The power of the institution: Overcoming barriers to the diffusion of low carbon innovation in the construction industry

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Abstract

The construction industry is responsible for approximately 50 per cent of greenhouse gas emissions globally (Ramesh et al., 2010). Prior strategies to limit emissions in the industry have been primarily technological. Despite an abundance of life cycle analysis technology (LCA) none have achieved widespread uptake suggesting that adoption barriers may be due to behavioural characteristics rather technological shortcomings. This paper explores the impact that institutional pressures have on the behavioural expectations in the construction industry regarding low carbon innovation.

Keywords: Construction, emissions, pressures

Introduction

With increasing anthropogenic emissions linked to the rise in global temperatures and climate change, many of the most highly emitting industries have been encouraged to look for ways to measure their emissions outputs in line with potential future legislation (Wang et al., 2010; Ortiz et al., 2009). The construction industry is responsible for approximately 50 per cent of global greenhouse gas emissions (Ramesh et al., 2010), second only to the energy generation sector in emissions outputs. The response to the perceived pressure has been an industry movement towards the use of technological measurement systems. Recently, an abundance of life cycle analysis (LCA) technology has become available, however, thus far none have achieved widespread uptake in the construction industry (Strategic Forum for Construction, 2010). The technological understanding of emissions measurement is evident and seemingly useful when applied correctly, yet the industry has failed to implement it.

The lack of uptake has led to a perception that the problem faced may not be entrenched in the technology, but may be due to the behavioural characteristics of the construction industry. In this paper behavioural characteristics are defined by business practices, as part of the supply chain and the institution. Familiar business actions often become ingrained throughout industry supply chains due to both formal and informal institutional pressures. These pressures can inhibit the development of innovative strategy by maintaining uniform behaviour. The possibility that poor emissions practices in construction may be due to institutionalised business behaviours and supply chain networks which contribute to poor low carbon innovation diffusion rates is explored in this research. The study develops a novel approach in the form of a model for understanding how institutional pressures affect the diffusion of low carbon innovation in linear construction supply chains. The qualitative methodology, findings and subsequent discussion will develop our understanding of how DiMaggio and Powell's (1983) institutional theory and Roger's (1971) diffusion theory can be combined to examine how the power of the institution affects the development and diffusion of low carbon practices in construction. The combination of these two theories applied to the construction supply chain provides explanation of how coercive, normative and mimetic isomorphic pressures act on supply chain actors and encourage homogeneity, bypassing innovation in institutionalised supply chain networks. These findings will be of interest to scholars and practitioners interested in how institutional pressures inflicted on the supply chain affect sustainable supply chain management.

In order to understand these phenomena, the following research question was posed.

> *How can the establishment of the institutional pressures exerted within the construction supply chain aid the diffusion of low carbon construction innovation?*

The literature

The predominant focus on technology in construction LCA literature has meant that very little attention has been directed at the wider picture of supply chain behaviour (Abanda et al., 2003; Koh et al., 2013). With the threat of increasing global temperatures and rising sea levels, it is becoming increasingly important to monitor and measure emissions in order to understand the anthropogenic impact of CO_2 on the natural world (Parmesan and Yohe, 2003). Measurement systems for CO_2 emissions outputs enable decision makers to gain an understanding of which products and/or processes have the greatest impact on the environment. Perhaps the most significant problem for assessing emissions in the construction industry is that despite the vast array of technology available for calculation, emissions are continuing to rise and life cycle technologies are not widely used (Giesekam, et al., 2014).

Thus far the construction industry has failed to implement CO_2 measurement systems as standard practice on construction projects. The main barriers to changing traditional ways of working in construction supply chain management have been coined as a lack of management commitment, poor understanding, inappropriate structures and lack of commitment from construction partners (Akintoye et al., 2000). These key principle factors can be related to the culture of the industry and its resistance to change, which is often embedded through institutionalised values enforced on each supply chain individual either directly or indirectly.

It is thought that the culture of an industry, often fuelled by institutional pressures can significantly help or hinder its development by acting as a powerful force that has the ability to influence behaviour, activities and procedures (Muratović, 2013). People, guided by the institution, inform the ways that developments are perceived and influence the way others within a supply chain see projects or the implementation of novel approaches (von Medling et

al., 2013). These cultures, practices and social norms are controlled and enforced by institutional pressure (DiMaggio and Powell, 1983). To understand the impact that ingrained actions forced through institutional pressures have on the diffusion of low carbon innovation, both DiMaggio and Powell's (1983) institutional theory and Rogers' (1971) diffusion theory will be used and combined as a theoretical lens.

DiMaggio and Powell's (1983) institutional theory

Beliefs and processes contribute to the values of an organisation (Oliver, 1992). Institutional environments enforce pressures on organisations to validate strategy (Tseng and Chou, 2011). Institutional pressures are thought to force an organisation to conform to guidelines, conventions, expectations and social norms (Dacin, 1997). These pressures can occur due to internal and external factors such as governments, society, legislation, professional influence and uncertainty (DiMaggio and Powell, 1983). Institutional theory can highlight the criticality of the institutional environment in motivating organisations to make changes in the pursuit of social legitimacy (Scott, 2013).

DiMaggio and Powell (1983) established three types of isomorphism; coercive, normative and mimetic. These pressures provide conceptions of how behaviour is adopted and how it is sustained based on coercion, mimesis and the transmission of norms (Mizruchi and Fein, 1999). Isomorphism addresses the notion of organisational homogeneity meaning that in order for businesses to remain the same, some must change (Prue and Devine, 2012).The prospect of change in order to remain legitimate is particularly useful in the explanation and understanding of the changes required for introducing sustainable practices into the construction industry. Changes brought about by isomorphism can have a positive impact on organisational change and culture, particularly in the case of construction which is accepted as an institutionalised industry (Kondra and Hurst, 2009, Forster et al., 2015). Additionally isomorphism advocates that in order to be successful, organisations must consider others to align themselves as a critical market player, emphasising a required focus on the supply chain (Aldrich, 2008). Companies do not only compete for customers and economic wealth, but political and social power and legitimacy in order to remain at the top of their industry (DiMaggio and Powell, 1983). Types of isomorphic pressure are summarised in Table 1.

Table 1 - Types of isomorphic pressure

Isomorphic pressure	Description	Reference
Coercive	Coercive isomorphism derives from power and influence. In addition to this is can also arise from formal and informal pressures exerted by organisations on other companies upon which they are dependent. It also occurs sometimes due to cultural pressures within an industry.	(DiMaggio and Powell, 1983) (Prue and Devine, 2012)
Mimetic	Mimetic isomorphism works on the basis of companies imitating each other. This occurs generally during times of uncertainty.	(DeMaggio and Powell, 1983) (Moehler, et al., 2008)
Normative	Normative isomorphism occurs when the informal social rules of an industry have influence over decisions.	(Winch, 2000)

Diffusion theory

Much of the literature surrounding diffusion theory has been based on Rogers (1971). Rogers argues that diffusion is not solely driven by invention or the innovation itself but also the flow of collaborative processes. There is strong avocation of influential relationships and the way in which they impact on the diffusion of innovation, more so than in other studies such as Brown (1981). Its application to the construction supply chain is highly relevant for the following reasons; firstly it focuses on collaborative pathways of influence which are seemingly lacking in the fragmented construction supply chain (Korneleus and Wamelink,

1998; Cheng, et al. 2001). Secondly its assumption of a linear decision making process replicates the top down approach to decision making within construction. It is highly applicable to the construction supply chain as decisions are often made in a linear format due to the hierarchical structure (Rosinski et al., 2014). Finally the consumer driven approach of Roger's diffusion theory is also highly applicable to this research. As the client appears to be the most important actor in the chain they assume the role of the consumer and so therefore it could be argued that construction is a consumer driven industry. Additionally it enables an understanding of how innovation could move throughout an industry with the use of adopter categories. The founding concepts alongside the adopter categories put forward in Rogers' theory can be found below in Table 2.

Table 2 - Rogers' (1971) diffusion theory foundations and adopter categories

Description	Theory foundations	Adaptor categories	References
Diffusion Theory Diffusion theory can be used to explain how new innovations or work process can move throughout an industry. The key themes which underpin the concept of diffusion centre on collaboration, communication and personal influences. All three are essential for the diffusion of technology or new work processes to occur.	The innovation concept ↓ Diffusion process Personal influence ↓ The adoption process ↓ The roles of innovators and adopter categories ↓ The social system in which the diffusion fits	**Innovators** *(High risk takers, diverse social relationships, significant financial backing)* **Early Adopters** *(Highly integrated into social systems. Most likely to be consulted by potential innovation adopters)* **Early Majority** *(Reliance on informal information, take longer to adopt innovations)* **Late majority** *(Sceptical and cautious acceptance of peers is vital to their adoption)* **Laggards** *(Slow to adopt, aversion to change low finance, traditional)*	(Rogers, 1971) (Gouwes and Reed van Oudtshoorn, 2011)

Combining theories

In this research Rogers (1971) diffusion theory will be used in conjunction with DiMaggio and Powell's (1983) institutional theory. Whilst institutional theory can provide explanation of the barriers faced to innovation implementation, diffusion theory can explain how these barriers may be overcome in order to achieve successful diffusion by understanding how adopter categories directly relate to the supply chain. Many scholars have found that the use of institutional theory and isomorphic pressure can be effective at explaining homogeneity throughout an industry. The construction industry is generally consistent in nature, following accepted paths which are fixed through institutional pressures. It does not however explain how those who wish to use innovative methods break away from norms, overcoming institutional barriers to implement new processes. The use of diffusion theory can aid the explanation of lead innovators, explaining how and why those who diverge from the set path can create legitimacy through long term success, overcoming sustainability barriers (Rogers, 1971). In essence by using these two theories an understanding of how a new process could be integrated into an industry and how it could ultimately become common practice as part of the institutionalised norm can be understood.

Methodology

Acknowledgment of a saturation of technology based studies has provided the foundation for this research. Bypassing technological and statistical emissions research for behavioural centred study has lent itself to a qualitative methodology. One of the most extensively used data collection methods in social science is the practice of interviews (Qu and Dumay 2011). It is thought that approximately ninety percent of all social research uses interviews in some form to enabledata collection (Silverman, 2011). The use of interviews in this research was considered appropriate as specific supply chain participants required targeting, i.e. clients, subcontractor and architects and considerable weight was placed on the importance of providing meaning to the results of this research rather than presenting numerical generalisations.

Research design

The themes and questions posed in the interviews procedure were based on the literature review findings. Themes were initially developed on thematic trends taken from the literature review and further codes were developed to inform inclusion and exclusion criteria for the interviews. An example of the way in which themes were extracted can be found in Table 3.

Table 3 - Thematic concept summary example

Theme	Thematic concepts	Key references
BIM	Technology, collaboration, visual information, communication processes , information exchange, design, building model, multidisciplinary, software, government recommendations	(Hardin, 2011) (Azhar, et al., 2009)

Participants were chosen using simple yet effective inclusion criteria. Interviewees were chosen based on their knowledge of the area of construction sustainability and their position in the supply chain. They were found via personal and business contacts and internet appeals. The supply chain was broken down into six sections to target participants:

1) Raw Materials 2) Component manufacture 3) Design team 4) Sub-contractors 5) Management team 6) Client

A selection of participants from each key supply chain section were interviewed in order to elicit views on construction emissions throughout the supply chain. Interviews were conducted with as many participants from each section as possible using a purposive sampling method. The interviews were conducted primarily face to face taking place at a neutral location, and were recorded and transcribed verbatim to facilitate the analysis.

The purposive sampling method meant that data could be collected with a number of participants in mind. For example, the notion was to interview at each stage of the supply chain, therefore there was an expectation to interview a number of participants from each section of the supply chain. When carrying out qualitative research, the findings are gauged based on data saturation. Saturation is considered to occur at the point when multiple investigations have been carried out as there is no defined number for data saturation (Francis et al., 2010). As a purposive sample was used to acquire data from different supply chain actors, more participants could have been interviewed, and would have been, however at the end of the data collection cycle there was a realisation that the data saturation point had been reached after twenty three interviews had taken place.

Analysis

The data was analysed in two stages, firstly thematically and secondly via theoretical lens application. Each transcript was scrutinised to develop codes in line with the literature; a process whereby each line of the transcription was meticulously considered. With the initial thematic concept formulation developed from the literature, the establishment of appropriate

codes for the data had a starting point prior to data collection. These codes were developed by analysing the frequency of the most commonly occurring themes. The process by which the data was analysed was in line with the common principles of qualitative investigation. Namely, the immersion of the researcher in the data in order to understand the collected information and its application to the investigative phenomena, and formulation of a data coding system through thematic selection and understanding the links between codes in order to establish theory (Morse and Richards, 2002).

The interview data was also evaluated further by applying institutional theory. Table 4 highlights the core indicators which were used to assign isomorphic pressures to the thematic data (Bhakoo and Choi, 2013). Each quotation relating to each theme was then assigned a relevant pressure based on Table 4.

Table 4 - Institutional pressure coding matrix for interviews (based on Bhakoo and Choi, 2013)

Description	**Coding Category**
Comments about pressures to conform to social norms	Normative pressures
Comments about professional systems i.e. supply chain structures, contracts etc.	
Comments about social values in order to appear legitimate	
Comments about negative impacts of normative pressure i.e. limited collaboration as a social norm	
Comments about positive application of normative pressure i.e. potential for institutionalising sustainability, ensuring that it becomes common practice	
Comments about established construction strategies	
Comments about enforcing compliance with sustainability schemes	Coercive pressures
Comments about the impact of cost/ budgets/finance	
Comments about contractual obligations in construction projects i.e. design-build	
Comments about government enforcement i.e. BIM implementation by 2016	
Comments about power i.e. - supply chain, client	
Comments about influence –driven by power	
Comments about external regulation	
Comments about legislation i.e. Climate Change Act 2008	
Comments about pressure to conform by viewing others' actions and influence	Mimetic pressures
Comments about the generation of communication channels via mimesis	
Comments about uncertainty/ risk reduction	
Comments about viewing success	

Findings

The following themes were found to impact on the development of low carbon innovation; supply chain integration, cost, client power, technology, behavioural change and risk. DiMaggio and Powell's (1983) institutional theory was then used to understand how institutional pressures felt directly or indirectly through these themes may encourage or inhibit the development of CO_2 emissions analysis throughout the construction supply chan. The interview findings were then considered using diffusion theory (Rogers, 1971), with a specific focus on the supply chain. Diffusion theory was used to assign an adopter category to each supply chain actor to understand how innovation may diffuse throughout the industry. The resultant analyses shown in Table 6 and 7 indicate firstly which data themes were most highly associated with each pressure and secondly which institutional pressures were most heavily associated with each supply chain position and adopter category.

Table 6 - Primary institutional pressure associated with each theme

Associated themes	Primary Institutional pressure (the pressure with the greatest impact on the supply chain section)
Supply chain integration	Normative & coercive
Cost	Coercive
Client power	Coercive
Technology	Normative & elements of coercive
Behavioural/ cultural change	Normative
Risk	Mimetic

Table 7 - Institutional pressure, adopter category and primary themes most commonly associated with each supply chain section

Supply chain position	Associated adopter category	Primary Institutional pressure	Associated themes
Raw materials extractor	Laggards	Mimetic	Cost, Supply chain integration
Manufacturer	Laggards	Mimetic	Cost, Supply chain integration
Design team	Early adopter	Coercive & normative	Supply chain integration, Behavioural/ cultural change
Sub-contractor	Late majority	Coercive & normative	Behavioural/ cultural change
Management team	Early majority	Coercive & normative	Supply chain integration, cost. Technology, Behavioural/ cultural change
Client	Innovators	Coercive	Cost, client power, technology

Discussion

Acknowledgement of technological LCA failures provided the impetus to seek the impact that behavioural and institutional pressures have on the implementation of low carbon innovation by using a supply chain perspective.

The most prominent themes extracted from the data collection process were supply chain integration, cost, client power, technology, behavioural/cultural change and risk. The extracted themes were used as an aid for understanding the pressures which most directly affected each supply chain actor; for example, client power was primarily a coercive pressure and was most likely to affect the client in the chain. Tables 6 and 7 were used in the development of a supply chain model for understanding how institutional pressures impact on the diffusion of innovation. The product of this research has been the establishment of the *'institutional diffusion wheel for low carbon innovation.'* (Figure 1). Figure 1 provides an illustration of the key institutional pressures that each supply chain actor is most subjected to. It also assesses how these institutional pressures align with the adopter categories in the diffusion process. The development of this wheel enabled these concepts to be taken into account when addressing how the diffusion of low carbon innovation may occur and what is currently inhibiting it. For example, the adopter category of the client as an innovator means that they are an integral point of the diffusion process; however the model also provides an awareness of the restraints placed on clients through coercive pressures.

The model also highlights the pressures which other supply chain actors are exposed to alongside their diffusion adopter categories. The design team are primarily subjected to normative and coercive pressures from the client who can act as a barrier to innovation by exerting hierarchical authority over them. The supply chain strives to adhere to client demands to ensure that they do not lose contracts; following traditional construction procedures is thought to eliminate this risk (Blayse and Manley, 2004). As the first to have contact with the client, the design team are considered as the early adopters for innovation. Most innovation begins at the design stage, the point at which most collaboration occurs in current supply chain formats (Basbagill et al., 2013). Collaboration or supply chain

integration as it is termed in this paper is considered a key component of diffusion theory and a significant diffusion enabler (Rogers, 1971). As a result of isomorphic pressure placed on the design team they are considered to be early adopters because of their supply chain position.

The early majority in the diffusion of innovation adopter categories was found to be the management team. They were also subjected primarily to normative and coercive pressures which are fed down from the client and design team. In order to be selected for contracts, the management team would be required to adhere to expected social norms in order to remain legitimate (Barreto and Baden-Fuller 2006). The late majority and laggards are considered to be the lower section of the chain, moving further away from client influence. Consequently these supply chain sections are the most difficult to reach. A high proportion of those working in construction are sub-contractors with up to 90 percent of work being carried out by sub-contracted teams (Ayalp and Ocal, 2014). Sub-contractors are generally smaller companies who do not have the freedom and high risk tolerance due to the competitive nature of the industry (Martins and Terblanche, 2003). In view of this they are unlikely to innovate but are likely to react to isomorphic pressures placed on them by higher ranks in the supply chain in order to remain competitive. They are however late to adopt new strategies. The laggards in this supply chain system are considered to be those who are far removed from the client such as raw material extractors and manufacturers. Considered as sectors in their own right, they are more likely to comply with their own regulation such as manufacturing regulations rather than those enforced specifically from the construction industry.

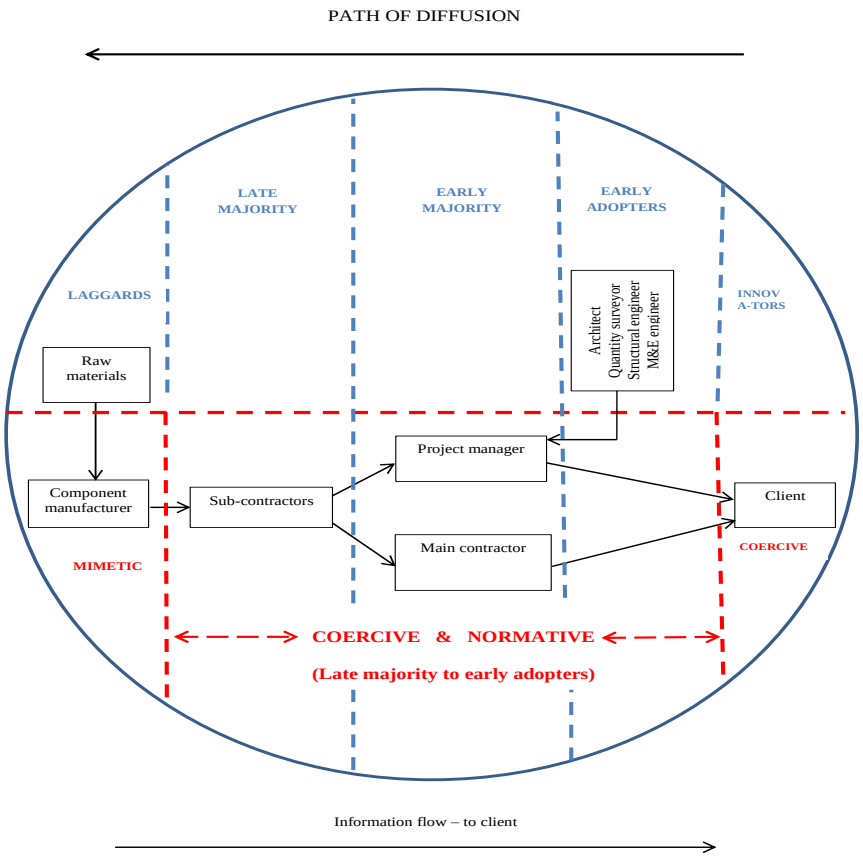

Figure 1 - Institutional diffusion wheel for low carbon construction

Conclusion

The qualitative approach to this research has enabled a preliminary understanding of the key institutional pressures exerted which may impact on the diffusion of low carbon construction. The understanding of these pressures has enabled the research to answer the following question;

> *How can the establishment of the institutional pressures exerted within the construction supply chain aid the diffusion of low carbon construction innovation?*

The establishment of institutional pressures does appear to have the potential to aid the diffusion of low carbon construction innovation. By stepping away from quantitative, technological approaches to sustainability, which have been widespread in construction, the understanding of the way in which ingrained industry ideals, culture, and internal and external pressures can be understood (von Medling et al., 2013). The study has provided insight into the power of the institution and how this impacts on the introduction of novel ideas across the whole supply chain. The development of the 'institutional diffusion wheel for low carbon innovation' could have positive application to the future development and diffusion of low carbon innovation strategies. It could provide a framework for understanding the power forces at play within the construction supply chain and how strong institutional influences impact on the decision making processes surrounding sustainability. It also outlines which supply chain actors are most heavily impacted by which pressures. Ultimately, understanding these dynamics within the supply chain could have positive implications for the development of low carbon innovation by highlighting which supply chain actors need to be targeted for effective diffusion and by outlining the possible institutional barriers which will need to be overcome to ensure the proliferation of low carbon construction.

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