HOW DO TECHNOLOGICAL NICHES EMERGE? A CASE ANALYSIS OF SERVITIZATION IN CONSTRUCTION

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It is widely recognised the design and operation of more energy efficient solutions within buildings will play a significant role in the wider global battle to reduce energy consumption over the coming decades. If the industry is to succeed in delivering high energy performing buildings in the future then it will require the implementation of a variety of radical innovations. One potential avenue is for organisations involved in the design and manufacture of building systems to find innovative ways of playing a more prominent role in enhancing the through-life performance of those building systems. It is here that we locate this study, with an in-depth case analysis of a construction firm that is transitioning toward the delivery of servitized solutions. We position the paper within the field of socio-technical transitions. These studies have highlighted the role technological niches play in socio-technical change. There is, however, a limited understanding of how technologies acquire the form and attributes of a niche. In this paper, ConstructCo's pursuit of a technological niche as they transition towards greater servitization. We trace this pursuit of a niche through three turns: the turn towards establishing a business need, the turn towards developing product intelligence, and the turn towards supplier development. The findings suggest that technological niches emerge as constellations of different technologies develop in parallel in different projects. Secondly, that by developing radical through-life solutions organisation seek to acquire greater control of the nature and direction of sustainable transitions. Finally, by unpacking different interactions between multiple actors involved in the pursuit of niches we offer fresh insights into the costs and contradictions involved in making sustainable transitions within construction.

Keywords: mechanical and electrical products, servitization, technological niches, transitions.

INTRODUCTION

The building sector is responsible for approximately 40% of total energy consumption in the EU (European Commission 2008). Thus, increasing energy efficiency within buildings will play an integral role in the global challenge to reduce energy consumption. Looking forward this will require the emergence of new energy-efficient solutions that radically challenge existing socio-technical regimes within the construction industry (Rohracher 2001) (Quitzau et.al, 2014). Traditional boundaries between design, construction, maintenance and operation, as well as predominantly capital cost-driven procurement routes, represent just a few of the numerous barriers facing radically new innovations in the industry. Organisations within the industry

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will be required to re-examine their existing business operations and actively pursue the design and development of innovative solutions that enhance the ongoing energy performance of building systems. To unpack this challenge, we position our enquiry in the context of the growing debates surrounding sustainable transitions (Geels 2002) (Schot and geels, 2008). These studies found that sustainable transitions are stimulated by radical innovations which breakthrough in niches. A niche is a protected space where a radically new innovation is offered the opportunity to develop in isolation from wider market conditions in selective market, cultural, technological and geographical environments (Kemp et.al 1998). The studies suggested that sustainable transitions are brought about as niche innovations emerge due to instability in existing socio-technical regimes (Geels, 2005). The studies have taken on particular significance in policy studies where ongoing work explores the role of developing appropriate policies to protect and empower niches during the management of sustainable transitions (Smith and Raven 2012) (Schot and Geels, 2008). The socio-technical transitions studies offer a suitable perspective for policy studies because of their ability to examine the wider and longer term picture (Geels 2011). However, by placing the emphasis on understanding the wider perspective, there is an underlying tendency to over-simplify the micro-processes included in niche formation and development (Shove and Wlaker, 2010) (Smith et.al 2010). Research into niches as sources of radical innovation can be enhanced by paying greater attention towards the role of specific organisations in influencing the formation and emergence of niches. We purposively avoid taking a niche as a starting point because it offers the opportunity to retrospectively simplify the complex dynamics and multiple contradictions at play as new technologies acquire the form and function of a niche.

Therefore, the purpose of this paper is to examine how and under what circumstances do organisations pursue technological niches when transitioning towards greater servitization. To do so, we focus more explicitly on how the visions and goals of organisation actors interact with the wider selection environments to influence the motive to finance and protect the development of certain technological innovations. Case analysis unpacks a construction firm's pursuit of a technological niche in the context of their motivation to develop more servitized ways of operating. Existing research (Tukker and Tischner, 2006) suggests that by shifting their attention towards the through-life performance of the systems they design and deliver, there is the potential to develop new ways of increasing the on-going efficiency of their assets and collaborating with end-users to reduce energy consumption patterns. We observe how they explore integration of several technological innovations into one niche space as they pursue more servitized operations. Our findings indicate that the development of radical innovations is beyond the control of one organisation and that our case organisation’s pursuit of a technological niche was being framed by their continuous interaction with supply chain partners and reactions to customer demands. We also observe that constellations of technologies that gather momentum and backing separately can combine and complement each other to stimulate emerging niches. Furthermore, that the costs of implementing radical innovations were multi-layered. Therefore, the contribution of this article is two-fold. Firstly, that by elaborating on the development of visions and goals within certain organisation we can better understand the complex dynamics that play out as technologies acquire the form and function of a niche. Secondly, we elaborate on how a multi-level approach is required to deconstruct in greater detail the multiple interactions at play as firms in construction pursue more servitized ways of working.

SOCIO-TECHNICAL TRANSITIONS

The socio-technical transitions literature advocates that radical innovations emerge in niches (Schot and Geels 2008) (Kemp et.al 1998). Niches are depicted as being incubation rooms for radical novelties that are insulated from normal market conditions within protective spaces (Schot 1998). Geels (2002) introduces a multi-level perspective to enhance our understanding of how radical innovation within niche spaces can stimulate wider sustainable transitions. The emergence of these niches is understood as being dependent on the interplay between three different analytical levels: technological niches, sociotechnical regimes and sociotechnical landscapes (please see Geels (2002) for clarification of what these levels consist of). Changes at the landscape level are understood to trigger instability within existing socio-technical regimes which creates opportunities for emerging niches to breakthrough. Geel's draws upon the transition from sailing ships to steamships 1780-1900 within the shipping regime as the basis for his first study. The retrospective study found that the emergence of the steamships could be traced back to the development of a niche. The niche consisted of small wooden vessels using low pressure steam engines whose development had been stimulated through a range of macro and meso factors This most prominently included the emergence of inland waterways during the canal boom (Geels 2002). Subsequently, similar retrospective studies have explored how the emergence of niches has triggered socio-technical transitions (Geels, 2005) (Verbong etal, 2008). Subsequently, the concept of niches has been used to look forward and explore the implementation and diffusion of sustainable solutions (Smith 2005).

Whilst using niches as a means to examine the breakthrough of radical innovations has become increasingly popular, commentators maintain that greater attention needs to be paid towards the interdependencies and interactions between internal niche processes and external processes as niches develop (Raven 2005) (Smith 2007). Early research suggested that the successful emergence of a niche was dependent on three main internal processes: articulation and adjustment of expectations or visions, the breadth and strength of the network of social actors enrolled and learning and articulation process (Geels 2011). Raven (2006) suggested that the likelihood of niche innovations breaking through is dependent on the comparative stability of emerging niches and existing regimes. Smith (2007) analysis of the niches eco-housing and organic food illustrated that the translation of niches into regimes is a reciprocal process. Subsequently, a typology for depicting different pathways for socio-technical transitions brought about by niche innovations has been developed which are identified as: transformation, de-alignment and re-alignment, technological substitution and reconfiguration. By constructing these different typologies they acknowledge the need to shift away from a niche-driven bias and illustrate how the timing and nature of multi-level interactions conditions the pathways of transitions. Verbong et.al (2008) explored the relationship between parallel emerging niches within the Netherlands (solar PV, biomass and wind energy) and found that the breakthrough of one niche is dependent on the momentum surrounding parallel niches.

Understanding niches as opportunities for sustainable innovations has provided commentators with a tool to understand socio-technical transitions from a wider and long term perspective (Schot and Geels, 2008). However, it is by taking this more distanced view (Shove and Walker, 2007) that a tendency is developed to neglect how specific organisation are implicated by these transitions. Consequently, there remains a paucity of research depicting how organisations can develop new ways of delivering sustainable solutions (Shove and Walker, 2007) (Berggren et.al 2015). Indeed much of

the research on niches focuses on informing policy about how radical innovations can be constructed, protected and maintained (Shove and Walker, 2010). In this paper, we argue that greater attention should be paid towards how visions and motives towards more sustainable operations emerge within organisations. In doing so we can build upon the sustainability transitions literature by shedding greater light on how and why firms re-configure their processes towards radical innovations in niches. With this in mind, we do not take a 'niche' as our starting point but rather the *"pursuit of a niche"* becomes our route of enquiry.

RESEARCH SETTINGS: A CASE STUDY OF CONSTRUCTCO

The analysis presented in this article is drawn from a single case study of ConstructCo, a major contractor in the UK formed in 2001, with historical roots stretching back to 1848. ConstructCo has since expanded its operations beyond the UK to cover international markets in Canada, Europe, the Middle East, Asia and Australia. It is well-known for its role in delivering high-profile iconic projects. Access to study this transition was granted in earnest in December 2012.

Case Context

In this study, our research concentrated on the department within ConstructCo that focused specifically on the design, manufacture and installation of mechanical and electrical systems. In its quest to grow and diversify its revenue streams, they had embarked on a strategy (and emergent journey) of servitization. Our research team observed closely as they explored ways in which they could develop through-life solutions for the systems they deliver. Their emphasis was shifting away from selling products towards delivering value propositions geared around selling their customers the use and performance of their products. For example, rather than selling their customer a boiler system, they sell them the availability of heat to specific areas of the building. Existing research (Tukker and Tischner, 2006) (Mont 2000) indicates that by taking a view to take responsibility for the ongoing performance of their systems through-life they can radically reduce the emissions associated with those systems. They can do this by optimising the ongoing performance of their assets and developing innovative ways to influence their customers' usage processes. Shifting towards delivering these through-life solutions is requiring the firm to radically re-evaluate their business operations. Central to this process is the development of new technological properties within their mechanical and electrical products Indeed, evidence from other industries suggests that transitioning towards greater servitization often requires significant technological change (Lay et.al 2014) (Wise and Baumgartner, 1999) (Vandermerve and Rada, 1988) (Mathieu 2001). We observed within the company and across their value chain that new innovations geared towards greater modularity, greater embedded intelligence and remote monitoring capabilities were becoming increasingly available. However, the challenge of integrating all these innovations, which were located within different supply chain actors into one radically new through-life solution still remained a huge challenge. One way in which they were seeking to overcome this challenge was by actively seeking out specific markets and specific technological offerings in which they could integrate all these innovations into one servitized offering. Therefore, for the purpose of this paper we explored how and under what circumstances they were pursuing this potential niche.

Data Collection

The case study research was informed by two phases of data collection and analysis. The first phase involved an exploratory set of interviews (n = 24) with a range of key personnel in ConstructCo. The purpose of the exploratory interviews was to elicit perspectives from these interviewees regarding their experiences, highlights and challenges faced in their everyday routines. Because we wanted to capture perspectives that were relevant to the central theme of servitisation and technological change, we deliberately selected interview participants who were enrolled by selected mechanical and electrical technologies. This proved an invaluable phase for the research team to quickly enter the field as relative outsiders. The second phase entailed following a live hospital project. This yielded, to date, a further set of 17 interviews with participants directly involved in this hospital project. Additionally, follow-up interviews (n=10) with manufacturers and suppliers of technological solutions associated with ConstructCo and/or the hospital project were also undertaken. The interviews were supplemented by a range of other data sources, including non-participant observational notes developed by the research team, visual representations of the materials and technologies used on the project (e.g. schemes and drawings), and other forms of textual data (e.g. project documents, technical specifications, email correspondence etc.). This provided a rich set of data to help in piecing together a fuller picture of ConstructCo's journey towards greater servitization. The field notes and documentary evidence also allowed us, to a degree, to corroborate the claims made by our interviewees. Interviews were audio-recorded and transcribed verbatim.

Data Analysis

At the end of each interview, the interviewer would reflect on the interview and record, using interview summary sheets to identify key emerging themes that are striking from each interview. The transcripts were then read and reviewed by the two authors, and discussions ensued such that analytical categories would inductively emerge. Form our different data sources, we observed that three turns were apparent as the organisation were pursuing a niche for greater servitization. These turns were: establishing a business need, developing product intelligence and embarking on supplier development. For the purpose of this paper we analysed our transcripts to explore how our interviewees' everyday practices were changing in reaction to these three turns and ways in which they were questioning the implications of these turns on their own everyday practices.

FINDINGS AND DISCUSSION

In this section, examine how ConstructCo is pursuing a technological niche in engineering greater servitization. We present this transition through the three turns identified above. It is critical to note that these turns are not necessarily sequential; rather, the turns happen simultaneously.

Turn 1: Establishing a business need

ConstructCo's transition to greater servitization had at least two starting points, both relating to the need to respond to and drive consumer demand. By the time we entered the field in December 2012, ConstructCo was emerging from the fallout of the global financial crisis. The construction industry in the UK had seen its output fall by 8% in 2012 (see Construction News, 8 March 2013). This was exacerbated by ever-tightening public sector budgets. ConstructCo were keen to explore how they could

shift away from these product-dominant practices by leveraging ideas about servitization from other industries. Furthermore, there was a growing need for consumers to reduce the cost associated with energy consumption. This in turn created an opportunity for ConstructCo to look more seriously into servitising their mechanical and electrical product offerings.

As one of ConstructCo's Design Managers interviewed remarked,

"So we are in the building industry, we are still years away. So it's not only the automotive and aerospace probably in terms of monitoring and maintenance – predictive maintenance – I think we should look also to the supermarket and retail sector"

Another interviewee, a Construction Process Engineer, refers to the fact that in doing so they can capture and conceptualize new management opportunities to pursue greater opportunities within the product aftermarket:

you've got so much certainty around that that if your building diagnostics and everything else you are lining yourself up to delivering a long term service and we will have that capability going forward.

We observed how ConstructCo's motive of diversifying their revenue streams and surviving in a competitive but financially-constrained environment play out. We saw how ConstructCo actively sought to identify equivalence from other industries, learning from a diverse range of other industries including retail, automotive and aerospace. Indeed, as the aerospace sector is generally well-known for leading in the area of servitization, ConstructCo deliberately sought to recruit senior executives and engineers from that sector, in the hope of accelerating developments of their own model of servitization. This turn towards other industries began to raise new questions for ConstructCo, including exploring equivalence in the technological space (e.g. comparing aircraft engines with turbines in boilers) and trying to unpack similarities in terms of life cycle performance and critical components. Other forms of establishing equivalence included the need to alter the rules of engagement between ConstructCo and the clients. Comparisons were often made between the construction sector and the automotive and aerospace sectors to see how contractual obligations ought to change towards performance guarantees for different M and E technologies. Thus, in establishing a need for a technological niche, ConstructCo actively turned to learning from how other sectors transformed their operations through developing new tools (or technological devices), new rules of engagement, and new communities of practice, geared towards increasing the reliability and efficiency of their products.

Turn 2: Developing product Intelligence

The turn towards learning from other industries revealed to ConstructCo the need for developing new knowledge and competences. More specifically, there was a need to create new product intelligence that was not required before within a product-based way of working. This new intelligence related to understanding performance envelopes and interfaces between design, manufacturing, and maintenance. A service-based way of operating required deeper understanding of how mechanical and electrical products were used, and how the products were themselves interacting with one another within the services system. We observed how ConstructCo were now trying to answer these new questions by investing in a whole range of new activities, including capturing asset information through building information models, interrogating performance envelopes (e.g. through technical data sheets, historical

models and datasets, facilities management helpdesk records etc.) more carefully to consider how new maintenance regimes would work, and integrating new technological products such as pressure, temperature and flow sensors. Thus, we see how developing the technological niche demands the incorporation of yet new specialisms (e.g. BIM modellers) and new devices (e.g. sensor technologies). In turn, these new models, devices and competences enabled the existing ConstructCo staff to change in their thinking. As the Lead Mechanical Engineer interviewed noted, the use of these new sensor technologies stimulated the need to deepen his understanding of their products. He was no longer thinking in terms of systems but deconstructing how things work at a component level:

"So then the big challenge is understanding the physics of failure"

Throughout our case study research, we see the creation of new spreadsheets and new ways of coding data within ConstructCo as they attempted to get closer to understanding the physics of component failure. Yet, this creates the information paradox; that is, there is now so much data that it requires more people and intelligence to analyse the data and do something with this analysis. Thus, we find Engeström's framework useful again to unpack the turn towards developing new product intelligence. The realisation of the need to develop new technological devices raises new questions about how products are used and how products interface with one another at both a system and component level. This again enrols new actors (e.g. BIM modellers) and new rules for recording technical data not only of the product but also of its use. This in turn calls for the embedding of new sensor devices. It is the embedding of new sensor devices that ConstructCo has to also turn to developing its suppliers.

Turn 3: Embarking on supplier development

"No. I think the supply chain for the construction industry is not ready for that. So if you buy, you know, a clamp for an injection system of a car then you know, because they are used every time BMW buys a part, they want to know a lot of stuff; like a medium time between failures, you know, they want to know everything. But we are not used to that level of detail in the construction sector." (Lead Mechanical Engineer)

In developing a technological niche that would help in ConstructCo's transition towards greater servitization, we have previously described how they turn externally to the marketplace, and how they turn to reflect internally on their (lack of) intelligence. This involved the need to capture new forms of data and data modelling, facilitated by the use of sensor technologies to help ConstructCo better predict failure. To accomplish this requires ConstructCo to turn towards their suppliers. But, there are hurdles in this respect. As an interviewee working for a chiller manufacturer noted, sharing of knowledge between suppliers and ConstructCo can be difficult, especially where failure rates are concerned.

"The thing I think our factories do have, is failure rates for some of the key components, but yes I don't think our factories are going to want to give that."

Nevertheless, we have also observed instances where ConstructCo collaborates with their suppliers to develop new technologies. Here, we hear of how a long-term partnership between ConstructCo and a boiler manufacturer facilitated the desire on both sides to develop a new 'intelligent' boiler:

"This is a good point. The secret is in long term relationships. So with [these suppliers], we had dozens of meetings with them because they are now our preferred supplier. So we can do some co-design. They tell us their new developments, so they tell us, "Oh, in two years I am going to launch a new boiler." So, "Oh, interesting; so can you add this feature because it's interesting for us?"

Therefore, using Engeström's Activity Theory framework, we can see that ConstructCo's object of developing more intelligence has resulted in the need to have meaningful conversations about embedding technologies like sensors within the products offered by their suppliers. This can be challenging given the short-termism and fragmentation that typically characterises the construction industry. But, by adjusting the rules of engagement - through incentivising long-term partnerships in the case of the boiler manufacturer - we can see how this can pave the way for greater collaboration and co-production of technology between ConstructCo and their suppliers.

CLOSING THOUGHTS

The reduction of energy consumption within buildings over the next 20 years will continue to play a prominent role within the global drive to reduce energy consumption and carbon emissions. There will be increased scrutiny on organisations to deliver radical innovations geared around energy efficient solutions. The socio-technical transitions literature indicates that radical innovations often breakthrough in the form of technological niches. However, because these studies take a more distanced view they often underplay the complex micro-level dynamics at play during the formation of niches. Therefore, in this paper we propose a different approach. Rather, than taking increased technological complexity, increased technological intelligence or a new technological niche as a starting point for conditioning greater servitization, we subtly change the focus towards analysing what happens within an organisation as they pursue the development of a technological niche. We have drawn upon extensive research with ConstructCo, a supplier of mechanical and electrical products, to unpack the interactions and developments that take place within the organisation as they pursue a technological niche when they transition towards the delivery of servitized solutions. Servitized solutions offer the potential to develop new revenue streams as well as reduce the consumption levels of their customers We observed that during ConstructCo pursuit of the development of a new technological niche that three main turns (a new business need, developing product intelligence embarking on supplier development) were increasingly conditioning new processes and new relationships within the organisation. By tracing how events unfolded as they pursued a niche we unpacked new dimensions of complexity with respect to the multiple costs that organisations face when they implement radically new innovations. Furthermore, we observed how the pursuit of radical innovations was underpinned by an aspiration to proactively steer the pathway of sustainable transitions by taking greater control of consumption processes. We recommend that research must pay greater attention towards the role that specific organisations play in socio-technical transitions. In doing, so we can shed greater light on the interactions and contestations that play out during the formation and development of niches innovations in construction. This will allow future studies to add a new dimension to existing sustainable transition studies when conceptualising niches as a source for radical change.

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