Social construction of innovation and the role of innovation brokers in the construction sector

Abstract

Purpose - The purpose of this article is to re-visit Social Construction of Technology (SCOT) framework in understanding of innovation in the construction sector and unpack the role of innovation brokers in this context.

Design/methodology/approach – This is a conceptual article adopting Social Construction of Technology (SCOT) framework to understand innovation in the context of the construction sector. The role of innovation brokers is unpacked in the article, currently under-explored in the construction innovation studies.

Findings - We suggest SCOT framework as a useful overarching frame through which to understand construction innovation. We argue that innovation brokers should be positioned to oversee the interface of multiple social groups.

Research/ limitations/implications – Further empirical research is proposed to test the theoretical assumptions outlined in the article. The research agenda is to conduct further empirical research adopting a socio-technical theoretical lens and appropriate qualitative or mixed-design methodologies. There are other socio-technical theoretical frameworks that could be used to explore socio-technical interactions in different ways, e.g. socio-technical systems theory, sociomateriality, actor-network theory etc.

Practical implications - Three propositions are developed regarding the position of an innovation broker from the perspectives of multi-social-groups interfaces, shifting significance of the roles of innovation broker and the collaboration with government.

Originality – We outline the value of SCOT framework for innovation study within project-based construction sector. We contribute to better understanding of the role of innovation brokers in the system of construction innovation.

Keywords: Social Construction of Technology (SCOT), innovation, social constructivism, innovation broker, system

Paper Type: Conceptual paper

Introduction

Organisations are forced to innovate in order to survive the competitive business environment (Akintoye *et al.*, 2012; Sergeeva and Green, 2019). However, due to the project-based and technology-intensive nature of its products, the construction sector struggles to accomplish what other sectors managed to achieve (Haugbolle *et al.*, 2015). At the time of research, the study of innovation virtually spans every scientific and social domain, including organisational management (Dainty and Loosemore, 2012), economics (OECD, 2000; Ive and Gruneberg, 2000), technology (Langford and Hughes, 2009), politics (Winch, 2010), sociology (Yousefikhah, 2017; Harty, 2005) and so forth. Studies of innovation to date have been extremely dispersed, characterised by overwhelming number of frameworks and rare effort to reconcile the occasionally conflicting frameworks.

With constantly growing scale of community (Harty and Leiringer, 2017), recent research trended to a focus on contextual factors rather than technical factors of construction projects (Brady and Davies, 2014; Harty, 2005). In terms of methodology, the commonly adopted philosophy of mind is reductionism, the scientific attempt to make sense of the complexity of an entity through explaining more fundamental phenomenon of the constituent elements, and the interaction between the individual parts (Alashwal and Adbul-Rahman, 2014; Honderich, 1995; Ruse, 2005). The methodological reductionism has been reflected in models of innovation, capturing one or more parts of the entity of innovation, mainly under two regimes. Firstly, based on

the causality of events, the entity of innovation is procedurally reduced into a series of linear events, be it vertically based on power hierarchy, or horizontally based on sequentiality (time, process, etc). Examples under this regime include the model of *innovation superstructure and substructure* of Miller *et al.* (1995) and the model of *construction innovation process* of Winch (2010). Upon reducing the entity into smaller processual units, each of the units (such as a certain stage of innovation) is then treated as the subject or focal point of study. The second approach for reduction is built upon the nature and character of innovation, where innovations are classified under different categories. Slaughter (1998) differentiated innovations in construction sector based on the magnitude and scope of change. The researchers in this paper critique the methodological reductionism and propose holism for the study of innovation, acknowledging the complexity of understanding innovation in the construction sector.

Although opposing scholars stress on the materiality of the study of construction project management (Styre, 2017), methodological pluralism is allowed for subject to certain boundaries (Dainty, 2008). In this paper we argue that SCOT framework outstands for its capability of integrating the technical and social elements where innovation is understood as subject to multiple interpretations by social actors and groups in a range of social contexts. We follow the work of Schweber and Harty (2010, p. 673) who argue that SCOT presents "a coherent and in inclusive approach for interrogating the complex realities of interactions between people, technology and institutions in empirical settings". In this article we aim to address the interplay between the social and technical sides of innovation, framed under Social Construction of Technology (SCOT). Under this framing, we unpack the role of innovation brokers in the construction sector, that still remains largely under-explore in the literature.

Re-interpretation of innovation in the construction sector under SCOT framework

Bijker (1995) crystallised and extended the essential work he had done in the 1990s to establish a full-scale theory of socio-technical change that described where new technologies come from and how societies deal with them. The inseparable two sides of innovation construct a process of "*social shaping of technologies and technological shaping of society*", shedding light onto the fundamental elements of the SCOT framework. This article prioritises the three themes followed, and the sub-units of analysis under each of the themes.

Social group and interpretative flexibility

Social group is where the interpretative flexibility of artefacts is hatched, said Bijker (1995): "'*Machine works' is not an explanation... Machine works because of the relevant social groups.*" Social group is part of the system where the whole economy of an individual is expressed, such as the relations, outlook and so forth (Schumpeter, 1983). Where an individual is casted in multiple social groups, the values and interest may potentially clash.

In the construction sector, pre-fabricated houses have demonstrated the concept. The swarm-like emergence of pre-fabricated houses in post WWII Japan and Germany, has in extremely short time fulfilled post-war reconstruction. It has however not been equally appreciated by purchasers in UK due to the cultural and legal factors (CIRIA, 1996). The examples above have as well demonstrated the concept of *symmetry*. The symmetry principle extends the metaphor of "seamless web" to "seamless web of technology and society" as a reminder that non-technical factors are important for understanding of the development of technology (Bijker, 2010).

Identifiable social groups play a role in the development of innovation. The key element is that such groups share a meaning of an innovation. Innovation can be re-interpreted by social groups over time and within broader social contexts. Whilst there are many social groups that can be identified in relation to innovation, in this paper we will focus on innovation brokers.

Closure

Closure refers to the stabilisation of interpretation, and emergence of consensus in science community, where one interpretation of artefact dominates all social groups. It is generally an irreversible process, yet exceptional cases do exist. An example in construction sector is the rise and fall and revival of structural timber in Germany (Gold and Rubik, 2009) and UK (Sutherland, 2010). By mid 1900s, timber as a construction material had been mostly replaced by iron, steel and reinforced concrete as the Industrial Revolution fundamentally improved the production method and reduced cost. Since 1945, however, a revival of the favour for structural timbers overwhelmed, accrediting to the invention of new adhesives and connexion technologies. On top of the technical factors, Sutherland (2010) stressed a crucial social factor at individual level, the formation of a "loose and informal group", where "*in a small way they* (the early users of timber at the beginning of the revival) *felt like pioneers*".

Oti-Sarpong and Leiringer (2016) adopted the theoretical lens of the SCOT to examine the socio-technical interactions between the human actors and construction technology in technology transfer between contractors and joint ventures. They used SCOT to demonstrate "interpretive flexibility" and "closure and stabilisation" in revealing how learning is an integral process within the social-technical interactions. Boyd (2016) used SCOT approach to explore co-development of the technology and the building, and the adoption process. Decision-making was found to be affected by the

alignment of technological and social frames being mobilised by actors at different times. Boyd and Schweber (2017) used SCOT analysis of documents to show how the energy generation of building-integrative photovoltaic (BIVP) technology disappeared from view at certain points as actors focused on building features. They contributed to the theoretical development of SCOT in two ways: privileging of cognitive closure mechanisms and the neglect of institutional analysis.

Power relations and micro-politics

Bijker (1995) demonstrated how the design of fluorescent light bulb had been altered through decades as a result of micro-politics and the power relations in utility sector. In the construction sector it is not rare of individual firms lobbying the government, affecting the legislations or micro-politics of the industry (Rankin, 2018). Peer-reviewed work on this subject includes Winch (2010) which illustrates the political settings of innovation. The model of *innovation superstructure and substructure* of Miller *et al.* (1995) also reflects the power relations influencing the innovations in the UK construction sector.

Other relevant study includes van Baalen *et al.* (2016) who extend the SCOT framework along four dimesnitons in order to ensure it suitability for the gitial world: (1) technology – focus towards digital technologies; (2) interaction - focus on interpersonal, person-technology, technology-technology and technology-physical environent interactions; (3) social groups – focus on networked individualism, and (4) context – focus on socio-digital context.

Based on the reviewed literature, the researchers have come with the *Proposition 1: The technical system of innovation is shaped by the characters of the social system where the organisation is situated, or the micro-politics of the specific sector.*

Understanding the role of innovation broker in the construction sector

Traditionally, the study of innovation brokers has strictly defined and confined their role within the technical sphere. The researchers in this article shift the spotlight towards the social functions of innovation broker. Winch and Courtney (2007) based on the work of Howells (2006), construed the role of three types of innovation intermediaries, within and without construction sector. Traditionally, there were only two types of intermediaries:

- Knowledge and technology broker: knowledge intensive business service firms, typically providing cross-sector knowledge/solution referencing through making analogies. The key element of such firms is the structural position between source of ideas and potential implementations.
- Co-operative technical organisation (CTO): CTOs work through binding together firms in the innovation network, within the same industry, as a comparison to knowledge and technology broker. CTOs also organise working groups to form cliques and isolates.

Winch and Courtney (2007) as a comparison to the two categories initiated discussion about the independent broker. The key trait distinguishing independent broker is its sole purpose of knowledge brokering, which is only a by-product of primary business activities of the other two. They define innovation brokers as organisations that both act in a liaison role between the sources of new ideas and the users of those ideas. Building Research Establishment (BRE), an example of independent broker, provide innovation forums for the sharing and learning of the R&D activities of various institutes. The separate research and brokering functions of an independent broker allow the trade-off between research and brokering capacities. It is, as Winch and Courtney (2007) concluded, “a distinct evolution” or new innovation model in the way it introduced pure

broker function without significant research capability. We are in agreement with Winch and Courtney (2007) that innovation brokers are likely to play an important and distinctive role in networks of innovation by enabling organisations to innovate.

According to Blayse and Manley (2004, p. 148) innovation brokers *"can assist in orchestrating co-operation and knowledge growth to achieve innovation outcomes. This class of industry participants include professional institutions, universities and other tertiary institutions, construction research bodies, and individual academics and researchers."*

They further reinforce that innovation brokers can act as information intermediaries between construction firms and others who are helping firms to become aware of emerging technologies, capabilities and competencies. Ørstavik (2014) and Ørstavik *et al.* (2015) defined the systematic effect of innovation as a process of re-institutionalisation, where the sector is being re-shaped by the interrelationship between local innovation and structural forces therein. He particularly analysed how this process could undermine the position of third party innovation brokers despite the importance of their presence. Although links to government and financial dependency on the sector empower the brokers at a certain point, it is challenging to maintain the position over time as the brokers are tied to existing technology.

The positioning of innovation brokers might be of strategic significance for their efficiency and effectiveness in facilitating innovation. The SCOT framework, as the researchers argue, is a powerful framing for the analysis of the nature and the role of innovation brokers. More specifically, the research questions are: *What is the role of innovation broker in the socio-technical construction of innovation? Should innovation brokers be granted regulatory power?*

Innovation broker in the construction sector under SCOT framework

Although different types and nature of innovation brokers in different social systems, their functions can be best explained as sociotechnical under the SCOT framework.

Interpretative flexibility and innovation (re)labelling

The pre-condition to label a technology as "innovative" is to evaluate the level of its innovativeness. However, the measurement, validation and eventual labelling of innovation can be much more ambiguous than other constructs (David and Strang, 2006). As SCOT framework suggests, innovation exists in multiple dimensions, and therefore the challenges of unifying the units, languages and parameters. In a number of cases the label of "innovative" has been defaultly attached to other labels and therefore diverted from the plain definition of "innovation" (Blindenbach-Driessen *et al.*, 2010). The example of BRE would be re-mobilisd to illustrate the issue of multitrait labelling: the green building rating systems (GBRSs). BREEAM is the longest established GBRS by BRE that assesses, rates, and certifies the innovativeness and sustainability of buildings. The programme measures building performance under nine categories, implying the label of innovation has been attached to the nine elements. As the innovation broker, its labelling is based on the socio-technical elements (Gambatese and Hallowell, 2011; BenRejeb *et al.*, 2008), impling its cross-disciplinary position.

There are a score of similar GBRSs across the world, attracting exponentially increasing number of applicants from different sectors especially after 2010 (USGBC, 2008; BRE, 2014). However, the many GBRSs have distinctly different legal positions in different social systems. On the spectrum of "voluntary to mandatory", the researchers have placed a few of the leading schemes according to their positions: BREEM, Green Globes; LEED, Energy Star, CASBEE (Japan), Passivhaus (Germany), Green Mark (Singapore). Voluntary schemes such as BREEAM and Green Globes,

provide consultancy services, guidance for planning and design process, as well as post-occupancy assessment and rating. None of the assessment is enforceable on the project. Towards the other side of the spectrum, programmes such as LEED and Energy Star have been influencing the industrial legislations. CASBEE (Japan) and Passivhaus (Germany) have higher level of influence due to their direct relations with the government. The one with the highest influence on minimum building standard is BCA Green Mark in Singapore. It has been delegated by Building and Construction Authority (BCA) to write the legislations for minimum building performance. No project (new building or retrofitting) would be appproved to commence unless meeting the Green Mark prerequisites and validated by a certified assessor. Notwithstanding the varying positions of GBRSs, the number of organisations seek for their labels has been rocketing gloabally with different drivers behind.

Positioning of innovation broker

As discussed earlier, an organisation could be positioned in multiple social groups, and the various groups may have conflicting interpretations of innovation (Bijker, 1995, 2010). This could be adversarial as most of the radical innovations are likely to evolve at the intersection of multi-groups, as Swan *et al.* (2002) suggested. However an important role has been missing from the process: the innovation manager to manage the interfaces between the social groups. The innovation manager may not necessarility be monolithic or all-powerful (Reed, 1984), but rather encompassing the conclicting interests and contradicting practices of different social groups. In light of this, innovation has become a political act, as the medium of power that is embedded in the social system (Drazin, 1990). Therefore innovation brokers, especailly in the cases of radical innovation, should be positioned to oversee the interfaces of various social

groups involved. The discussion till this point concluded the second proposition for the positioning of innovation broker:

Innovation broker is positioned the way that the interfaces of multiple social groups could be effectively overseen (Proposition 2).

Another important factor regarding the role and position of innovation broker is the diminishing significance of its leadership towards the end of diffusion process. "*The more perfect our control of fact, the less the significance of innovation leader*", Schumpeter (1983) contended. In the five stages of innovation curve of Rogers (2003), the diffusion tips at the "late majority" stage. The tipping point is very likely where the significance of innovation leader shifts towards innovation manager. In SCOT theories, the diffusion of innovation encompasses a process towards the stabilisation of multi-interpretations of technology. During this process, the significance of innovation leader, or the initial role of innovation broker, diminishes and shifts towards the role of innovation manager. The role and function of innovation broker should therefore be dynamic rather not static (Buwanpura *et al.*, 2010; Kim and Yoon, 2015;). The positioning of innovation broker should satisfy the changing needs for their role and function, drawing the third proposition:

The position of innovation brokers allows for flexibility in their role, as the need for their function changes throughout the innovation process (Proposition 3).

On the mandatory end of the "voluntary-mandatory" spectrum sits BCA Green Mark, the scheme that is delegated to stipulate national minimum building standards in Singapore. Although it may not be viable to plant the same mechanism in other countries, the idea of embedding the innovation-labelling scheme into legislation merits consideration (BCA, 2015).

Singapore has been internationally recognised as a leading country in construction innovation and sustainability, especially in tropical and sub-tropical continents. BCA Breen Mark, the counterpart of BREEAM in Singapore, has been endorsing National Environment Agency's (NEA's) Mandatory Energy Labelling Scheme (MELS) since 2008. Green Mark stipulated the use of specific energy-efficient products under MELS as the prerequisite to apply for a higher Gold Plus or Platinum rating.

Since the bilateral endorsement between Green Mark and MELS, the energy-efficient products have effectively penetrated the market in Singapore. Behind the two schemes, the real players are the two governmental authorities: Building and Construction Authority (BCA) and National Environment Agency (NEA). The successful case implies the diffusion of innovation hinges on the collaboration of governmental authorities, or a Whole-of-Government Approach (WGA). With the case study of BCA Green Mark, the forth proposition could be drawn:

Innovation broker, regardless of its legal/political status, collaborates with the government in the form of bilateral endorsement, embedding the label of innovation into legislations (Proposition 4).

Discussion and implications

The researchers have based on literature and recent cases established the basis for SCOT theory and the positioning of innovation brokers within the framework. Before concluding the article, the researchers further evaluate the theories against the opinions of professional institutions and industrial reports.

Culture as the key social factor shaping innovation: How do narratives help stabilise interpretation?

In its recent publication ICE (2015) eight blocks are proposed for promoting innovations in construction sector, to which culture is central. The report stressed the significance of culture as a social background when constructing the interpretation of innovation. Decades after the publication of Latham (1994) and Egan (1998) reports, the construction sector has certainly improved, yet still been encumbered by its culture of fragmentation and risk-averse supply chain. A direct drawback of those traits is the lag of initiation, diffusion and sharing of innovations at multiple social levels.

As SCOT framework suggests that the misaligned interpretations of innovation gradually attenuate towards the end of innovation diffusion process, where consensus should eventually be achieved across the social groups. During this process, the role of narratives is prominent in constructing agreed definition of innovation and shared vision at multiple levels (Sergeeva, 2016).

Aligning the goals at the three social levels: Mechanisms of incentive

Taking on the discussion regarding risk-sharing mechanism, ICE (2015) suggests improvement of procurement method, including "pain-and-gain" mechanism of the contract and an integrated supply chain. The report suggests SMEs are not capable of financially investing in innovation, but do have insight, expertise and agility for idea generation, therefore the solution of Early Contractor Involvement (ECI).

The researchers have suggested creative destruction for the construction sector to maintain sufficient investment in the corporates capable of radical innovations. However, given that the goals and objectives of Tier 1 contracting firms and the rest of the corporates aligned, the investment in Tier 1 firms would as well benefit the contractors while being paid off by their export of ideas. Therefore it is essential to

align the goals and objectives at the three social levels of SCOT framework (individual, organisational and industrial) to optimise the incentives with limited budget.
Another key point for the alignment between government and corporates is to ensure the suitable level of regulation and standard for policymakers, as innovations could somehow be stifled by overly rigid specifications. In light of this, another important function of narratives is to maintain the continuous interaction between sectoral policymakers and the corporates to ensure dated level of regulations.

Correlated supporting innovations shaping radical innovation

Adner (2006, 2017) contended the determinants for radical innovations are very likely being allocated externally beyond the sector. According to Schumpeterian theories, the needs for the radical innovations may arise from neither the demand nor the supply side within the sector, but the need for social development embedded in the social system. The technical characters of innovations could be notably influenced by that of the supporting innovations beyond the industry itself. Within the construction sector, the blueprint for how the industry would transform were envisioned in Digital Built Britain agenda, Construction 2025 and other industrial reports. It implies the image of future construction sector is primarily shaped by the broader revolution of Information Communication Technology (ICT). It reinforced the position of Proposition 2 that innovation brokers are positioned at the interface of multiple social groups for effective knowledge brokering.

Organisational and industrial restructure

HM (2013) and the ICE (2015) both strategically prioritise the investment in the workforce for higher competency, efficiency and the leadership that is necessary for promoting innovations. This somehow gives rise to possible organisational restructure

as a result of socio-technical shaping process. Innovative practices require higher standard and qualification of workforce. Improved individual competency triggers a shift towards flatter organisational hierarchy, consisting mainly of four stages:

- Need for radical innovation for social development
- Requirement for higher qualification and skill of the employees (socio-technical shaping at individual level)
- Increased power and authority of individual employees
- Flatter organisation (socio-technical shaping at organisational level)

The four stages might be of particular interest to policymakers to consider the possible outcome of innovation diffusion in term of workforce revolution in social wise. Farmer (2016) evaluated the current and future state of construction industry using a medical process analogy. The review recommended government as the initiator for the step-stage change, and the call of initiator is to be answered by a strong leadership across clients, government and industry. The review also proposed the Construction Industry Training Board (CIBT) to be reformed as the agent between the initiator and the industrial players. Loosemore and Richard's (2014) findings also confirm the importance of client leadership yet also shows that lowest price remains the dominant selection criteria in tenders.

Socio-technical construction of innovation: A seamless, fluid and self-oriented process

The four points discussed above imply the fluidity of the socio-technical construction process. In summary, the process is a rather smooth and fluid flow of events, proceeding in a self-oriented manner without additional instructions.

The innovations were firstly self-triggered by the need for social development, followed by a socio-technical shaping process progressed without any enforceable interventions imposed. It seems to be a rather intuitive response of the organisations to the changes that might even be beyond the boundary of the sector.

These traits somehow implicitly link to the concept of "innovation trajectory", which according to Moore (2006) and Schieffer and Lessem (2014), is central to continuous improvement and advance. A major source of sustainable competitive advantage is to create closed and iterative strategic loop (Sull, 2007) and evolutionary business model (Velu, 2016). The fluid and self-oriented nature of innovation shaping process under SCOT framework could potentially extend its value to those related fields of research.

Conclusion, limitations and future research

With the aim of contributing to SCOT theories and their application in the study of innovation in construction sector, the research has been oriented by the overarching proposition: *The technical system of innovation is shaped by the characters of the social system where the organisation is situated, or the micro-politics of the specific sector.* While examine the *Proposition 1*, the researchers have answered two questions regarding the socio-technical shaping process, and the role and position of innovation brokers in this process under SCOT framework. Upon answering the questions and rationalising the implications, the researchers proposed three more propositions for policymakers regarding the position of innovation broker, from the perspectives of multi-social-groups interfaces, shifting significance of the roles of innovation broker and the collaboration with government.

In terms of theoretical contribution, the researchers firstly challenged methodological reductionism while proposing holism, for the inseparability of the social and technical sides of innovation. Secondly, based on the three major stems of innovations study, the

researchers proposed SCOT framework as the frame to coordinate the existing multi-dimensional frameworks within the domain. Thirdly, SCOT provides a useful framing for better understanding of the intermediate and enabling roles of innovation brokers. We argue that innovation brokers play crucial roles in driving innovation in the construction industry, surprising little attention has been paid to the nature and their roles. The theoretical arguments were evaluated against the opinions of a number of renowned industrial reports, with the implications further discussed.

Despite the contributions, there are a number of limitations with the article and theories. Firstly, the applicability of SCOT framework is relatively narrow. The *proposition* implies the industry-specific character of SCOT framework. Secondly, as Winner (1993) criticised, SCOT theories actively avoid ethic issues, particularly the ignorance of the social groups having no voice in the socio-technical construction process, which could lead to elitism and conservatism. Thirdly, the propositions developed in the article need to be tested through empirical research. We set the agenda for future research studies and can tackle the following research questions: 1. Should capital and trade credits flow towards, and inject into demand-oriented or supply-oriented innovation? 2. Should social norm or market norm dominate the incentive mechanisms for different forms of innovation? Should innovation brokers employ more legal roles in the construction sector? There are other socio-technical theoretical frameworks that could be used to explore socio-technical interactions in different ways, e.g. socio-technical systems theory, sociomateriality, actor-network theory etc.

Overall, this article discusses the value of SCOT framework for innovation study and the nature and role of innovation brokers, within project-based construction sector. The fundamental is that none of the disciplines of innovation should be treated as an isolated subject, there are always implicit but crucial interrelations amongst the multiple

dimensions of innovation. What marks the boundary between innovation and Rube Goldberg Machine, between innovativeness and "something for nothing", between leadership for innovation and pro-innovation bias, is nothing but the holistic thinking of the socio-technical construction process. The contribution of this article is a small step towards this under-researched area, the theories still require substantial future research to be legitimised.

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