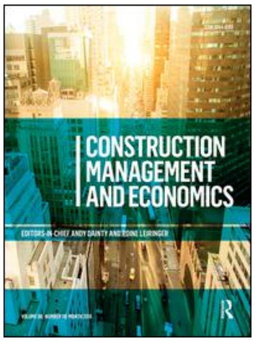

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The impacts of industrialization on construction subcontractors: a resource based view

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ABSTRACT
Industrialization of the construction process is increasing around the world due to its potential to improve safety, sustainability, effectiveness, productivity and efficiency. While there has been research into the impacts of various forms of industrialized construction on the construction sector, surprisingly there has been little research into the impacts on subcontractors. The lack of subcontractor's voice in the industrialization debate is important to address since they operate at the coalface of the industry where the impacts of such changes will have a significant impact. The resource based view of the firm (RBV) is used as a theoretical lens to study these potential impacts through interviews with senior executives and managers of six major subcontracting firms which have worked with off-site bathroom pod technologies in Australia. It is found that the key subcontractor resources affected by this off-site technology are human, financial, intellectual and social and that subcontractors will need to pursue strategies which develop new skills, knowledge, networks and deeper supply chain collaborations if they are to turn the potential risks associated with off-site into potential opportunities to achieve competitive advantage.

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Off-site; sub-contracting; resource based view

Introduction

Industrialized construction applies production processes and technologies from the manufacturing sector to construction in order to improve key project objectives of time, cost, quality, environment and safety (Gann 1996, Egan 1998, Gibb 1999, Lawson *et al*. 2014). The concept of industrializing construction activities is not new. However, today the concept is much more complex with various overlapping definitions used throughout the literature, including: off-site production (OSP) (Nadim and Goulding 2011); off-site manufacturing (OSM) (Hampson and Brandon 2004); Prefabrication (Prefab) (Steinhardt *et al*. 2013a, Steinhardt *et al*. 2013b); modern methods of construction (MMC) (Rahman 2014); Industrialized Construction (Lewicki 1966); and modular construction (Modular) (Parrish 2012, Lawson *et al*. 2014). In order to avoid any confusion we adopt a typology developed from the work of Lewicki (1966), Gibb (1999) and Gibb and Isack (2003) who introduced a simple hierarchical model to classify various levels of industrialization of construction techniques (Figure 1).

Traditional building is craft-based construction by hand which involves *in situ* manufacture and installation of prefabricated elements such as windows, doors, pipes, roof trusses, bricks, tiles, etc. On-site prefabrication is the assembly of building components on-site which are then moved into position such as timber framing, handmade roof trusses or façade units. In contrast, off-site prefabrication involves the off-site assembly of building components such as roof trusses or air conditioning units which are then transported to site and assembled in place. Pods are pre-assembled units such as toilets or bathrooms manufacturer off-site that enclose space which are transported to site to be connected to other building elements. At the highest level of industrialization to date, complete modular encompasses fully finished units that form the complete structure and form of a building.

This paper focuses on pods as one particular type of industrialization in the context of the Australian construction industry because of its growing use and due to numerous research projects and government reports in Australia which have highlighted its many potential benefits (CIDA 1993, Hampson and Brandon 2004, Blismas and Wakefield 2009, Mostafa and Chileshe 2015). Pods are also increasingly used in many other countries particularly in the residential building market where customers are open to industrialization as a way to meet shortages of affordable housing (Allison and Parker 2014). Pods may be load bearing or non-load bearing modular units, typically used to install highly serviced building components. Pods are normally manufactured entirely off-site through

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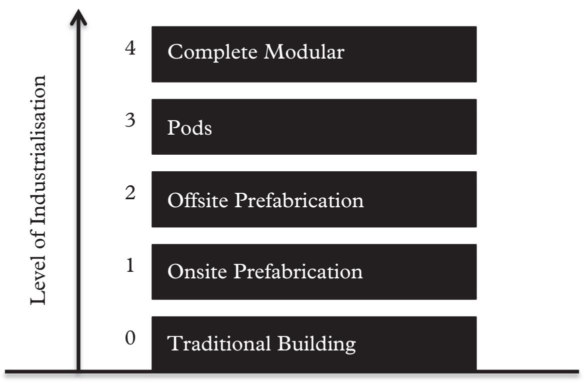


Figure 1. Industrial construction hierarchy adapted from Lewicki (1966) and Gibb and Isack (2003)

a production line process modelled on car manufacturing, complete with all internal finishes. They are then transported to site for installation by a specialist installer which works alongside traditional subcontractors to connect the pod to the building services and functional elements. The pods are then commissioned and tested to ensure functional performance.

However, the construction industry is well known for being slow to adopt new innovations such as pods in comparison to other industries (Loosemore 2014, Goulding *et al*. 2015). Furthermore, to date, the limited research on pods (Kempton and Fergusson 2004, Taylor *et al*. 2009) and on the adoption of innovations in general, has neglected to sufficiently consider the special innovation challenges faced by the multitude of subcontractors that dominate the construction industry in adapting to these types of new emerging technologies (Sexton and Barrett 2003, 2005, Barrett *et al*. 2008). Giving subcontractors a voice in this debate is important, not only because of their critical role in the adoption of such innovations but because subcontractors are likely to face very different challenges in adopting new innovations than large firms. As Sexton *et al*. (2008) found, subcontractors are typically smaller, more highly geared and less technology-intensive than larger construction firms and lack the scale and slack human, physical, intellectual and financial resources to invest in innovation (Sexton *et al*. 2008). Demonstrating the complexity of this issue, Koebel *et al*.'s (2004) investigation into innovation diffusion in the US residential market found that national and regional firms, multi-family and modular builders, and custom builders are more likely to adopt innovations such as industrialization than single-family production builders. They also found that large builders tend to be first to adopt new technologies that offer cost savings, improvements in production, reduced call-backs, or reduced exposure to liability. In contrast, smaller builders are often first to adopt technologies where high consumer awareness of a material exists. Interestingly, Koebel *et al*. (2004) also found that early-stage adopters tend to rely on technology transfer programmes and universities more than middle or late-stage adopters. Furthermore, they tend to be proactive in educating their customers about the benefits of new technologies, employ technology advocates in their business and reduce path dependencies on traditional risk-averse supply chains. Finally, first movers tend to be less concerned about immediately profiting from innovation and stress the longer-term contributions of innovation to culture and productivity. In contrast, middle- and late-stage adopters tend to be locked-into established supply chains, are more likely to learn about new technologies from other builders and trade shows and will wait for others to show that the benefits and costs of new technologies are known. However, in general they argue, there is substantial financial and market risk associated with innovation in residential building where product failures among risk-averse customers, can cost builders dearly, both in direct losses and in damage to the firm's reputation.

Within the above context, the aim of this paper is to explore the impact of emerging industrialized pod technologies on subcontractors in the Australian residential construction market. More specifically, given the above discussion which demonstrates the importance of intellectual, financial, human and social resources to innovation in the residential construction sector, this paper will explore the value of the resource based view (RBV) of the firm as a theoretical basis to better understand which subcontractor resources will be affected by this new technology, providing new strategic insights into how subcontractors should adapt.

The opportunities and risks of industrialized construction

The modern drivers of industrialized construction are influenced by a holistic view of the industry, with advantages spread through the whole building lifecycle covering design, manufacturing, construction and facilities management (Nadim and Goulding 2011, Goulding *et al*. 2014). For example, Jaillon and Poon (2008) found a saving of up to 20% compared to on-site construction time on Hong Kong construction sites, following adoption of off-site prefabrication. Gibb and Isack (2003), Blismas and Wakefield (2009) and Steinhardt *et al*. (2014a) point to numerous indirect cost benefits associated with off-site prefabrication associated with reduced site preliminary costs, reduced site congestion, and earlier income generation for clients, etc. Court *et al*. (2009), Gibb (1999) and Chen *et al*. (2010) show that off-site prefabrication can also reduce safety risks by about 35% due to, less site congestion and removing operatives from a dangerous site environment to a controlled factory environment with better working conditions. Off-site prefabrication has also been proposed as an effective way of reducing the negative environmental impacts of construction (Chen *et al*. 2010) through reduced waste, increased reuse and recycling and reduced emissions on-site and in use (Jaillon and Poon 2008). At the same time, construction quality and maintenance costs are also said to be improved through opportunities for tighter managerial control of production (Gann 1996, Steinhardt *et al*. 2013a). Indeed, Pan *et al*.'s (2008) survey of the top 100 UK house builders identified achieving high quality as the most important driver for utilizing off-site prefabrication. Finally, there are said to be many advantages associated with off-site prefabrication around skills and diversity. For example, Blismas *et al*. (2006) and Blismas and Wakefield (2009) found that off-site prefabrication reduced the need for many trades that are currently in short supply and Steinhardt *et al*. (2014b) and Loosemore (2014) argued that off-site prefabrication has many benefits for groups which are normally excluded from the construction labour market such as the aged, disabled and women.

However, numerous barriers have also been identified in the effective uptake of off-site technologies such as: lack of technology awareness; supply chain capacity constraints; cultural perception; lack of viable business process models/solutions; high initial investment costs; incompatibility and inflexibility of designs; separation of design from manufacturing; perceived higher overall cost; logistics and transportation challenges; and a lack of skills to work with these new technologies and components (Gibb 1999, Chiang *et al.* 2006, Lu and Liska 2008, Loosemore 2014, Rahman 2014, Goulding *et al.* 2015). In Hong Kong, the Provisional Construction Industry Coordination Board has noted upfront investment remains a significant barrier to the adoption of off-site prefabrication techniques and to unleashing the full potential of cost savings (Chiang *et al*. 2006). Pan *et al*. (2008) found the most significant barrier to the adoption of off-site prefabrication was high initial set-up costs and in a survey of 47 UK industry professionals (including clients, consultants, contractors and manufactures). Rahman (2014) found the main barriers were cost and design incompatibility and flexibility issues. This was supported by Lu and Liska (2008) who also found that inflexibility of design was a major challenge because off-site prefabrication requires and an early design freeze, whereas the industry has become accustomed to projects progressing with incomplete designs which involve numerous changes and adaptions throughout construction. Transportation and logistics issues are also seen as major impediments to the adoption of off-site prefabrication (Nadim and Goulding 2010) and in both US and Australian studies by Lu and Liska (2008) and Blismas and Wakefield (2009) identify other related constraints around industrialized component sizes, transportation costs, congestion, community impacts and the need for special permits. The location of both site and manufacturing facilities is also seen as a major determinant of off-site prefabrication viability, particularly in countries like Australia where there is no longer a strong domestic manufacturing capacity (Loosemore 2014). Furthermore, Gibb and Isack (2003) highlight the need for high levels of supply chain co-ordination between designers, developers, builders, manufacturers and suppliers to enable the benefits of off-site prefabrication to be fully realized. As Goulding *et al*. (2014) argue, successful off-site prefabrication requires three traditionally separate groups of people with very different skill sets to work more effectively together: designers, manufacturers and constructors. Goulding *et al*. (2014) found design and manufacturing stakeholders could easily adapt to the changes required when adopting off-site prefabrication. However, in contrast, he found that other construction stakeholders, such as subcontractors, would require significant help to do so. The finding that on-site workers may not possess the skills required for adoption of off-site prefabrication technology is reinforced in findings by Lu and Liska's (2008) study of US general contractors, architects and engineers.

The RBV of the firm

A central theme which emerged from the literature above is that a firm's resources and the way that they are used and managed are central to the adopting of industrialized construction. However, there has been no research into how a firm's resources can be affected by the adoption of off-site technology such as bathroom pods. To this end, the RBV of the firm is a useful theoretical lens since it recognizes that every firm has a unique pool of tangible and intangible resources which interact in unique ways to give a firm its distinct identity and ethos (Penrose 1959, Wernerfelt 1984, Rumelt 1984). In simple terms, the RBV suggests that the resources possessed by a firm are the primary determinants of its competitive advantage. These resources include: Financial (cash, capital, etc.); physical/technological (land, premises, plant, etc.); organizational (culture, reputation, relations, etc.); human (people, experience, expertise, etc.); intellectual (knowledge and ideas); and social (relationships, networks, and connections) (Rumelt 1984, Wernerfelt 1984, Barney's 1991). The RBV argues that a firm's sustainable competitive advantage is maximized when these resources are rare, valuable, inimitable, non-tradable and non-substitutable, as well as firm specific (Barney 1991, Makadok 2001). It also argues that firms should develop and protect resources that possess these attributes (Crook *et al*. 2008) and focus on building unique "imitable capabilities", "core competencies" and "dynamic capabilities" based on its unique resources (Prahalad and Hamel 1990, Teece *et al*. 1997, Eisenhardt and Martin 2000).

However, the RBV is not without its critics. For example, Priem and Butler's (2001a, 2001b) formative criticism of Barney's (1991) original work raised many key points of criticism which include: its tautological and self-verifying nature and its lack of empirical content to enable generalized causality to be proven. According to them, the theory does not explain how different resource configurations can generate the same value for firms. They also argue that the role of product markets is underdeveloped in the argument, there is a limited focus on capabilities, success could be attributed to a number of reasons other than unique resources, and the theory has limited prescriptive implications. Furthermore, there is insufficient focus on depreciating resource value and it is extremely difficult in practice to find a resource which satisfies all of the Barney's (1991) criteria. Also, there is the assumption that a firm can achieve competitive advantage as long as it can exploit advantageous resources, but this may not necessarily be the case since many other competitive factors and industry-specific influences can be at play. Indeed, through external changes, initial competitive advantage from unique resources could be nullified or even transformed into a weakness. Finally, Ritsumeikan (2005) argues that the RBV has overlooked the role of entrepreneurial strategies and entrepreneurial abilities as one of the crucial sources of the competitive advantage of a firm. Ritsumeikan (2005) argues that a firm's main source of competitive advantage is not the heterogeneity of its resources and dynamic capabilities, but the abilities of the entrepreneur to recognizes and capture the future value of these resources to enable core capabilities to be harnessed to meet a firm's vision and strategy.

However, despite these criticisms the value of the RBV in understanding construction innovation has been recognized by Barrett *et al*. (2008) who argued that the potential for innovation does not come from the unique resources a firm owns but from how a firm uses and develops them to drive innovation. Barrett *et al*. (2008) argue that the proactive "resource-push" view of innovation offered by the RBV (where firms innovate because they can), provides a more stable grounding for construction innovation research than the dominant reactive "market-pull" orientation (where firms innovate because they are asked by clients). As Loosemore and Phua (2011) and Loosemore and Richard (2015) have found, the reality is that very few sophisticated clients will specifically ask for an innovation or be prepared to pay for it. So market-pull theories are of little value in understanding what drives firms to adopt new technologies in construction. Furthermore, research by Barney (1986), Green and Brown (1997), Boxall (1998), Rangone (1999) and Leila *et al*. (2006), has shown that it is possible to successfully utilize the RBV to understand strategy in SME's which are similar to the many subcontractors that characterize the construction industry. However, no one has yet used the RBV as a theoretical framework to understand the impact of new innovations such as pods in the construction industry. To this end, the following section discusses in more depth, how each of the resource categories in the RBV might be affected by off-site in the construction sector.

Financial resources

Green and Brown (1997) define financial resources as funds from any monetary source used to start, operate and grow the business. These funds are known as a firm's working capital (Elsas *et al*. 2014) and according to Garcia-Teruel and Martinez-Solano (2007) firms can adopt an approach along a continuum from conservative (maintaining high levels of working capital to reduce risk) to aggressive (investing heavily to increase efficiency and production). As discussed above, off-site prefabrication requires significant up-front set-up costs, requiring a firm to move towards a more aggressive working capital strategy, at least in the short term, as capability is built-up. However, this might represent a major challenge for many subcontractors, not only because they are generally highly geared and might find it difficult to secure necessary finance, but because the majority of these firms' financial resources are also normally held in the form of "cash" assets (White *et al.* 2003).

Physical resources

A firm's physical resources include the raw materials or products, tools and equipment, plant and buildings used to create an organization's products and services. The adoption of off-site prefabrication by a subcontractor has obvious implications for its physical resource base since it will likely require the purchasing or renting of new manufacturing equipment and facilities, transportation technologies and installation equipment which is different to those needed for traditional construction processes. Off-site may also result in the abandonment of traditional physical assets which are no longer needed such as equipment around wet trades. The physical capital requirements associated with off-site will vary depending on the decision a subcontractor takes about manufacturing their own components (alone or in partnership with existing manufacturers) or simply buying ready-made components from established manufacturers.

Organizational resources

A firm's organizational resources fall into three categories: firm structure; systems and policies; and culture (Barney 1991, Haeri and Rezaie 2014). Although there is currently no research on what impact the adoption of off-site prefabrication might have on a subcontractors' organizational resources, contemporary models of innovation proposed by researchers such as Eisenstat *et al*. (2001), Tidd (2006), Samson (2011) and Muller and Becker (2012) offer some insights. These researchers argue that modern innovative companies must develop a "systematic" innovation capability and innovative culture which develops a flexible portfolio of resources which they can bring to bear on promising opportunities. In these decentralized, organic, opportunity-based firms, quasi-autonomous business units are connected by a corporate centre. Resources from multiple business units are not held in silos, as in traditional businesses, but are organized around emerging opportunities in different parts of the organization. Eisenstat *et al*. (2001), Tidd (2006), Samson (2011) and Muller and Becker (2012) offer some insights. These researchers argue that in the modern business environment, few firms have all the resources to be able to innovate. So they must pursue partnerships which facilitate the collaborative co-creation of new knowledge, products and services in deeply integrated supply and demand chains. In other words, subcontractors will need to secure new supply and demand chain partnerships to allow them to secure the resources, connections and knowledge they will need to make off-site prefabrication work.

Human resources

Human resources refer to the individuals who make up the workforce of an organization and their associated commitment, skills and capabilities. In contrast to manufacturing which is typically technology-intensive, construction is a service-based industry which is inherently labour-intensive meaning that adopting an innovation like off-site prefabrication, which typically involves less people on-site, has a strong human and behavioural dimension (Sundbo 1996). As Gronroos (2000) shows, even when a service-based organization develops a systematic innovation capability, innovations themselves must be developed by the people working in that organization, often working closely in collaboration with customers as co-producers of knowledge. So the adoption of off-site prefabrication is likely to have many implications for a subcontractor's human resources. Less people may be needed in certain roles, new attitudes, knowledge and skills will be required and old ones replaced or adapted, meaning that people will need to be educated and given opportunity to experience and work with the new technology. Industrial relations will need to be managed to navigate around fear and resistance to change, traditional role demarcation, changes in status and power and even the potential loss of jobs linked to the replacement of people with old redundant skills (Loosemore 2014).

Intellectual resources

A firm's intellectual resources refer to the intangible assets provided by a firm's employees' knowledge and experience and is typically measured by assets not normally listed on a firm's balance sheet such as the number of patents, trademarks, copyrights, and other results of human innovation and thought (Edvinsson and Malone 1997, Choo and Bontis 2002, Leila *et al*. 2006). A simple way of measuring a firm's intellectual capital is the amount by which its market value exceeds the value of its tangible (physical and financial) assets. In terms of adopting off-site fabrication, a firm's intellectual resources are likely to be very important in developing and protecting competitors from copying new products and services. Off-site prefabrication by nature involves new technologies or new combinations of old technologies which already exist and the knowledge required to do this will often not exist. New knowledge will also be required about how to install and transport these new products and new services, supply chains and value streams built around them.

Social resources

Social resources (or social capital) is the most intangible resource a firm possesses. As Nahapiet and Ghoshal (1998) and Burt (2005) point out, the central proposition of social capital is that a firm's connections and positioning in its network of relationships represent a valuable resource. Social capital differs from traditional sources of capital in the sense that it is intangible and tacit, it is located outside the business in relations with others and is not owned by any specific firm. It is also important to realize that a firm's social networks do not translate automatically into social capital. Rather, it is the positioning of a firm in its social network and the nature and quality of its relationships with others in that network which creates its social capital (Nahapiet and Ghoshal 1998).

Gann (2000) and Walker and Rowlinson (2008) have both pointed to the potential of collaborative models of business and project organization to stimulate innovation in the construction industry. Therefore, social capital is a critical resource for subcontractors engaging in off-site prefabrication because they will need to develop new supply and demand chain partnerships to allow them to secure the resources, connections and knowledge they will need to make off-site prefabrication work.

Method

By using the RBV as a conceptual lens, the discussion above suggests the process of moving from traditionally craft methods to off-site prefabrication will impact significantly and in many ways on a construction subcontractor's financial, human physical, intellectual, social and organizational resources. To better understand what these impacts might be and how they may need to be managed differently in the future, data was collected around the utilization of modular bathroom pods in the Australian residential high-rise building sector. Modular Pods and residential high-rise buildings were chosen as the focus of analysis because as stated above, they are an increasingly popular form of advanced (Level 3 – see Figure 1) off-site prefabrication in many countries (Vokes and Brennan 2013). The most common types of pods used in Australia are bathrooms, kitchens and plant rooms. Bathroom pods were chosen as the focus of this research because their widespread use across the construction industry. Bathroom/toilet pods have been used "ad hoc" on commercial and government buildings since the 1980s (Lawson *et al*. 2014) and in UK, Pan *et al*. (2008) found 44% of the top 100 house builders thought kitchen and bathroom pods offered the greatest potential for OSM. Furthermore, bathroom pods offer a unique window into the impacts of off-site technologies on subcontractors since they are particularly complex and affect at least five different trades to achieve a high-quality installation and finish. Bathrooms are also well known to account for a large proportion of rework due to poor quality and for a relatively small space with high-quality requirements, bathrooms offer an excellent opportunity to gain an insight into the impact of off-site prefabrication technologies on a wide range of subcontractors in the construction industry.

Following Silverman's (2010) research design methodology, this research adopted a qualitative approach, which used semi-structured interviews designed to: examine the impact to subcontractor's firm resources of the move from traditional craft-based construction to off-site prefabrication; and to examine the impact on different subcontractor resources and success strategies through the lens of the RBV. In developing the interview questions a pilot study was undertaken by interviewing six construction professionals from different backgrounds. This revealed that some of the resource categories identified by the RBV (especially social and organizational capital) were poorly understood in the proposed sample frame and that the interview questions had to be simplified and clarified to ensure that every respondent was talking about the same thing. The final interviews were divided into three parts. Part one collected data about the firm's background, trade, size, operating sectors. Part two was designed to collect information about a firm's experience of using bathroom pods and part three was designed to collect information about the impact of bathroom pods on its financial, physical, intellectual, human, social and natural capital/resources. The interviews typically lasted for about an hour and interviewees were emailed a copy of the interview before it was conducted to allow them to think about it in advance. Price (2010) implemented specific strategies when interviewing directors and managers of small to medium sized enterprises to maintain consistency and reliability in the data. These strategies were used here and included active listening, interview flexibility and probing questioning and this guidance was followed in the conducting of our interviews for this research. The population for this study was all subcontractors working in the Australian construction industry and the sampling frame were subcontractors that had worked on bathroom pods. To obtain a representative sample we used non-probability snowball sampling (Berg 2006) which involved starting with a small sample of subcontractor senior managers who had worked with bathroom pods and asking them to nominate others who had similar experience. Bathroom pod technology is relatively new in Australia and this process resulted in a sample of only six subcontractors represented by senior managers with experience of working on projects which had used bathroom pods as detailed in Table 1. While we could have interviewed other managers in the same firms, after interviewing each senior manager we felt that no further insights would be gleaned from lower managers in the same firms. We also noted, in analysing the results as we were progressing, that the same themes were emerging in the data as illustrated in our

Table 1. Sample description

Respondent	Position	Trade	Firm age (years)	No. pod projects	Size (No. employees)	EBA status	Turnover million ($)
R1	Director	Hydraulic	10	2	18	No EBA	14
R2	Director/State Manager	Mechanical	30	2	60	No EBA	70
R3	Director	Electrical	23	2	56	Yes EBA	12
R4	Director/State Manager	Mechanical	30	3	197	Yes EBA	140
R5	Director	Hydraulic	4	2	95	Yes EBA	22
R6	Director	Hydraulic	60	3	150	Yes EBA	40

Note: EBA = Enterprise bargaining agreement with construction union exists.

ongoing Leximancer analysis (see below) which mean that our sample of six subcontractors had enabled us to reach theoretical saturation (Fusch and Ness 2015).

The data from the semi-structured interviews was transcribed and analysed using Leximancer software (Leximancer 2011). In contrast to content analysis which involves the manual pre-coding of data to produce a coding framework (Myers *et al*. 2012), Leximancer uses a process based in advanced computational linguistics and Bayesian theory to produce results without the requirement for manual pre-coding (Sotiriadou *et al.* 2014). The software performs an automatic content analysis, utilizing a thesaurus as a classifier Rooney (2005) and Smith and Humphreys (2006) cites a high level of coding stability and highly stable concept maps as key advantages of this approach. In addition to extracting concepts and themes from the data, Leximancer identifies underlying connections within and between concepts and themes and graphically presents the results in a concept map. In an assessment of qualitative software, Sotiriadou *et al*. (2014) divided computer assisted qualitative data analysis (CAQDA) tools into two categories: tools that emphasize the manual handling of data (e.g. NVivo and Atlas.ti); and tools that provide automated analysis based on statistical properties of text (e.g. Leximancer). While NVivo has been the most widely used software package to date in qualitative management and business studies, the use of Leximancer software has been growing steadily since it is useful when there is no "a priori" theory to develop a coding framework and does not require the researcher to code data, introducing potential bias into the results. However, the main limitation of using Leximancer as an analytic tool is that while the software produces mapping and relational data, the eventual results depend on the researcher's skill in interpreting the concept maps it produces. A typical concept map is illustrated in Figure 2.

Concepts are essentially related words occurring with a high frequency throughout the interview transcripts and are clustered together through attractions defined by the frequency of co-occurrence within a coding block. Concepts with high co-occurrence will therefore group closer together on the concept map. The lines of connection define links between concepts and proximity of concepts gives an indication of association strength. Leximancer also produces a table of ranked concepts by: Relative Frequency (Rel Freq), Strength and Prominence (see Table 3 under results). Relative Frequency (Rel Freq) is a measure of the conditional probability of the concept, given the category. Strength is a measure of the conditional probability of the category given the particular concept. Prominence is a combination of the strength and relative frequency, given by joint probability/product of marginal probabilities.

The themes generated by Leximancer are higher-level groupings of related concepts and are labelled using the most prominently occurring concept within the cluster. Each theme is graphically represented on the concept map as a coloured circle. Circle colour and size is directly proportionate to the relevance of a theme within the data. Leximancer produces a themes report (Figure 3) which includes the connectivity and relevance ratings of each theme on the map. The connectivity score indicates the degree to which each theme is connected to others and the relevance column represents the importance of each theme.

Utilizing Leximancer's review function to interrogate the source of these concepts within the narrative response identifies the Resource Category "most" associated with a particular theme. This understanding allows connections to be drawn between the Qualitative data (interview Responses) and the Quantitative outputs of Leximancer. For example the third theme from Figure 2 is Pods which comprised of the concepts Pods, Resources, Human, Financial and Having. When the concepts source within the text is extracted the concepts are identified as highly associated with a response to the interview question regarding Human capital. Hence the authors can draw conclusions as to the link between a Leximancer output theme and a particular RBV resource category.

In reporting our results narrative analysis was also used narrative to assist in contextualizing the individual perspectives of each respondent, while allowing the expression of individual connections and differing views. Narrative analysis has evolved from what has been described as the "narrative turn" in social science research. As Reissman (2008) points out, the key skill in good narrative analysis is an ability to produce a good narrative account of a phenomenon, using questions which are inculcated early on. The questions used in this research were deliberately broad to allow respondents to follow their own individual and "instinctive" path through their experiences.

Although there is some dispute among researchers about whether the results of narrative analysis should also be presented as a narrative (Connelly and Clandinin 2000), it was decided to summarize the narrative of the discussions in selected quotes rather than reduce the data to quantitative counts of variables. There are two reasons for this. First, Leximancer effectively conducts a numerical analysis of the data and second, we wanted something to complement this and communicate the full richness of insight contained in the narratives we collected from these highly experienced respondents. As Meisel and Karlawish (2011, 2023) argues that the power of narrative is in translating respondent accounts into data that people can comprehend.

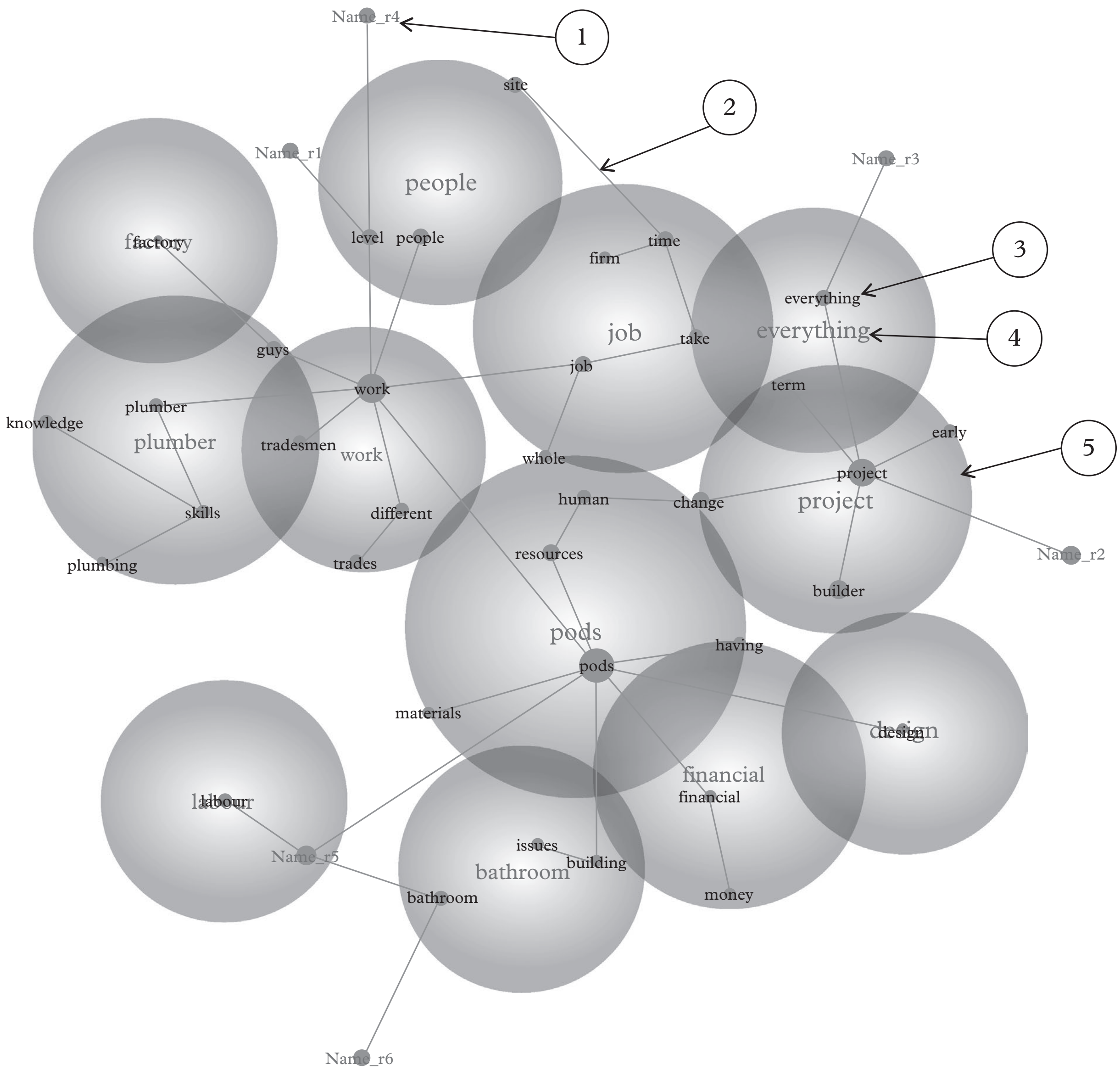


Figure 2. Leximancer concept map

Results

Table 2 shows the results relating to the general impact of bathroom pods on our respondents' businesses.

Table 2 shows a balance between positive and negative impacts although the respondents who argued for negative impact were more extreme in their responses.

The narrative analysis of our interview transcripts in relation to each type of RVB resource explains this further.

Physical resources

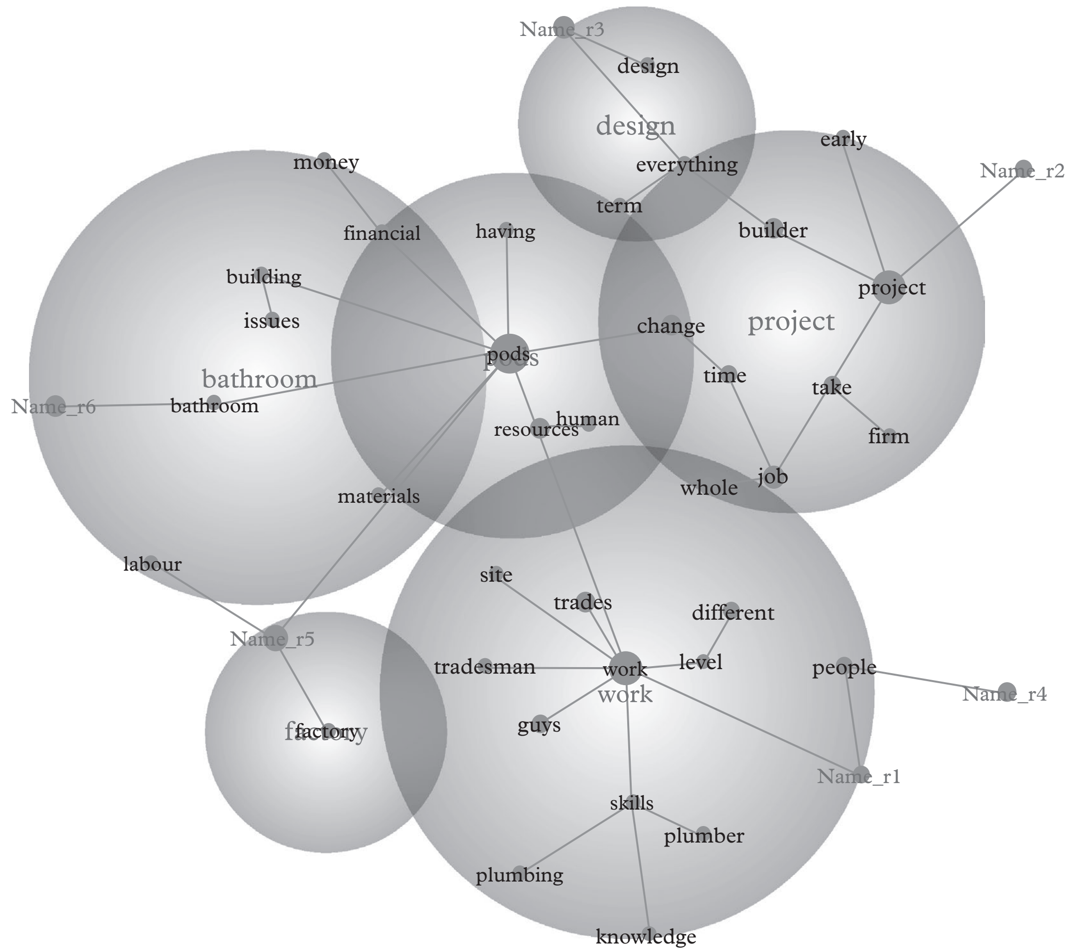
The respondents indicated that bathroom pods had not resulted in any significant change to the tools, equipment, office space and technology used by their firms and that there was a general reluctance to invest in new resources to position them for the future.

> No [change] you still have to have the same office, tools, and that to run the company. So the overheads still all run the same. R1

With further probing, it was evident that there was a clear demarcation between trades regarding changes to physical resources but also an important link between physical and financial resources. For example, respondents in the hydraulic trades argued that bathroom pods reduced the physical raw materials they invested in a project. These were resources from which they traditionally derived significant income.

> They [pods] are taking the whole cream of the job its gone, I don't see any other avenues to get the cash. R1

The results also show that the resources of different trade subcontractors are impacted in different ways. For example, mechanical subcontractors pointed to the need for



Theme	Connectivity	Relevance
project	100%	
work	92%	
pods	60%	
bathroom	26%	
design	07%	
factory	03%	

Figure 3. Concept map and summary output

Table 2. Overall impact of bathroom pods

Respondent	Impact	Impact category	Why
R1	8	Negative	Financial
R2	3	Positive	Small impact
R3	6	Positive	Better projects
R4	7	Positive	Smoother project
R5	9	Negative	Financial
R6	9	Negative	Financial

upgraded information technology (IT) systems to improve coordination with new pods manufacturers in the supply chain.

> I think with the pods we should have done them in 3D it would have helped especially with the prototype pods [for coordination]. If you move to hospitals or other led typical you will need 3D. R4

Financial capital

All respondents noted the impact of bathroom pod technology on financial resources. However, there was considerable disagreement about whether this was positive or negative. On the positive side, R1, R5 and R6 agreed if

Table 3. Concepts and prominence by respondent (I = intellectual capital; H = human capital; F = financial capital; O = organizational capital; S = social capital; P = physical capital)

Concept and resource	Rel Freq (%)	Strength (%)	Prominence
Category: Name_r1			
Guys (H/F)	20	29	2.5
Skills (I)	15	24	2
Different (I)	15	22	1.9
Site (H)	15	21	1.8
Take (F)	15	17	1.5
Job (H/F)	22	16	1.4
Category: Name_r2			
Design (S)	13	28	2.2
Project (S)	80	28	2.1
Builder (S)	36	26	2
Early (I)	18	25	2
Change (H/I)	20	19	1.5
People (I)	11	18	1.4
Category: Name_r3			
Everything (S/F)	18	43	2.7
Site (H/F)	18	35	2.2
Time (F)	24	34	2.1
Early (S)	16	29	1.8
Take (F)	15	23	1.5
Change (ALL)	20	23	1.5
Category: Name_r4			
Plumber (S/O)	14	26	1.6
Resources (ALL)	14	23	1.4
Trades (S)	16	20	1.2
Job (F)	18	18	1.2
Work (S)	41	18	1.1
Take (I)	11	17	1.1
Category: Name_r5			
Skills (I)	12	40	1.6
Different (I)	10	33	1.3
Job (F)	19	30	1.2
Resources (H/F)	12	29	1.2
Take (F)	12	29	1.2
Trades (O)	15	28	1.1
Category: Name_r6			
Bathroom (H)	15	36	2.1
Building (F)	14	32	1.9
Tradesmen (S/H)	12	29	1.7
Design (S)	10	28	1.7
Labour (H/F)	10	26	1.5
Pods (F)	53	18	1.1

bathroom pod projects were constructed as planned then a reduction in project duration would translate to financial benefit.

> a quick job is a good job. R1

However, on the downside, others noted any financial gain was limited because intense competition for work, onerous subcontracts and traditional power structures ensured any gains were fell to major contractors rather than subcontractors.

> Competition is so high we don't get to retain any of the savings or indirect cost benefits for ourselves. We still end up making the same margin as per usual because everyone just passes the cost savings along. R3

On the downside, a loss of financial resources was also linked to a reduction of turnover from a reduced scope of work which reduce the earning capacity of each project, while labour and overhead cost remain constant.

> Say a 5 million dollar contract I don't do the fit out and I don't supply the fixtures so it reduces the 5 to a 3.8 but I still have my managers on site for the whole project … so while my workload reduces my overhead stays the same. R6

A coping strategy identified by a number of respondents was to "increase the margin on the work we actually do", or increase project turnover.

> When you take the bathrooms away we then have to make the money on the labour and when it is priced into the materials as a flat rate there is no risk allowance in there. We always lose money on labour, so it going to be a real issue…. Maybe we will have to increased our turnover and get more jobs, it can be catered for but it is expensive to take on more work. R5

Margins could also be damaged by the potential of pods use to increase competition.

> what it [pods] has done is open the door for a lot of other companies that wouldn't normally look at a big job can now look at the jobs and it will increase competition and the race to the bottom. R1

Human capital

All respondents saw human resources as a key impacted resource with anticipated reductions in lower skill level tradesmen of about 30–35% while senior site staff numbers remain the same. The cause of this reduction was unanimously seen as a reduction in project scope for subcontractors compared to a conventional project.

> As far as human resources go you still have your site manager, your leading hand. It is hard to measure however, we reduced the workforce a little. R6

There were also implications for more involved workforce planning as a result of bathroom pods.

> If anything it may be a little more intricate in the planning of the worker's. We may require more skilled people in the detailed work … Your plumbers are always changing but your leading hands and foremen are staying and they work together. R6

Significant potential impacts on skill levels of tradesmen and apprentices were also noted by a number of respondents, both in transitioning to pod projects and back to traditional work.

> I had a lot a guys actually leave me because they were not getting the knowledge of plumbing, they were losing their skills and the work was becoming boring … they didn't want to work like that doing all the connecting work without being challenged in that regard. R1

Interestingly respondents also noted moving workers from a site-based role to a factory environment could cause motivation problems.

> The thing with the pod factories they go out and get local labour and trade professionals and they basically work on the production line. The tradesmen work in the factory and it would kill our guys to work in that sort of environment. Doing that kind of repetitive work all day. R3

Social capital

All respondents agreed the use of bathroom pods increased the need for greater collaboration between subcontractors, designers and manufacturers.

> We had to be heavily involved in the initial design process and design of the connections … I would say we will need to communicate more with people and other trades … R6

> With the pods you need to start to think differently because we had to do things we had not done before like get a special fitting made up to connect the pod to the floor waste. R6

Interestingly a number of subcontractors noted a reduced need for normal raw material supplier relationships, on which their business traditionally depended.

> Take for example (supplier name) the largest tap ware and sanitary supplier in Australia. Our relationship with them will reduce because we will not be purchasing the product any longer. R5

Intellectual capital

The intellectual resources question drew a mixed response. On the downside there was a sense that new apprentices would see a loss of skills due to not having the experience of seeing multiple trades go into a traditional bathroom.

> If you're a young apprentice if you work on three pod projects you will be finished [the apprenticeship] and will have never set a bathroom you have never set a pan, put a basin in or put a shower on the wall that is a huge risk [to my company]. R6

However, on the upside, in contrast to concerns over a loss of trade skills, there was also a need to develop better and new planning, logistics, designing, scheduling, estimating and coordination skills, especially at supervisor and manager level. However this skill was not seen as in-imitable or rare.

> We are trying to leverage off that knowledge … But I really think that is just a short-term thing once everyone has done it and it becomes the norm the competition is back. R6

Firm strategies to retain intellectual resources as forms of competitive advantage differed. For example, R6 did not document knowledge since he saw them as "the family secrets" and his strategy to retain this resource was to retain skilled tradespeople who would in-turn transfer the knowledge through the business. In contrast, R5 had begun to document or codify the knowledge gained from working on projects with bathroom pods and noted a strategy to develop skills in tradesmen through a rotation process to gain experience on projects using pods.

> Based on our knowledge and skills with prefabrication we are looking to do way more of it … working with multiple trades on the one unit to share the cradles and bits and pieces this is much like the bathroom pods where various trades are organised together to do the complicated work elsewhere. R6

Organizational capital

Organizational resources proved the most difficult for respondents to comprehend. Organizational routines were not seen as generally impacted by the use of pods, although it was noted that there were not yet enough projects using this technology to require significant organizational change.

> We didn't change the organisational structure on the job you couldn't we still had the same number or management people there from day one for the start up to the end of the project. R6

> In the front end of the project we had our drafting guys in earlier and longer to get the prototype working and signed off. It didn't fundamentally change our structure. R4

Leximancer analysis

The Concept Map in Figure 3 expresses the concepts from our data clustered into six themes with its associated thematic summary report. The respondent tags are located on the map in red where Name_r1 relates to Respondent R1, etc.

Figure 3 identifies "project" as the most important theme emerging from our qualitative data with 100% connectivity to all other themes and concepts. The theme "project" comprised of the concepts *project*, *builder*, *job*, *change*, *time*, *take*, *early*, *everything*, *whole* and *firm*. Interestingly, our narrative analysis showed that these concepts cover the whole range of RBV resources suggesting that the introduction of off-site technologies challenges the project-based nature of construction by moving it off-site and in doing so, affects many parts of a subcontractor's business. The second most important theme "work" comprised the concepts *work*, *trades*, *plumber*, *different*, *guys*, *skills*, *people*, *tradesmen*, *site*, *level*, *plumbing* and *knowledge*. These concepts were mainly associated with the intellectual, human and social resource impacts of off-site technology. This indicates that respondents considered new knowledge as necessary to exploit the benefits of off-site and social resources in the form of new logistics and coordination skills, supply chain partnerships and collaborative working during early project involvement. The inclusion of the concept "plumbers" within the second most important theme in the map expresses the significance impact of these new technologies on this trade and on existing and new skills. The third most important theme "pods" comprised the concepts *pods*, *resources*, *human*, *financial* and *having,* conveying a view that the use of bathroom pods required a change in human resourcing strategy since pods required different amounts of tradesmen at different times, compared to traditional bathroom construction. This theme also supports the qualitative data in highlighting the financial resource implications of using pods in terms of increased competition and reduced scope of work, etc. theme "bathroom" comprised the concepts *bathroom*, *building*, *labour*, *issues*, *materials* and *money* articulating the risks involved with the use of pods. Particular reference is made to human, intellectual and financial risks when using bathroom pods. The "design" theme comprised the concepts *design* and *term* and indicates the need to increase social resources linked to long-term coordination and collaboration in the effective use of bathroom pods. Finally, the theme "factory" was again linked to an increased need for social resources particularly through new connections to pod manufacturers which did not currently exist. This theme also indicates the importance of the cost of human resources since moving work to a factory is seen as a financially beneficial move away from union negotiated EBA rates. However, the data also indicated that site workers value their site environment and might not like to work in a factory.

Table 3 compares the individual respondent's concept lists for the six most prominent concepts and related RVB resources in rank order. Analysing the results on an individual basis with reference to the interview transcripts for each respondent is useful in triangulating the results and more deeply understanding the impacts of bathroom pods on the respondents' subcontracting businesses.

Table 3 identifies the differences in prominence of particular concepts and related resources between respondents. These are discussed in detail below in relation to each respondent.

R1's response focused on the following concepts: *guys* (H/F) – the loss of employees and skills, and reduction in financial gain available from this type of project; *skills* (I) – a loss of trade skills and knowledge and a reduction in the competitive advantage of their firm; *different* (I) – firm employees need to develop new skills and knowledge; *site* (H) – a reduction in tradesmen on the project; *take* (F) – bathroom pods were taking "the cream" out of the projects; *job (HF)* – a reduction in skills combined with a loss of financial gain.

R2's response focused on the following concepts: *design* (S) – new social networks required to improve the process of integrating pods into a project; *project* (S) – early subcontractor involvement in the project would be beneficial; *builder* (S) – builders controlling the outcome for the subcontractors which involves reliance on the resources of another firm; *early (I)* – new knowledge required about manufactured units and fixing in place; *change (H/I)* – new skills (especially coordination and logistics) are required; *people (I)* – the respondent didn't not intend to use this new knowledge as a source of competitive advantage.

R3's responses focused on the following concepts: *everything* (S/F) – a major improvement in communication between project participants required if future projects to be successful and avoid negative financial impacts due to miscommunication; *Site (H/F)* – less site operatives needed and reduced scope will lead to reduced revenue; *time* (F) – financial gain from a reduction in overheads and project duration; *early* (S) – a lack of established manufacturer/designer/subcontractor networks prevent effective use of pods; *take* (F) – financial benefits passed up the chain; *change (ALL)* – change was associated with all the resource categories.

R4's responses focused on the following concepts: *plumber* (S/O) – the plumbers (hydraulic subcontractors) required to take a more leading role on the project; *resources* (ALL) – all resource types affected; *trades* (S) – new joint ventures will increase need for new business networks; *job* (F) – early completion brings financial benefits; *work* (S) – new supply chain relationships need to be forged; *take* (I) – need to ensure capture benefits of new intellectual resources developed.

R5's responses focused on the following concepts: *skills (I)* – intention to use the knowledge learned to improve the firm; *different* (I/F) – reduction in firm financial resources and intellectual resources due to scope reductions; *job* (F) – utilizing pods was purely a financial decision; *resources* (H/F) – a reduction in both human and financial resources; *take* (F) – pods reduce turnover unless new value can be created through joint ventures with manufacturers; *trades* (O) – the respondents have to adapt future business strategy to develop new value-propositions around this new technology.

R6's responses focused on the following concepts: *bathroom* (H) – reduction in human resources needed on projects due to reduction in scope of trades involved with pods use, how to balance with blend of existing traditional work; *building* (F) – a perceived negative impact to financial resources with pods; *tradesmen* (S/H) – increased connections with other organizations such as manufacturers needed and new skills to manage these relationships; *design* (S) – increased connections with designers needed; *labour* (H/F) – emphasizes strong link between human resources and financial prosperity; *pods* (F) – reductions in financial rewards associated with pod use.

Discussion

Overall, according to Kahneman and Tversky's (1979) Prospect Theory, the overall negative results we obtained in Table 1 from our respondents and in the narrative analysis is not surprising. Although impacts varied by trade, the vast majority of comments made by our respondents were negative (reduced scope, increased competition, reduced margins, contractors capturing benefits, loss of skills, etc.). Prospect theory describes the way that peoples' utility function when assessing a new situation is asymmetrical, meaning that potential losses hurt more than gains feel good (an affect called loss aversion). When it comes to interpreting the results relating to each type of resource categorized by the RBV the discussion below summarizes our findings.

Physical resources

Both the narrative and Leximancer results do not reflect the literature around off-site prefabrication regarding impacts on physical resources. Although G4C (2015) notes IT will be a significant resource for firms in the future, surprisingly IT was not seen by respondents as being significantly impacted (though some respondents noted the use of bathroom pods would increase the use of CAD as an integrating technology). Interestingly BIM was not mentioned by any subcontractor suggesting this new "integrating" technology has not yet penetrated the Australian construction subcontractor sector. Our results suggest that until pods have greater market penetration, subcontractors will be reluctant to invest in new technologies such as BIM to support them. This finding supports Cidik *et al.*'s (2014) recommendation that it is important to evaluate different uses of BIM models by different stakeholders in order to understand the implications of new technologies on design collaboration. In other words, the implementation of new technologies like BIM will likely only move at the same pace as the other technologies it depends on and which depend on it. This linking between interdependent resources is a common theme throughout the results in relation to other resources. Our results also support those of Bidarianzadeh and Fortune (2002) which show subcontractors prefer to operate on a just-in-time model, purchasing new materials, plant and equipment on a "needs" basis.

Financial resources

The results show off-site prefabrication can significantly impact subcontractor financial resources. However, the impact was not uniform across the supply chain with hydraulic subcontractors noting a negative impact and mechanical and electrical subcontractors a positive impact. Respondents with a negative impact saw this manifest in a reduction in turnover, scope of works, working capital and rewards being passed up the chain, whereas the positive impact respondents noted faster and more productive jobs enabling higher long-term turnover. In some ways, our results support Steinhardt *et al*. (2014b) who reported an increase in turnover as the result of higher project clearances. It appears that the nature of the financial impact on subcontractors is contingent on how firms can position themselves in the new value chains that will emerge. This supports Loosemore (2014) who showed that any innovation like off-site prefabrication will create winners and losers and disturb the long-established power and reward structures of the construction industry.

Human resources

Human resources are identified in the OSM literature as an important and significantly impacted resource with researchers such as Blismas and Wakefield (2009) and Court *et al*. (2009) forecasting significant reductions in on-site labour. Our results support this and also suggest a significant reduction in trade labour on-site. However, our results indicate that levels of management staff are likely to remain the same due to the wider coordination requirements from design through to manufacturing and construction. However, the skill base of these managers will need to change. Turnbull *et al*. (1992) and Helper and Henderson (2014) identify employee empowerment as a key contributor to the successful transition from craft-based production to off-site. However, our results show that this may be a challenge because manual workers see off-site as deskilling the industry, threatening wages rates and conditions and moving workers from site to controlled factory environments. Sliwinski (2004) and Aburas (2011) also identify training as a key to the successful implementation of off-site, a conclusion supported by our subcontractors who noted training as a significant issue. Furthermore, and importantly, our results add some qualifications to Blismas and Wakefield (2009), Gibb (1999) and Chen *et al*. (2010) who all argue that a move to a factory environment is beneficial to employees. While this may result in a safer environment with fewer accidents, our findings show that there may be a hitherto unrecognized mental welfare issue associated with the increased repetition and control such as environment entails, compared to traditional site work.

Social resources

Overall the results support the literature indicating the high importance of social capital for subcontractors engaging on off-site prefabrication. However, in contrast to other industries such as car manufacturing where subcontracting firms horizontally integrate social capital into their businesses through processes such as co-opetition and long-term relationships with subcontractors (Wilhelm and Kohlbacher 2011), our results suggest that these social resources are currently project-based and not held as long-term cooperative strategic relationships. Furthermore, in contrast to the relational contracts found in other industries that effectively use OSM (Helper and Henderson 2014), our respondents were hampered by traditional subcontracts which resulted in rewards being passed up the line to head contractors. Until this is resolve the incentive to collaborate will not exist.

Asanuma (1989), McMillan (1990), Turnbull *et al.* (1992), McIvor *et al*. (1998), Subrahmanya (2008) and Helper and Henderson (2014) all support joint product development as a key to the successful transition into off-site technology in other industries. Our results provide strong support for this strategy and indicate that subcontractors would benefit greatly from greater input into the design of bathroom pods at the prototype stage. However, respondents noted that pod designs agreed was not always what arrived on-site, a breakdown in communication which hindered project success and new relationships between subcontractor, head contractor and the pod manufacturer. This supports Zhai *et al.*'s argument that high levels of supply chain co-ordination are required between project participants to successfully utilize off-site prefabrication.

Intellectual resources

As Leila *et al*. (2006) argue the majority of a firms competitive advantage is derived from its intellectual resources. Our results reflect this and suggest that a move to off-site will increase the importance of intellectual resources to the competitive advantage of subcontractors. All respondents pointed to the importance of developing new skills in the areas of IT, planning, collaboration, logistics and supply chain management and firms can to take very different approaches to this issue, depending on their unique organizational culture. For example, one respondent is working to ensure that knowledge learned from projects is codified and circulated while another respondent "never wrote anything down".

Organizational resources

A firms organizational resources consist of its structure, systems, policies and culture. Grant (1996) identifies systems and policies as a key organizational resource but our results in relation to organizational resources were somewhat inconclusive. This may change in the future as off-site becomes more common, forcing firms to change their systems to integrate with other organizations with which they will need to collaborate more closely. On the one hand our narratives indicated that organizational resources are very important to the success of a change from traditional craft-based methods to off-site but on the other hand our Leximancer results do not reflect this finding, perhaps because of the esoteric nature of this concept to many of our respondents. Loosemore (2014) identifies a spectrum of organizational structures from organic to mechanistic and argues that organic forms are more conducive to the adoption and diffusion of innovations like off-site. However, our results reflect no structural change to the organizational resources of the firm in the form of a move to an organic structure.

Conclusion

The aim of this paper was to explore the impact of emerging off-site technologies on construction subcontractors in Australia. This paper has shown the potential value of the RBV of the firm in understanding how off-site will impact on subcontractors in the construction industry. The value of the RBV is its ability to isolate the resource impacts of new construction technologies such as bathroom pods, allowing firms to think about how they might adjust various aspects of these resources strategically. In other words, while our research has highlighted the main impacts on the resources of subcontractors, its real value is in showing how changes in the resources of subcontractors can also affect their potential to successfully adapt to the use of these new technologies in the future. The key resources affected by off-site technologies like bathroom pods appear to be human, financial, intellectual and social. As pointed out earlier, the RBV argues that a firm's sustainable competitive advantage is maximized when these resources are rare, valuable, inimitable, non-tradable and non-substitutable, as well as firm specific. It also argues that firms should develop and protect these key resources and focus on building unique "imitable capabilities", "core competencies" and "dynamic capabilities" to respond to changes in this type of technology as they emerge into the future. To this end, our results indicate that as the construction sector becomes more industrialized, new business models and ways to increase turnover will need to be developed in the subcontracting sector, new knowledge, relationships and partnerships, skills and human resource management strategies will need to be developed to secure competitive advantage in the new value chains which industrialization will create. In the longer term, while our respondents pointed to little impact on organizational structure, it is inevitable that subcontractors will also need to consider how to adjust their organizational and physical resource management strategies as they move from production to service-based organizations which is likely to involve less physical production on-site but more management, moving more work into factories and the adoption of more vertically integrated organizations and collaborative structures such as supply chain joint ventures and alliances. The future for subcontractors is different but not necessarily worse, assuming they can adapt their resource management strategies in response to these changes. So there is potential for positive impacts growth and diversification if the subcontractors manage their resources with a strategy to take advantage of the increased use of industrialization. However, our results suggest that at the moment most subcontractors were only just beginning to understand these impacts and still retaining the old structures in a newly emerging production and technological world.

The limitations of this research are based in the relatively small sample size which reflected the limited number of subcontractors who have had enough experience of pods to provide reliable insights. As pods and other forms of off-site prefabrication develop and become more common into the future, further research is needed to deepen the insights into subcontractor strategies provide by this exploratory research. The research was also confined to large residential sites in Australia that currently use bathroom pods and while the construction technology around pods is similar in many countries making the results transferable, it is also important to note the unique industrial relations environment in which the subcontractors operated in Australia. This might have influenced their ability to respond as quickly as firms in non-unionized environments to the industrialization of their traditional trades. There are also logistical differences between countries in terms of manufacturing and transporting pods to site. For example, in Australia, many components are manufactured in Asia and have to be transported large distances before they are installed on-site, whereas in Europe, the logistics can be less complex. So further research is also needed to understand impacts and strategies in other geographical, industry sector and industrial relations contexts.

Disclosure statement

No potential conflict of interest was reported by the authors.

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