Overcoming barriers to the adoption of novel materials in the UK construction industry

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Abstract

In the face of lowest cost tendering the UK construction industry has become locked into a path-dependent improvement trajectory of cost and risk optimization. Achieving sustainable development requires the decoupling of economic growth from the use of non-renewable resources and creates an emergent improvement trajectory of resource efficiency. Many barriers to the adoption of new materials and techniques in construction, including closed-loop and secondary materials, have been identified. This paper places these barriers in the context of a model of human behaviour which provides a framework for understanding the underlying causes of the barriers to adoption. An empirical study explores contexts in which barriers to adoption are overcome, finding that some designers are motivated to adopt new resource efficient approaches for any number of reasons. However, the opportunities to include the materials in projects are limited by resistance arising from perceived increases in costs and risks. Successful adoptions arose where the use of the new material satisfied a constraint which other construction techniques were unable to meet and clients were convinced of the materials appropriateness and cost effectiveness.

Keywords: Construction; innovation; barriers; behaviour; interdisciplinary;

1 Introduction

Achieving sustainable development requires the decoupling of economic growth from the use of non-renewable resources (Crane et al. 2011) through increased resource efficiency. This will require the adoption of new construction materials and techniques such as closed-loop and secondary materials.

The proposed use of by-product-based and innovative products in construction in pursuit of resource efficiency often meets with resistance, even for materials where there is no danger of pollution.

Previous literature has identified many barriers to the use of such unconventional approaches and materials by a traditionally conservative industry. Giesekam et al. (2014) present a meta study which analyses these barriers under four headings: Economic; Institutional and Habitual; Technical & Performance related; Knowledge & perceptions.

These headings aid understanding of the nature of the barriers identified and begin to suggest areas of focus which might help to reduce barriers to adoption. However, there is evidence to suggest that interventions 'are more likely to be effective if they target causal determinants of behaviour' (Moodie et al. 2011). If the barriers to the adoption of unconventional materials and approaches are to be overcome, the causes of the resisting behaviour of industry participants must be explored.

2 Conservatism in The UK construction industry

The UK is a market economy with an efficient stock exchange and widely dispersed ownership of listed companies. This efficiency means that listed companies which under-perform compared to *market expectations* may be at risk of divestment by shareholder groups (Hirschman 1970; Miozzo and Dewick 2004). Such divestment can lead to a falling share price, increasing the risk of takeover and making raising finance in the capital markets more problematic (Demirag 1995).

Market expectations are defined as a rate of return (profitability) on an asset with a given risk profile. The required trade-off between risk and return for a given asset is described by the Capital Asset Pricing Model (CAPM) (described by Perold 2004). Broadly, the higher the risk, the higher the expected return. There are, therefore, two primary ways of meeting market expectations if a company is to increase its market value: to lower risk, or increase profits on a given asset base. Reducing the asset base is a third possible approach. This was the approach taken in the 1980's during a shift to management contracting, leading to a further fragmentation of the construction industry (Gann 2000).

Delivering reduced risk and increased profits (increased income, reduced costs) can, therefore, be considered to be the historic improvement trajectories for companies listed on the stock exchange.

Traditionally, contractors have bid for work on the basis of a lowest cost tender. This common value auction-based approach (Dyer and Kagel 1996) seeks to lower costs for construction clients, but also creates downward pressure on income for contractors, limiting their scope to meet market expectations of profits by increasing income on projects.

This pressure, together with shareholder pressure to deliver a consistent pattern of dividends (Servaes et al. 2006), means that listed construction companies focus on reducing the cost and risk of their operations to meet market expectations. This pressure to minimize cost and risk is passed along the contractor's supply chain and indirectly to other competing contractors through the auction of construction work.

In the search for savings, organizations look to improve the cost efficiency of the way they work, often using familiar materials and processes – so called incremental improvements (Slaughter 1998). The adoption of incremental improvements is an effective way of reducing the cost base as it requires little extra investment of time, building on what has gone before.

Such path-dependent development of technologies can lead to the emergence of dominant technologies which have had the benefit of scale economies, learning & network effects and the adaption of actor expectations (Foxon 2007). These effects direct market actors towards the use of the dominant solution(s) in order to deliver on the improvement trajectories of the market: risk & cost.

Thus industries can become 'locked-in' to a given set of technologies (Unruh 2000) based on the optimization of knowledge, processes and systems around those technologies to deliver on expected rates of return (Christensen 1997). Ultimately, companies' '..core [process] competencies become … core rigidities' (Unruh (2000) after Leonard-Barton (1995)).

By their nature, novel and unconventional approaches have not had the benefit of these path-dependent improvements in risk and cost reduction and as a result are likely to be more expensive, or be perceived to be more risky.

A growing need for resource efficiency has introduced a new trajectory for improvement which threatens profit margins based on the use of cost and risk efficient technologies, and hence threatens market value.

As such, in the absence of regulation or client direction, a contractor seeking to minimize cost and risk would lack the *motivation* to adopt such an approach as it may jeopardize the delivery of acceptable rates of return or the winning of projects in a lowest cost auction.

3 Preconditions to behaviour change

Motivation is one of the key drivers of behaviour described by Michie et al (2011) in their COM-B model of behaviour. This model describes that, for a particular behaviour to be demonstrated, an agent needs to have the capability, opportunity and motivation (COM) to display the behaviour (B).

Capability is described as having the physical and psychological capacity to perform a particular behaviour; opportunity reflects the physical opportunity and the social acceptability of the behaviour. Finally, motivation considers both the conscious and sub-conscious processes which go towards directing behaviour. If any of these pre-conditions are not met for a particular behaviour, then the desired behaviour is unlikely to be displayed.

Whilst created in the field of healthcare, the COM-B model was developed from an analysis of existing behavioral change models addressing behaviours in fields such as environmental conservation, technology & finance related behaviour (Davis et al. 2014). The model has been shown to be useful in areas outside of health interventions, including improving recycling rates (in progress).

The COM-B model provides a framework within which we can understand why construction industry participants demonstrate resistance to the adoption of novel approaches to construction. It helps diagnose why a target behaviour is not being displayed by exploring whether the decision maker has the capability, opportunity and motivation to display the target behaviour.

4 Empirical study

We have seen how contractors lack the motivation to adopt unconventional approaches as a result of their profitability profile being based on mature cost- and risk-efficient technologies. However, the recent growth in the use of cross-laminated timber (CLT) suggests that there are contexts under which new materials and processes will be adopted irrespective of novelty.

A case study was undertaken, using an industry survey *(n=49)* and series of semi-structured interviews *(n= 8)*, to identify the contexts and drivers for organizations' first adoptions of CLT. The interviews were coded to reflect according to their impacts on capability, opportunity and motivation and sub-categorized to reflect the cause of the source of the impact.

5 Results

The survey respondents were primarily architects (*n=34, 69.5%*). The majority of other respondents were either structural engineers (*n=7, 14.5%*) or contractors (*n=6, 12%*). Of the survey respondents, 55% (27) had used CLT on a project. This reflects the fact that previous users of CLT were an explicit target for distribution of the survey. Of those who had not used CLT (22), approximately a third (7) had considered using it before, but had been unable to get the material adopted. The resistance on the grounds of cost was reported as high in 5 of these. Those who hadn't considered using CLT reported cost based factors as the primary reason for not considering the material.

5.1 *Capability*

The majority of respondents agreed strongly or somewhat strongly that their organizations were technically excellent (85.2%). However, a later question on barriers to adoption of unconventional products in general highlighted that the most significant barrier to adoption is 'uncertainty over technical performance' (reported by 53% of respondents), while the least significant is a 'lack of training courses' (75% of respondents). This echoes the findings in Watson & Walker (2012).

Interviewees presented very few responses suggesting a lack of capability. Whilst some indicated that learning needed to happen for the adoption of new materials, it was not presented as a reason for non-adoption. Indeed, one interview reported high confidence in being able to use any material they were asked to, irrespective of previous experience.

There is a significant need for organizations in the industry to be technically competent, given the scale of the projects at stake and often adversarial nature of dispute resolution. Technically inadequate organizations would be unlikely to survive for long.

5.2 *Opportunities presented by project contexts*

The largest number of first adoptions reported were on schools and arts and culture buildings. No commercial buildings had been reported as using the material. The project values are concentrated in the region of £0-5m (65%). Given that the average cost of a school at that time was in the region of £25m (Gove 2014), the values of the projects on which CLT was adopted can be considered to be relatively small.

All proposals for the use of CLT were made before the contract was let for tender and the majority were proposed by designers (82.3%). It is notable that the *successful* adoptions were proposed at the very early stages of projects. Accordingly, contractor involvement in first adoption decisions was limited. Interviewees were clear that for CLT to survive value engineering, its use must be included in the project from a very early stage and be seen as integral to the successful delivery of the project by the client. Once the client had agreed to the use of CLT, the contractors were motivated to use the material to win the work. Some interviewees reported that even then, attempts were made to remove the material from the project to reduce perceived costs and uncertainty.

The majority of projects for which CLT was first adopted were for client occupation or known end users (61.7%). This suggests that clients who will be occupying buildings might be open to innovation in those buildings, or have different value drivers than speculative developers.

Most projects which adopted CLT for the first time were for non-commercial clients (78%). Interviews suggested that '[o]rganizations which don't build regularly have different risk attitudes to those that build frequently. Because they are already doing something that they perceive as risky…everything is new to them.'

Where CLT was used in projects, its adoption was reported in the survey as being mostly due to client concerns for the environment (29.4%). However, a significant number of respondents indicated that there was no particular client driver for adoption (22%). Further, whilst it is recognized that materials are adopted for more than one factor, the sustainability benefits of CLT were described in interview as generally ancillary to the project requirements. Interviewees described the opportunity to use CLT as being presented by: site constraints [$n=1$]; project delivery requirements [$n=3$]; client business activities [$n=1$]; the desire to *display* sustainability credentials [$n=2$]; and marketing [$n=1$].

5.3 *Motivations ~ Values*

In response to a question of descriptions of the respondent organizations ($n=28$), it is unsurprising, given the predominance of architects responding to the survey, that the highest number of respondents strongly agreed to being design-led (46%). The top four descriptions ranking highest when replying 'strongly agree' or 'agree somewhat' were: innovative (85.7%); socially engaged (85.2%); technically excellent (85.2%); and sustainable (82.1%). This suggests that majority of respondents felt that drivers other than profits (profit focused - 25%) were motivating factors in their work.

5.4 *De-motivators ~ barriers to adoption*

Over half of respondents (55%) had experienced resistance to the use of CLT from a quantity surveyor (QS) and reported that most of this resistance related to risks to costs. Unfortunately, the survey did not explore whether the QS was on the client or contractor side. Overall, concerns over risks to costs and unfamiliarity with the product were the two key barriers experienced by all respondents.

Interviewees almost unanimously identified the perceptions of increased risks to cost certainty as being a significant barrier to the adoption of CLT. When cost related barriers were presented in response to the proposal for CLT, these were generally concerned with the elemental up-front material cost, with no holistic view being taken on lifetime costs or benefits accruing elsewhere. CLT was generally described as cost neutral (or better) by interviewees over the construction phase with the increased capital cost being offset by savings in time on site. Once clients were convinced of the need for a different approach, this cost neutrality was very important in convincing clients that the material was an appropriate one to use to address project constraints.

6 Discussion

The COM-B model provides a framework for linking the drivers or inhibitors of behaviour to the capability, opportunity or motivation to undertake an action.

Industry technical capability was reported to be high. While the lack of understanding of innovative materials was found to be a significant barrier to adoption, the lack of training courses was suggested to be the least significant barrier. This suggests that capability may not be a limiting constraint on the use of CLT in construction, but rather that the opportunity to explore the material capabilities and properties may not be available day to day.

The surveys and interviews highlighted that many designers were motivated to propose the use of CLT for a number of values based reasons, but often found that perceived cost constraints denied them the opportunity to include CLT in projects.

The literature review describes how contractors lacked the motivation to adopt unconventional materials and approaches delivering resource efficiency as a result of organizational capacity being optimized to align with the improvement trajectories of risk and cost. Their position as builders with significant post contract bargaining power (Chang and Ive 2007) provides them with the opportunity to specify them should they so wish.

The study found that project constraints or contexts created niche-like environments (Geels 2002) that provided designers - who were motivated to use an unconventional approach by their values - with the opportunity to propose the use of CLT. These project contexts were created by client values and experience, site constraints, or planning and regulatory requirements. In many cases of successful adoption, the client had not generally specified resource efficiency or sustainability as a project priority and other relative advantages of the material (Rogers 2003) came into play to address particular project constraints.

New approaches were most likely to be adopted when introduced early in the design process and when considered integral to the satisfaction of the project constraints, importantly, at no extra cost, usually by a non-commercially focused client. This reduced the opportunity for contractors to change materials post-tender.

The contexts creating opportunities for successful adoption reflect theory on innovation diffusion summarized in Akintoye, Goulding, & Zawdie (2012) and Manseau & Shields (2005) which both give good overviews of innovation theory in relation to the construction industry.

7 Conclusions

- Path dependent development of a competitive UK construction industry has led to cost and risk minimization in contractor organisations and an associated technological lock-in.
- Resource efficiency requires the adoption of unconventional approaches to construction and represents a conflicting improvement trajectory.
- The causes of barriers to the adoption of new materials and techniques arising from this conflict can be described using the COM-B model of behaviour.
- Understanding the behavioural drivers allows for more coherent interventions to be developed using existing behaviour change tools and techniques.
- Some designers are motivated to adopt new approaches as a result of their value system. Their opportunities to include the materials in projects are limited by the resistance arising from perceived increases in costs and risks.

- Project constraints or contexts, formed by client values and experience, site constraints, or planning and regulatory requirements, create niche-like environments which might not be satisfied by dominant technologies, requiring an alternative approach to construction.
- Understanding and exploiting these niche conditions is key to successful deployment of unconventional approaches.

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