A REVIEW OF METHODS OF MEASURING CONSTRUCTION INNOVATION, A UK PERSPECTIVE

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Innovation is a specific process to exploit change as an opportunity and is consistently found to be associated with organisational success In particular, the construction industry is widely perceived as being among the less innovative sectors, in part due to its project-based and fragmented nature This thesis will address a gap in the knowledge to which organizations systems measure the success of innovation projects and review which projects to select to realise value. The research is positioned in the wider context of the corporate objectives and principally asset management programmes of work. Following an initial review of innovation project selection systems, a set of research questions will be developed to investigate the potential for a new benchmark solely focused on Innovation Potential. It will deliver an original contribution to knowledge by developing an empirically validated conceptual model that consists of the main factors that have an influence, and are influenced by, innovation selection. The Paper will first, systematically review the existing literature in two broad sections: innovation studies within the construction industry and then specifically, the way in which organisations choose which projects to take forward and measure their success. Research studies on innovation measurement in the construction industry are a limited body of knowledge and as characterised by the industry, drivers and barriers appear to be the main focus of the studies. In addition, the majority of construction innovation studies have been carried out by academics with very few from industry. This research will ultimately identify a conceptual framework of the term innovation measurement within construction industry programmes to determine better innovation selection.

INTRODUCTION

A shift towards innovation has been witnessed over the last few decades as the construction industry comes to recognise the relationship between innovation and economic growth OECD (2005). The construction sector is under pressure to transform, adopting and developing new practices to meet current and future demands. This Government challenge aims to transform the construction sector – enabling it to produce safe, healthy, efficient building using the latest digital manufacturing techniques. (Transforming Construction Challenge 2018). Whereas the rate of change in the construction industry has been slow and the sector is considered relatively stable (AlHarmmodi, 2017), those operating in the sector are well positioned to innovate and benefit. Indeed, innovation is seen to offer a source of competitive advantage and acts as a major incentive for construction organisations, as they accommodate changes in their complex products and processes (AlHarmmodi, 2017). The built environment, of which the construction sector is a core component, shapes our society just as its citizens shape the built environment (Centre for Innovative and Collaborative Engineering, 2009).

Construction innovation distinguishes itself from other fields in which innovation takes place, generally because constructed facilities are large, complex, long lasting and are developed by a temporal and multidisciplinary project team (Slaughter, 1998). All types of innovation in construction are not equal, and therefore present different opportunities and require different actions in order to be successfully implemented. It is well known that the construction is recognised as a 'low R&D' sector. Shelton confirmed this stating that there is, "Poor uptake of implementing Innovation measurement systems in construction generally and in particular in large asset management companies" (Davila, Epstein, Shelton, 2013). More recently Lord Prior of Brampton offered the opinion, that UK construction is failing further behind in innovation potential and there is a real need to implement innovation much better in this sector. The need is so pressing that effort is being extended to understand the thinking of senior executives overseeing major assets in the UK, there is a need to "better understand the philosophy and processes that influence their approach and decision making when considering innovation" (Centre for Innovative And Collaborative Engineering, 2009).

Addressing the more defined theme of construction innovation measurement the work will consider the complexities inherent in the whole process of measuring innovation which is not an easy task (Orhozon, 2010). Historically, organisations and public bodies have tended to measure innovation in terms of inputs (e.g. R&D expenditure) and outputs (e.g. patent or trademark applications) (Archibugi and Pianta, 1996). Much construction innovation is project-based and unrelated to formal R&D expenditure and many innovations, particularly organisational or process innovations are neither patented nor trademarked (Slaughter 1993). This gulf between practice and measurement is referred to as the "innovation gap". Construction engineering consulting firms that carry out most of the design work in construction, where much innovation occurs, are in separate standard industrial

classification codes from construction contracting. (Barrett et al. 2007) pointed out that the standard definition of construction does not include much of the innovation rich and value-adding construction activity such as manufacturing, architectural and technical consultancy. So, although measures for innovation do exist, relevant metrics should be developed to distinguish the components of innovation at the programme, project, firm, sectoral, and national levels.

CONSTRUCTION INNOVATION BACKGROUND AND THEORY

Whilst continuing to carry out the systematic literature review, early general innovation work was carried out by (Slaughter, 1998), who presented five models of construction innovation categorised as incremental, modular, architectural, system and radical, which can provide a basis upon which companies can select and implement the innovations. (Waleed 2017) confirms that Rogers' Diffusion of Innovation (DOI) model is considered one of the most popular adoption models, with the majority of innovation research studies using the model as a framework (Sahin, 2006) and an explanation of how innovations spread. (Guerro and Lindblad, 2009) argued that clients are key in innovation and found that clients are often acknowledged as playing a critical role in creating the right conditions for innovation in construction (Blayse and Manley 2004; Bygballe and Ingemansson 2011; Loosemore 2015; Winch 1998). However, research has reported and suggested several different roles clients could enact to support innovation. Some research has indicated that clients might be in a particular good position to facilitate cooperation and coordination in projects, for example (Nam and Tatum, 1997) emphasized clients' active involvement in projects, showing commitment and leadership in projects; and (Kulatunga et al. 2011) suggest that client's influence can decrease the fragmentation of different stakeholders and facilitate innovation activities. (Dulaimi, 2009) goes further to conclude that the client, as the sponsor of the project, has the power to intervene to drive innovation in construction projects.

More recently (Loosemore, 2015) comments on 5th generation innovation, "in response to an increasingly networked society, fifth-generation systems integration models emphasize the role of systems integration, social capital, and business networks in facilitating the cocreation of knowledge across different knowledge domains". Also, Loosemore's research shows that clients lie at the heart of this problem, as does the subcontracting model of organizing construction work. Moreover, his findings reveal that there is much to learn about the 'catch it' phase of the innovation process, a process that once again is inextricably tied up with construction clients. Compared with other industries, this was broadly seen as a weakness in construction and more research needs to be done in this area, (Loosemoore, 2015) In conclusion, the construction sector is no less able to generate ideas than any other sector.

Analysis of Construction Innovation

Ozorhon (2010) found that due to the complexities inherent in the whole process, measuring innovation is not an easy task. Historically, organisations and public bodies have tended to measure innovation in terms of inputs (e.g. R&D expenditure) and outputs (e.g. patent or trademark applications). Much construction innovation is project-based and unrelated to formal R&D expenditure and many innovations, particularly organisational or process innovations are neither patented nor trademarked (Slaughter, 1993). Construction is a diverse sector and there is no single way in which innovation occurs. According to (Lansley, 1996) traditional indicators poorly reflect the true level of innovative activity in construction. Based on the review of construction innovation literature by Dickinson et al. (2005), studies on construction innovation lack a specific focus on the level of analysis, stage of lifecycle, and sector

Construction Innovation Measurement

Orzohan (2009) reviewed the research into how innovation could be effectively implemented in construction projects, following on from work undertaken by Tatum (1987), Slaughter (1998, 2000) and Winch (2003). However, none of these studies discussed the issue of measurement and effective use of indicators for construction innovation. (Gault's, 2013) handbook of innovation indicators and measurement, reviewed much of the work on indicators and measurement up to 2013 and examined emerging topics that could form part of future discussion of innovation measurement. These included innovation in the public sector and social innovation, and how they may be related to innovation in the business sector. Last year Gault's Paper attempted to   review the methods for defining and measuring innovation in all sectors of the economy, including a little on construction. In 2016, Orzohan homed in on the drivers of innovation construction, but did not raise any new interest in measurement.

Analytical Framework

As the aim of the research will be to investigate the stakeholder's experiences and thoughts in relation to innovation measurement and evaluation in construction projects, the qualitative approach will be used to achieve the opinion of the practitioners through direct conversation with them. The selection of qualitative research would help the researcher in explaining the practitioners' behaviours more explicitly based on the statements of their experiences and thoughts. It will allow a better study to analyse the participants' activities and obtain clear details of their intentions, feelings, and desires, (Abadi 2014). A mix of inductive and deductive approaches (the abductive approach) will be used with the primary objective of the research being to explore how sense is made of construction innovation measurement. According to Pinnegar and Daynes' (2007, p. 4) statement, "qualitative researchers are interested not in prediction and control but in understanding", the intention of this research is to focus on what and how questions rather than why questions (Gubrium and Holstein, 2001).

RESEARCH REVIEW AND METHODOLOGY

The work will review innovation measurement and through and company-based case study test a research informed framework, which has been informed and initially validated through the survey data.

Through investigation of the following research objectives, which will guide the study:

1. To examine various meanings of the term innovation evaluation and the principle theories in innovation management within the construction industry literature.

2. To critically and systematically review the relevant research on the evaluation and selection of innovation projects in construction

3. To set out the research framework, which underpins the strategy and design.

4. To establish methodological approaches to address the research questions.

5. To examine how the everyday activities of organisations become identified as an innovation by analysing the data from the narratives of practitioners.

6. To consider the practical and ethical implications of the data collection methods.

7. To analyse data obtained from a survey stakeholder executives and innovation leaders focusing on their rationale when choosing innovation projects.

8. To develop and critically examine the validity of a framework tool using a case study of an infrastructure asset company.

Qualitative research methodologies are used to explore why or how a phenomenon occurs, to develop a theory, or describe the nature of an individual's experience, while quantitative methodologies address questions about causality, generalizability, or magnitude of effect (Fetters, Curry, and Creswell 2013). Mixed methods research, frequently referred to as the 'third methodological orientation' (Teddlie and Tashakkori 2008), draws on the strengths of both qualitative and quantitative research. While there is no universal definition of mixed methods research, Creswell and Plano Clark (2011) outline its core characteristics: In a single research study, both qualitative and quantitative strands of data are collected and analyzed separately, and integrated – either concurrently or sequentially – to address the research question. Onwuegbuzie and Combs (2010) concur, writing, "mixed analyses involve the use of at least one qualitative analysis and at least one quantitative analysis – meaning that both analysis types are needed to conduct a mixed analysis" (414). Instead of approaching a research question using the binary lens of quantitative or qualitative research, the mixed methods research approach has the ability to advance the scholarly conversation by drawing on the strengths of both methodologies (Berman 2017).

A mixed method of data collection and analysis will almost certainly be required. Ideally an 'Exploratory Sequential Design method', may be the most effective for this research. (Berman, 2017) noted that by using an exploratory sequential mixed methods research design to uncover researchers' data management practices and the challenges in managing digital data, this type of study allowed for a deeper understanding of the issues and to develop a robust plan to implement research data services that meet these needs. In particular, the strength of the mixed methods approach allowed for a deep dive into understanding the lived experiences of researchers' data management practices via qualitative methods, while using the results of the qualitative analysis to build a framework to more accurately measure data management activities.

This is the preferred methodology for this research. Ideally an 'Exploratory Sequential Design method', may be the most effective for this research as the qualitative data collection first will be key to understand the decision reasoning, followed by the quantitative collection to enable deeper selection choice analysis.

This method will be a two-phase design. The qualitative data will be collected first, followed by collection and analysis of quantitative data. The purpose of this design would be to develop a framework to then develop a classification for testing, or to identify variables. Using the information from interviews and discussions to develop an appropriate tool to administer to a pilot group.

The first phase, qualitative reviews of current innovation selection processes via meetings, interviews and focussed group discussions will be needed to collect and understand the' why' decisions are made and will be key to understanding selection reasoning. Document analysis will almost certainly be required.

The second, more traditional quantitative data collection, via questionnaires, will then be required, to enable data analysis of selection choices in the second phase.

One of the most important pitfalls here will be sampling size. Thought will be required around the non-probability sampling method, (i.e. non-random manner) and non-random judgement sampling as specialist Executives and Managers will be targeted for this phase as the initial research population.

The focus of this research on innovation project evaluation and selection through wider culture and context support the mixed methods approach. Qualitative approaches will allow greater depth, (Berman, 2017) for the understanding of selection decision making and answer research question one; ("How is construction innovation measured in UK Civil Engineering?"), whereas quantitative methods, such as statistical analysis, will be better to evaluate and answer the second research question; ("How are Innovation Projects evaluated and selected for development?").
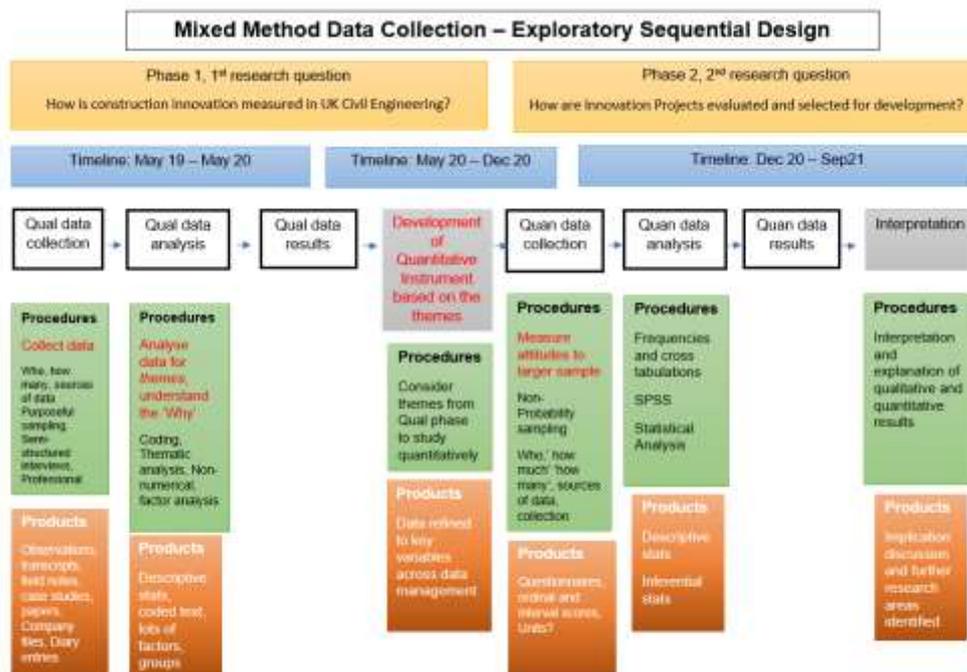

Figure 1. Exploratory sequential mixed methods research design (Berman, 2017)

PHASED RESEARCH METHOD

Phase 1a - Definition and Identification of Innovation

To define the relevant terms for the purposes of the research. work by both (Dickinson 2005) and (Kalutunga 2006) will be useful to ascertain key terms for searches. To establish the context, a systematic review of the construction innovation measurement data from the existing literature on the current use of innovation evaluation and selection in construction asset management programmes will be undertaken. A three-step systematic literature review research method used by (Nappi 2018) is proposed. Besides the analysis of previous discovery, techniques, ideas and ways to explore topics, the systematic review also allows the evaluation of the relevance of information, its synthesis and summarization. The notion of systematic review has recently gained significance in the management literature to identify performance indicators for NPD, for instance: lean performance (Mascarenhas Hornos da Costa et al., 2014); eco-design implementation (Rodrigues, Pigosso and McAloone, 2016), and environmental performance (Issa et al., 2015). This research method followed the procedure proposed by (Brereton et al., 2007) based on three main steps: 1) plan review; 2) conduct review and 3) document review (see Figure 2).
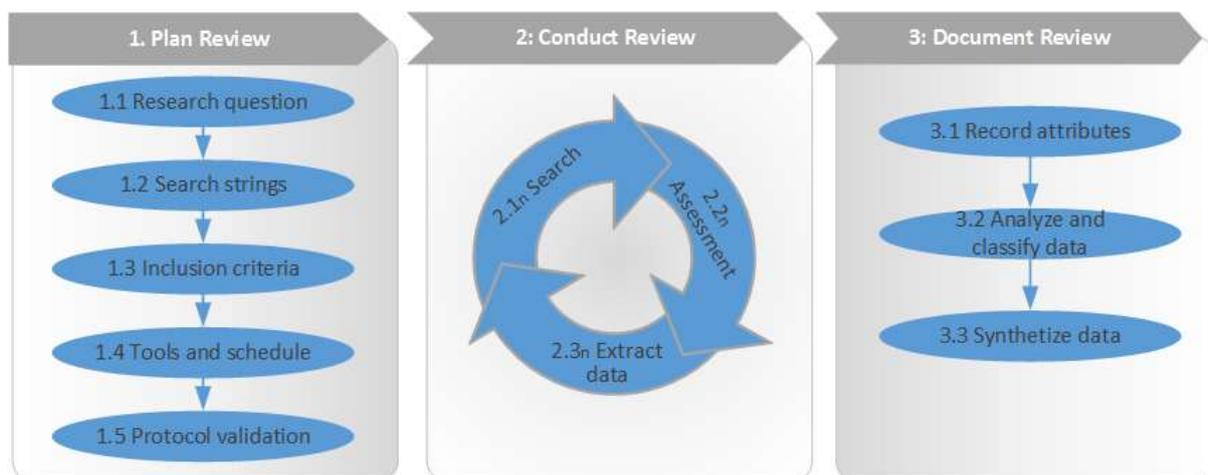

Figure 2. Research method with three steps. (Brereton et al, 2007)

Phase 1b - Development of Innovation

Structured questionnaires and face to face interviews and surveys of active practitioners, executives and stakeholders to identify and classify salient factors, and rate their relative impact, that influence an

organization's ability to generate and implement new ideas that improve business performance and determine how innovative projects are chosen. This will produce key themes.

Phase 1c - Identification of Appropriate Methods

Greene et al. (2005) argue that studies that adopt mixed methods are distinctively capable of generating better results than studies restricted to a single method. The appropriate exploratory sequential mixed methods will be selected following the earlier 2 Phases and will establish dependent and independent variables as required.

Phase 2a - Data Collection - Main research undertaking, data collected through companies, stakeholders and executives

Lomas commented that "For many observation and prediction problems, some sort of past and current organizational statistics are needed, if only to benchmark the present or provide a base for extrapolation into the future." (Lomas, 2011).

For the main data first phase collection, qualitative reviews of current innovation selection processes via verbal meetings, interviews and discussions will be needed to collect and understand the' why' decisions are made. The second phase, more traditional quantitative data collection, will be carried out via questionnaires, in a similar approach used by (Abadi 2017) to enable data analysis of selection choices. This will enable cause and effect to be established from the data. The rationale behind selecting the research participants will be to choose the individuals who are involved in innovation choice and selection and driving innovation in the construction industry.

Phase 2b – Analysis

For the Qualitative data then coding will be required. In addition, the need to understand an Executives' interpretive philosophy will be required. Some thematic type analysis could then be undertaken. Non-probability sampling techniques will be required for the qualitative data with some confidence sampling, Merriam's approach could be used (Merriam, S. B., 2019).

For the Quantitative data, structured questionnaires will be most appropriate. Likely project data sets will be graphs and charts of innovation selection variables from measurements and data. Analysis via statistical software will be used.   Focus is maintained on the 'unit of research' to ensure data are obtained from which valid discussion and conclusion can be made. Further to the analysis, the development of model or an innovative framework would be established, that would explain the findings, i.e. when Innovation works, and would simplify innovation project selection. This framework would then be applied to a local pilot study.

Phase 2c - Pilot Study

DISCUSSION

It is hoped that enough quality data is collected from the stakeholders to establish the key themes necessary to then take forward to the model creation phase, and case study work. The data will be thematically analysed, condensed and tabulated into its simplest form to create themes for discussion and for producing a model to then test in my own organisation which will hopefully then be expanded for any construction organisation. The findings should confirm others earlier work that the senior managers describe their organizations as having innovation at the core of their business that it is led by the owner, filtered to board of directors, onto senior managers and down the chain of command at project level. In addition, it will be useful to confirm that the process of innovation is bottom up and top down, and that everyone is expected to look for innovative practice at every level.

CONCLUSION

The purpose of this research will be to identify the key themes of innovation measurement when considering innovation adoption in the UK's main construction arena. Interviews will have been conducted and a thematic approach to data analysis will have been conducted engaging a thematic approach. It will be interesting to find out what the key drivers and barriers are to innovation project and programme selection. Discussions with senior stakeholders will doubt inform of their willingness to innovate, but the real outcomes will come after the data collection and analysis to find which organisations really get the best return on innovation.

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