it is that motivates each sector to react the way it does when confronted with change. The housing industry is not complacent, so much as ossified by its own complexity and the uncertainties it faces, which makes it increasingly difficult for any one business to jump for the fear of jumping alone.

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