Predicting Australian builders' intentions to use prefabrication

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Executive Summary

This study presents the results of the first large scale survey of Australian builders' beliefs about prefabrication, drawing on 454 surveys completed by representatives of building companies in Queensland and Western Australia. Previous literature has identified a number of broad themes affecting the uptake of prefabrication. The current study builds on this work by using a structured theoretical model based on the Theory of Planned Behaviour (TPB) and the Technology Acceptance Model (TAM), to further explore the specific factors influencing builders' intentions to increase their use of prefabrication. Information was gathered concerning the characteristics of respondents in addition to three aims. The aims were (1) To identify the relative importance of a number of key factors which may affect builders' use of prefabrication, 2) To compare the characteristics of builders using various levels of prefabrication (including none), and 3) To determine if a model based on the TPB, TAM, and other control variables can explain builders' intentions to adopt prefabrication on their housing projects.

With regard to respondent characteristics, the majority of builders were open to increasing their use of prefabrication in housing. There was also a significantly higher reported use of prefabrication than previous studies. One third of the sample reported having used structural panels such as SIPs or precast concrete on a housing project in the last 3 years, and one fifth reported the use of more advanced volumetric prefabrication. A majority (54%) agreed that they *intend* to move to a higher level of prefabrication in the next 3 years. An even higher proportion (75%) agreed that they would be *willing* to increase their level of prefabrication use if market conditions were supportive.

With regard to Aim (1), the two strongest factors driving attitudes towards prefabrication in housing were (i) increased construction speed, and (ii) increased quality of the finished product. The most influential groups impacting attitudes were: (i) Housing energy efficiency regulators, and (ii) Clients for housing projects / owners of houses. Changes that were perceived to have the biggest positive impact on future uptake were (i) Increased demand for prefabrication, and (ii) An increase in the number of people trained in prefabricated building.

With regard to Aim (2), the following builder characteristics were significantly and positively related to the use of more advanced levels of prefabrication: (i) The number of new houses or units built by the business annually, and (ii) Involvement in multiresidential housing compared to detached housing. The remoteness of the business and number of years operating were not significant determinants of whether a business used more advanced levels of prefabrication or not.

Finally, with regard to Aim (3) multivariate statistical modelling was used to predict builders' *intentions* and *willingness* to move to a more advanced level of prefabrication. Conclusions were that:

(1) Beliefs about prefabrication were a significant predictor of both intention and willingness, even after accounting for previous use of prefabrication, annual turnover, and remoteness of the business.
(2) All 3 of the TPB/TAM predictors of attitudes, subjective norm and perceived behavioural control were significant, indicating that addressing a range of builders' beliefs will be beneficial
(3) The intensity of feeling against prefabrication was not as strong as that in favour of prefabrication. 75% of respondents were willing to try prefabrication if circumstances were supportive.
(4) The builders most receptive to moving to a more advanced level of prefabrication were larger businesses with a turnover of more than 10 houses annually; based in urban as opposed to rural areas, and with prior experience in using prefabrication.

The results indicate that a multi-targeted policy approach can have a significant and interactive positive effect on the uptake of prefabrication. Such an approach should provide: (1) education directly to builders to change attitudes; (2) widespread engagement with various members of the housing industry to encourage a supportive network; and (3) changes to the contextual and regulatory environment to make adopting prefabrication easier. The report provides a number of recommendations for targeted initiatives in each of these three areas, namely:

(1) Provide direct funding for demonstration prefabricated housing projects, which could be used to solicit media and industry attention,
(2) Identify local prefabricated construction businesses and facilitate their networking between one another,
(3) Draw on the expertise of multiresidential prefabricators to (i) identify what technologies or methods could be successfully transferred to less advanced builders, and (ii) assist in the transition to greater urban density
(4) Develop media campaigns to highlight prefabrication's modern, high-quality image and drive growth in demand, and
(5) Better educate the housing industry about how prefabrication can assist with meeting stricter energy efficiency requirements for housing.

Introduction

The housing construction industry is a large, complex, project-based industry. Prefabricated housing manufactured in an offsite location is a disruptive innovation to traditional, predominantly onsite construction methods. It impacts multiple levels from day-to-day trivial decisions, to interactions with business partners, to macro business directions (Pan, Gibb, & Dainty, 2012). There has however been a lack of rigorous research presenting a multifaceted view of a shift to prefabrication (Pan, Gibb, et al., 2012). The current research seeks to address this gap in knowledge by presenting empirical data collected from a survey of Australian builders. The Australian housing industry's relationship to prefabrication provides a case study of an unrealised innovation that has often been promoted but not widely adopted (Hampson & Brandon, 2004). There is recent evidence of a growing interest in prefabrication in the Australian residential sector. A national peak representative body has been formed in the past year and a number of government and industry groups have recently reassessed their options (Australian Industry Group, 2013; Construction Training Fund, 2014; Daly, 2009; prefabAUS, 2013). An opportunity exists then to canvass builders' opinions on a range of factors relating to prefabrication adoption.

In any discussion of changes to construction processes and technologies, ease of use and their resultant business effects need to be considered (Björnfot & Sardén, 2006; Pan, Gibb, & Dainty, 2007). These immediate, practical issues are likely to significantly impact on day-to-day operations and builders' attitudes to prefabrication. Technical changes and innovations cannot however be imposed on industry participants. They must be accepted and embraced by stakeholders to maximise uptake. Understanding builders' perceptions and interactions with other key influential persons and groups is thus central to greater diffusion of prefabrication innovations. The broader socioeconomic context in which these interactions and opinions exist also constrains possible technical changes, attitude formation, and social interactions. The following three background sections summarise previous prefabrication respectively under each of the headings of processes and technology, stakeholders, and external contextual factors. Each of these broad influences are acknowledged to interactively affect prefabrication uptake (Nadim & Goulding, 2011). This discussion provides an evidence base and identifies research gaps to be extended upon by the current survey.

Processes and technology

From within the housing construction industry, the focus of contractors such as builders has typically been on process efficiency and profitability (Björnfot & Sardén, 2006). Costs have subsequently dominated discussion of prefabrication's worth to the detriment of a well-balanced perspective (Blismas, Pasquire, & Gibb, 2006; Nadim & Goulding, 2011; Pan, Gibb, et al., 2012). The potential cost savings of prefabrication are regularly promoted despite being difficult to objectively determine (Aburas, 2011; Bildsten, 2011; Elnaas, Ashton, & Gidado, 2009; Gibb & Isack, 2003). The cost savings promises of prefabrication are often dependent on the complexities and uniqueness of the building task, including the co-dependency between hands-on builders and their upstream suppliers (Bildsten, 2011; Vrijhoef & Koskela, 2000).

Prefabrication of housing also promises to reduce both process and product complexity and encourage automation (Bertelsen, 2005; Eastman & Sacks, 2008). Simplifying onsite construction tasks to the installation of prefabricated panels or modules can reduce the requirement for external contractors and 'wet trades' (Pan & Sidwell, 2011; Poon, Ann, & Ng, 2003). This has potential flow on effects in reducing the burden of staff management (Roy, Brown, & Gaze, 2003). Following from these simplifications, the speed of construction can then be increased (Lu & Korman, 2010). The reduced time onsite can offset the higher costs incurred in terms of new materials or preconstruction planning processes (Aburas, 2011; Bildsten, 2011). The non-traditional manufacturing processes involved in a shift to prefabrication can also introduce new sources of complexity such as the transport of bulky modules (Arif, Bendi, Sawhney, & Iyer, 2012; Lu & Korman, 2010; Nadim & Goulding, 2011). Significant effort may need to be expended in re-working and planning new processes to maximise efficiency (Shewchuk & Guo, 2011). With increased attention it is likely that prefabrication can universally reduce the complexity of house building and housing costs.

In addition to driving down immediate costs, the link between prefabrication and increased long-term housing sustainability has been long stated in both the academic and industry literature (Gann & Senker, 1993; Zainul Abidin, 2010). Researchers and industry surveys have pointed to the greater level of control and tighter specifications in manufacturing that reduces waste during construction and can deliver a more energy efficient final product (Blismas, Pendlebury, Gibb, & Pasquire, 2005; Dainty & Brooke, 2004; Elnaas et al., 2009; McIntosh & Guthrie, 2008; Monahan & Powell, 2011). Whether sustainability is a sufficient driver to encourage widespread adoption remains an issue to be addressed.

Despite the positive outcomes associated with prefabrication, strong negative community perceptions of prefabricated housing have been driven by its association with temporary, emergency or low-quality housing (Beamish, Goss, Atiles, & Kim, 2001; Craig, Laing, & Edge, 2000; Daly, 2009; Genz, 2001; Goulding, Rahimian, Arif, & Sharp, 2012; Hall & Vidén, 2005; Kährik & Tammaru, 2010; Kempton & Syms, 2009). The repeatability of construction tasks, along with greater opportunity to inspect and review output in prefabrication should however allow for increased consistency in quality and a more robust final product (Gaze, Ross, Nolan, Novakovic, & Cartwright, 2007; Gibb & Isack, 2003; Johnsson & Meiling, 2009; Lu & Korman, 2010). Such changes should result in improved community perceptions. Thus, while increasing the quality of housing remains a key driver for change within the industry (Nadim & Goulding, 2011), it is not known how much the historically poor image of prefabrication affects the size or receptiveness of the modern target market.

The negative perceptions of prefabrication have in part stemmed from the ‘boxy’ designs associated with repetitive manufacturing processes and low-cost construction. There is a trade-off between increasing efficiency and speed of construction, and the subsequent level of flexibility in designs and processes (Barlow et al., 2003; Elnaas et al., 2009; Lu & Korman, 2010). Compromising between total standardisation and total customisation is a requirement for success in the housing market from both consumer and industry perspectives (Barlow et al., 2003; Bertelsen, 2005; Gann, 1996). There have been examples of projects incorporating modular elements with high customisability but these are far from universal (Barlow & Ozaki, 2005; Friedman & Cammalleri, 1997). It is however arguable that traditional building methods have ever afforded the majority of consumers a high degree of flexibility in design (Roy et al., 2003; Schneider & Till, 2005; Thuesen, Jensen, & Gottlieb, 2009). Whether flexibility in house designs is a central issue preventing prefabrication uptake is thus debatable.

Prefabrication adoption is thus influenced by many factors directly related to the building task, spanning the interplay of direct and indirect costs, complexity of building and logistics, environmental performance, product quality, and the conflict between build efficiency and design flexibility. The relative advantages and disadvantages of these factors may not always be clear, depending on specific contextual factors. Builders are at a unique central position in housing construction projects, with their perceptions and resultant decisions potentially dictating the industry’s future directions. The current research aims to empirically measure the relative importance of each of these factors from the builders’ perspective, and compare how they may change dependent on the unique circumstances of their business.

Stakeholders

Shifting to a prefabricated approach to housing requires a complete rethink of processes, staff and management for builders overseeing housing projects (Bertelsen, 2005). Technology alone does not provide a compelling case for change. The attitudes and actions of a range of influential persons that the change affects is central to understanding its potential uptake (Egan, 1998; Goulding et al., 2012; Halman, Voordijk, & Reymen, 2008; Malmgren, Jensen, & Olofsson, 2011). Understanding these participants' relationships and perceptions of one another is thus key to understanding the full range of issues impacting prefabrication uptake. The potential influence of a number of stakeholders are discussed within this section, and key unresolved issues to be addressed by the current research are highlighted.

Cultural change to a greater acceptance of prefabricated housing is necessary for its success, particularly acceptance among the rank-and-file subcontractors responsible for hands-on work (Arif & Egbu, 2010; Friedman & Cammalleri, 1993). There are competing benefits and disadvantages to employment in factory-based manufacturing facilities, such as stability of work and more controlled conditions, offset against the unfamiliarity of manufacturing processes and the potential for tedium (Blismas & Wakefield, 2009; Dalton, Chhetri, Corcoran, Groenhart, & Horne, 2011; Elnaas et al., 2009; Gibb & Isack, 2003; Goulding et al., 2012; Nahmens & Bindroo, 2011). The technicalities of shifting to innovative products or materials is a lesser barrier than resistance to change in the workforce (Dalton et al., 2011; Daly, 2009; Elnaas et al., 2009; Nadim & Goulding, 2011; Sardén & Stehn, 2006). This may particularly be the case for Australia as opposed to colder climates, where moderate weather patterns may translate to a greater focus on culture and methods of work rather than a need to be shielded from the environment (Hedlund, 2006). Identifying the degree of negative or positive opinion in the subcontractor population through the current study is an important first step in knowing whether this is a major or minor issue to be addressed.

Prefabrication similarly presents challenges to the traditional roles of architects and building designers, particularly in aligning designs with the need for greater standardisation (Arif, Goulding, & Rahimian, 2012). This has implications for those designers who may wish to stamp their own style on projects, unrestricted by standardised specifications (Gann & Senker, 1993; Gibb & Isack, 2003). Designers can even feel displaced with a decrease in the importance of their role to the project (Jaillon & Poon, 2010; Madigan, 2012; Nadim & Goulding, 2011). Designers and architects may thus not be as likely to support prefabricated methods to the same degree as those invested in material manufacturing or supply (Nadim & Goulding, 2010). The need to form close relationships with suppliers is particularly important in light of prefabrication's frequent need for specific, standardised products (Blismas et al., 2005). The degree of contractor integration with upstream material suppliers is likely to affect whether they are going to be supportive of meeting downstream requirements (Hofman, Voordijk, & Halman, 2009). A mature supply chain does not often exist for prefabricated housing, in particular for smaller companies which rely on a network of casual business relationships (Pan & Goodier, 2011; Thorpe, Ryan, & Charles, 2009). The relationship between business size, supplier relations and attitudes towards prefabrication has not been explored sufficiently by past research and will be highlighted further by the current study.

Moving beyond immediately impacted stakeholders such as subcontractors, designers and suppliers, the consumer or end user is likely to have the most direct and long-term relationship with the finished, prefabricated house. While it could be argued that consumers should not care about how their housing is constructed, prefabrication can influence build quality, environmental outcomes and the range of possible designs, along with carrying the aforementioned stigma (Bildsten, 2011). Meeting consumers' expectations and delivering a low overall purchase price is a core concern for builders (Eleb, 2004; Goulding et al., 2012; Lessing, Stehn, & Ekholm, 2005; Linner & Bock, 2012).

Cost alone may however not be the only factor determining consumers' attitudes to prefabrication. Particular market segments such as rural Australia may embrace prefabrication due to its ability to deliver completed housing in a shorter time-frame than onsite construction (Jensen, Olofsson, Sandberg, & Malmgren, 2008). It is likely then that while consumer opinions will be important to builders, responses may vary depending on the types of products offered and target markets.

Construction industry bodies represent each of the groups discussed above, and are potentially influential in shaping not only day-to-day industry practices but also influencing high-level policies. There is however a low level of interest in research and development within the Australian housing industry. This is attributed to a lack of foreign competition, and an industry-stated perception that there are few benefits to be gained from new technologies (Australian Industry Group, 2008). Industry bodies such as the Housing Industry Association and Master Builders Australia represent a significant percentage of all house builders and thus wield a strong influence (Dalton et al., 2011). An industry 'lock-in' to traditional, inefficient construction methods is acknowledged in both Australia and international jurisdictions (Lovell, 2007; Lovell & Smith, 2010). The current survey seeks to assess the degree to which builders at the heart of the industry feel supported to adopt prefabrication.

This section has presented a summary of influential stakeholders that operate around house builders. These range from immediate influences such as subcontractors and clients which dictate day-to-day operations and specific projects, through to higher level influences among bodies which represent the entire construction industry. Determining which of these groups is most influential in driving builders' beliefs and actions regarding prefabrication, as is done later in this report, is of central interest to developing informed policy. A number of specific questions remain to be answered from a builders' perspective. These include clarifying the perceptions of subcontractors towards adopting prefabrication in Australia, and testing if architects and building designers are seen as a particularly negative group. The study will also address perceptions of suppliers and consumers attitudes towards prefabrication and how these may vary dependent on builders' business characteristics. Finally, builders' perceptions of industry bodies support for prefabrication will be assessed, distinct from the positions formally advocated by the bodies themselves.

External contextual factors

Understanding the broader context in which prefabrication exists is core to understanding the drivers and barriers to its uptake (Goulding et al., 2012). The nature of the construction industry is shaped by market, regulatory and societal influences (Barlow & Ozaki, 2005). Government assistance targeting the development of low-cost housing has been a key factor in the establishment of manufactured housing companies in countries such as Japan (Barlow & Ozaki, 2005). The offering of financial incentives for the use of prefabricated technologies has also resulted in increased adoption in Singapore and Hong Kong (Chiang, Hon-Wan Chan, & Ka-Leung Lok, 2006; Jaillon & Poon, 2010). The banking and finance industry has however been hesitant to support prefabrication projects, citing uncertainty that such housing will last and be attractive to a wide market (Craig et al., 2000). This is on the basis that prefabricated houses and materials do not have an established history of quality or verified lifespan (Lovell & Smith, 2010). Self-funding such projects is often not viable (Nadim & Goulding, 2011), and thus financing remains a key sticking point for many businesses both in Australia and internationally. The importance of government and financial backing has been underresearched, and will be assessed empirically across the Australian housing industry for the first time by the current study.

Government decision making beyond simply providing funds also has significant potential to affect prefabrication's future. Fragmentation in public sector decision making has been identified as a key factor leading to the failure of innovative, prefabricated building projects (Stansfield, 2005).

Adapting existing building codes and processes to any new system of building requires consultation and dedicated effort across multiple levels of stakeholders. Regulations, building codes and planning regulations have not been well tailored for prefabricated building and have introduced inconsistencies across jurisdictions (Blismas & Wakefield, 2009). It is likely then that more supportive regulations specifically targeted at prefabricated housing would be an encouraging factor for adoption. One of the most relevant regulatory changes in line with the previously mentioned link between prefabrication and sustainability would be the introduction of stricter energy efficiency guidelines. Measuring the performance of houses post-occupation may particularly benefit prefabrication as repeatable, consistent work processes may aid meeting these requirements (Gaze et al., 2007; Pan & Goodier, 2011). A large gap exists in sustainable construction research examining the effect of external pressures such as legislation, consumer sentiment, and the economic and political climate on innovation adoption. It is hypothesised that these influences interact with the organisational culture and capabilities of individual businesses to affect sustainability (Afzal & Lim, 2012). For instance, firms in commercial construction have a higher awareness of emissions and environmental performance than residential construction (Australian Industry Group, 2008). The current study addresses this gap in research by assessing if stronger energy efficiency legislation is a significant influence on builders' intentions to use prefabrication.

Along with legislative and funding deficiencies, potential adopters have to deal with higher up-front material and labour costs (Friedman, 1992; Gagnon & Adams, 1999), and also potentially the costs of establishing a factory environment (Lovell & Smith, 2010; Poon et al., 2003). The simplification of tasks mentioned earlier can however save money by reducing the number of staff and costly onsite operations. Finding suitably trained staff for prefabricated construction projects may be challenging, and up-skilling of the labour force may be required for non-traditional materials such as prefabricated panels (Construction Training Fund, 2014; Daly, 2009). Both of these factors put upward pressure on labour costs. Another labour issue concerns the ageing construction workforce in Australia. This is likely to result in a shrinking workforce, and negatively influence the transferability of skills to manufacturing (Blismas & Wakefield, 2009). There is also resistance to the provision of specific training for prefabricated construction methods (Daly, 2009), leading to a dearth in training options (Lovell & Smith, 2010). Demand for skilled construction workers continues to increase without a corresponding increase in supply, incentivising the simplification of construction tasks and potentially more use of prefabrication (Luo, Riley, & Horman, 2005).

In the long run, demand and supply is influenced by the cyclical nature of the housing sector, which is particularly vulnerable to slow economic growth, posing a challenge for builders trying to secure income streams (Australian Industry Group, 2008; Blismas, Wakefield, & Hauser, 2010; Nadim & Goulding, 2009). Identifying and meeting market demand is thus a key consideration for house builders. Researchers have pointed to particular circumstances generating greater demand for prefabrication such as a sudden need to produce a large number of houses (Gibb, 2001; Lovell, 2007). As Luther (2009) notes, there is a co-dependency between consumer demand for prefabrication and the high volume of production needed to maximise prefabrication's benefits. As Australia is a relatively small market with a low-demand for prefabrication, an increase to a higher baseline of interest may aid in seeding the industry.

There are thus a range of potential influences on builders' choices to use prefabrication. Direct financial government assistance and the breaking down of barriers in the wider financial industry are key issues for both Australian and international markets that deserve further attention. Outside of financial assistance, governments could also act through relaxation of building regulations and introduction of stricter energy efficiency standards for housing. The current study provides a unique opportunity to add to the relatively little evidence about how the housing industry would respond to these legislative changes. Challenges are posed within the industry itself by the potential unavailability of low cost materials and skilled workers to facilitate uptake. The degree to which builders see these challenges as affecting their decisions regarding prefabrication will be clarified further by this study's evidence. Finally, market demand may be the most critical factor driving interest in prefabrication for builders and other supply-side industries. The other contextual influences may only serve to support an industry which already has sufficient demand. Each of these factors is also likely to determine the impact of the various process and people issues previously discussed.

Business characteristics

The characteristics of individual businesses in the housing industry will determine the weight given to certain technological, people or contextual factors. Larger companies are better resourced to develop the economies of scale that factory-based prefabrication promises (Friedman & Cammalleri, 1993; Gibb, 2001; Poon et al., 2003). The exemplar prefabricated housing industry of Japan is dominated by a small number of very large businesses (Noguchi, 2003). The largest firms are also leading in the adoption of sustainable building practices, with smaller firms lagging behind (Afzal & Lim, 2012; Shearer, Taygfeld, Coiacetto, Dodson, & Banhalmi-Zakar, 2013). Conversely, it could be argued that the largest housing construction companies have the most to gain from perpetuating traditional models of construction and housing and are simply paying lip service to innovation.

There is also evidence that the age of construction businesses is related to both their likelihood of adopting new innovations like prefabrication, and their subsequent business success. There is however no simple relationship between company age and innovation. Empirical analysis has shown new construction companies are most likely to fail in the first 3 to 4 years and may be unlikely or unable to take risks on new methods while in the process of establishing themselves in a traditional housing market (Kale & Arditi, 1999). Conversely, smaller start-ups may be able to develop a new, innovative business from scratch while established operations focus on reaping the rewards of their strong, traditionally-targeted products (Bhide, 2000). The current study will provide evidence to resolve whether prefabrication adoption is being driven by new entrepreneurs or established, well-resourced businesses looking to get ahead of their competitors.

The likelihood of prefabrication uptake may also vary significantly depending on business location as there is an acknowledged shortage of construction trade skills servicing remote locations. There are thus potential time and cost savings associated with delivering prefabricated structures to these otherwise under resourced areas (Blismas & Wakefield, 2009). Local and state-based differences in planning and building regulations may also guide behaviour by presenting or reducing barriers to operating a prefabricated business (Blismas & Wakefield, 2009).

There are thus a range of business characteristics which may interact with the previously discussed process and technology, stakeholder, and contextual factors to determine the housing industry's use of prefabrication. At a basic level, the size and scope of the company, their years of operation, and their location may impact on their perceptions and decisions. The existing literature on these factors is not definitive on how they relate to innovation uptake. The focus of the current study on the adoption of prefabrication innovations will provide specific evidence cutting through this uncertainty to develop targeted policy.

Summary of influential factors

The previous four sections have provided an overview of relevant impacts on the uptake of prefabrication under the broad headings of processes and technology, stakeholders, external contextual factors, and business characteristics. It is clear that there is no single factor that can drive prefabrication uptake. A set of interacting factors, which may vary both within and across different organisations and contexts needs to be considered.

A number of key points can be taken from the preceding discussion. The cost of shifting to prefabrication has been and is likely to remain a key issue for the foreseeable future. While other issues such as speed of construction, reduced complexity of building and the resultant quality of housing are of import to builders, they are likely to be second tier influences below costs. There is a wealth of literature suggesting that the most important stakeholders for encouraging (and discouraging) prefabrication are likely to be consumers and end users. Against a historical community backdrop of poor opinions towards prefabrication it is acknowledged that meeting consumers' needs is paramount. Architects and building designers are also tipped to have an overall negative view of prefabrication stemming from a restriction of design sensibilities. While rank and file workers, suppliers and industry groups have sometimes expressed negative views on the adoption of prefabrication, these have generally been mild or not clear blockers of progress. The development of more consumer demand is slated as the strongest contextual factor for prefabrication uptake. Recognition needs to be given that this demand may arise from reduced building costs or other issues discussed in this review. Even with the hopes of establishing of demand, banking and financial support remains a key sticking point to facilitating trade within the prefabricated housing industry. Less critical factors include legislative changes to building codes, and the development of material and labour support. The likely impact of stricter energy efficiency requirements on prefabricated housing remains an unclear issue which the current study will be able to provide some initial evidence. Understanding the relative importance of all these factors in a structured way is required to develop informed policy. The following section describes a theoretical context in which this ranking of importance and exploration of interactive factors can be undertaken.

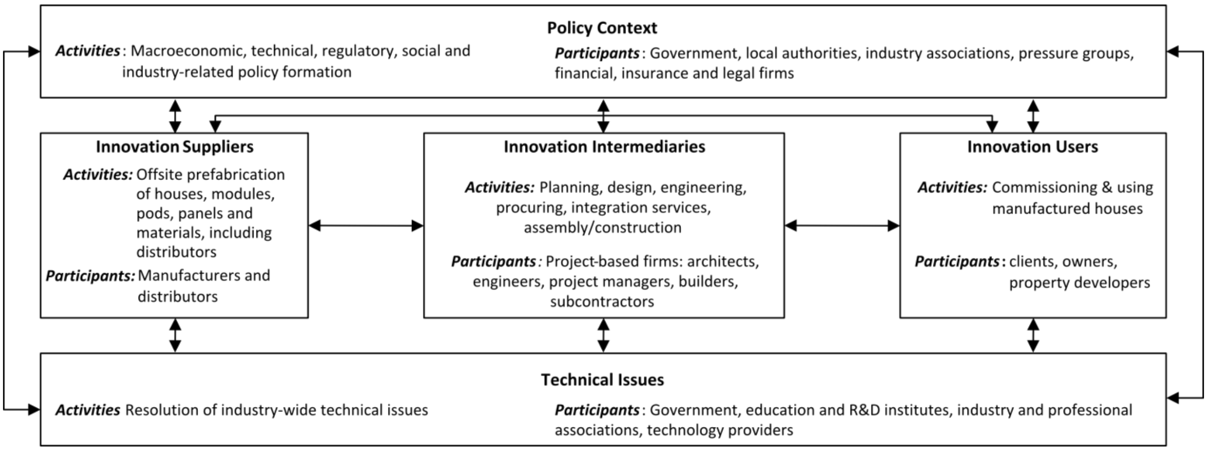
Aims

The current study addresses three primary aims:

1) To identify the relative importance for builders of a number of key factors which may affect builders' use of prefabrication. These factors are examined in three groups, aligning with the previously discussed TPB and TAM constructs:
    a. TPB/TAM attitudes, measuring process and technology factors
    b. TPB Subjective norm, measuring the influence of people factors, and
    c. TPB Perceived behavioural control, measuring the influence of external contextual factors
2) To compare the characteristics of builders using various levels of prefabrication (including none), and
3) To determine if a model based on the TPB, TAM, and relevant control factors can explain builders' intentions to adopt prefabrication on their housing projects

Theoretical context

This section describes a theoretical framework for understanding the range of factors affecting the adoption of the innovation of prefabrication. An open innovation systems model (Gann & Salter, 2000) is firstly used. This model hypothesises that prefabrication uptake is influenced by the traditional manufacturer-builder-owner supply chain as well as the macro policy context (e.g. regulations) and technical issues. The adapted Prefabricated Housing Innovation System model is shown in Figure 1.



Source: based on Gann and Salter (2000)

Figure 1. Prefabricated Housing Innovation System

Builders sit in the centre of this model as the primary contractor responsible for realising a housing project. The focus of this study is on understanding builders' perceptions on key issues within this model. While these issues may not necessarily be under the control of builders, they impact them both directly and indirectly. This broad innovation systems framework does not suggest a clear method for empirically collecting this perceptual data. Given this shortcoming, the Theory of Planned Behaviour (TPB, Ajzen, 1991) is employed in this study. The TPB is a widely used social psychological theory based on the core hypothesis that an intention to take part in a specific behaviour is a direct antecedent to the actual behaviour occurring. The TPB model suggests that these intentions are in turn predicted by the three theoretical constructs of attitudes, subjective norm, and perceived behavioural control (PBC). Attitudes in this instance refers to the favourable or unfavourable evaluation of the elements of the behaviour, subjective norm to the pressure of key influential persons on the likelihood of taking part in the behaviour, and perceived behavioural control to the perceptions an individual holds regarding their ability and opportunity to perform the behaviour. The behaviour of interest here is the adoption of prefabrication by builders.

As there are significant implications for process and technological change resulting from prefabrication adoption, this should also be acknowledged within a model predicting prefabrication adoption. This issue is addressed by drawing on Davis' (1985) Technology Acceptance Model (TAM) which uses the explanatory variables of Perceived usefulness and Perceived ease of use. Further development of the TAM (Venkatesh & Bala, 2008; Venkatesh & Davis, 2000) has suggested specific determinants underlying these two variables. Perceived usefulness is underpinned by (1) the quality of outputs associated with the new technology, (2) the resulting image of adopters, and (3) the effect on complexity and efficiency of processes. Perceived ease of use is underpinned by the flexibility of the technology and frustration associated with new processes. The combination of the TPB and the TAM as a single theoretical model is shown in Figure 2. This model is used to guide both the data collection and interpretation of results.

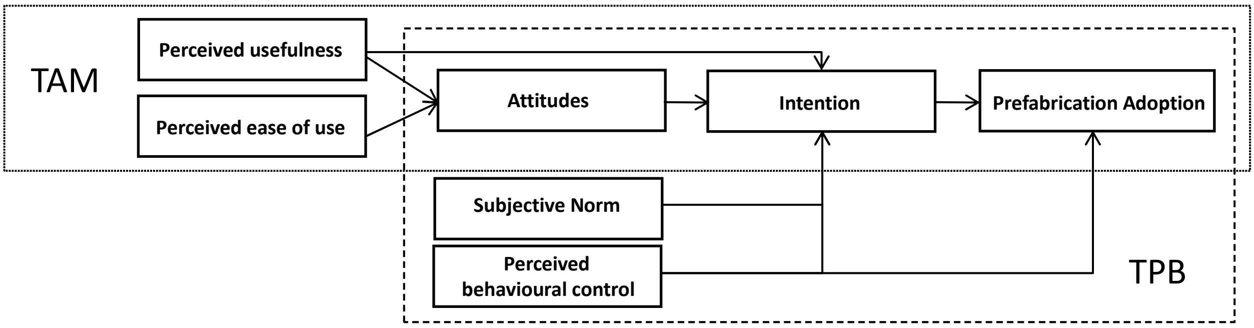


Figure 2. Combined TPB and TAM model for predicting prefabrication use in house building

This model thus aligns well with the previous discussion of factors in the introduction to this document. The process and technology issues align with the TAM model's realignment with the TPB Attitudes predictor, the people issues with the TPB subjective norm predictor, and the external contextual factors with the TPB perceived behavioural control predictor.

Method

Procedure

Participants were recruited primarily through direct email distribution lists managed by the respective government organisations that are partners in this research, namely the Western Australian Building Commission and the Queensland Department of Housing and Public Works (Building Codes Queensland). The Western Australian list contained all builder licensees in the state. A similar list was not accessible in Queensland, and thus the survey was distributed to subscribers to a government-controlled list which publicises updates to building codes. Each recruitment email contained a short description of the project and provided a direct web-link to the live survey page. A random prize draw for a tablet computer (worth approximately 600AUD) was publicised in the email as an incentive to participate. An initial email was distributed in both states, with two follow-up emails occurring at 7 and 14 day intervals after the initial dissemination.

Additional indirect recruitment methods in Queensland included promotional text and a survey link included in the state builder licensing authority's digital newsletter distributed both online and via email to all building licensees in the state. The same promotional text was also distributed to all members of the Queensland branch of the Master Builders Association (MBA) through their regular newsletter. Additional methods in Western Australia included distribution of the survey link to members of the Western Australian branch of the MBA, and publicising of the survey on the website of a Western Australian building trade publication.

Participants

The target group of participants for the current study was defined as residential builders, currently operating within at least one of the Australian states of Queensland or Western Australia. Participants' companies needed to provide at least some form of residential building, classified as detached housing, small multi-residential blocks of residences, or high-rise multiresidential units. Screening questions at the beginning of the survey directed participants immediately to a 'thank you' page if they did not meet both of these selection criteria. Surveys were completed by individual company representatives, thus the unit of analysis for the current paper is individuals representing companies. The survey targeted all builders regardless of whether they used prefabrication or not. A total of 454 valid responses were recorded, 300 (66.1%) operating in Western Australian only, 122 (26.9%) operating in Queensland only, and 32 (7.0%) operating in both states. While estimates of the total number of registered builders or building companies in the state could be calculated, no specific data is available on the numbers of builders undertaking residential versus non-residential construction work. Calculating exact response rates is thus not possible using the available information. Nevertheless, the large number of observations lends authority to the results.

Measures

The majority of the survey questions concerned the measurement of the core TPB constructs, including intention to adopt a higher level of prefabrication, and the predictor variables of this intention. A further five questions were asked regarding the characteristics of the participant's business, namely the level of prefabrication previously used, years operating, number of new houses built annually, postcode of primary office, and external walling materials used on housing products. A detailed description and rationale for inclusion of all questionnaire items is presented in Table 1. A complete reproduction of the survey is also included as an Appendix to this document.

Each predictor and outcome variable question referenced a specific action and time period, namely:

'*moving to a higher level of prefabrication than your business has previously used, on at least one housing project in the next 3 years*.' This specificity is suggested by methodological guidelines suggested by the authors of the TPB model (Ajzen, 2002, 2006b). The three year time period was chosen to allow a sufficiently long time period for assessing potential change in the conservative construction industry, whilst being short enough to increase the accuracy of predictions or recall.

The bulk of the current survey concerned indirect TPB measures. The specific attitudinal outcomes, key persons/groups and contextual factors used for these questions were derived from detailed interviews with 14 prefabricated builders in Queensland and Western Australia to identify the most prominent issues affecting the uptake of prefabricated housing. The use of a prior 'belief elicitation study' to guide further quantitative surveying is also recommended by the authors of the TPB Ajzen (2006a) and TPB research guidelines (Francis et al., 2004).

Given that the survey was to be distributed *en masse* using database lists, and that the population of Australian builders were known to be a hard-to-reach population for recruiting into research, reducing the complexity of the survey as much as possible was prioritised. While many more questions could have potentially been asked, keeping the survey completion time less than 10 minutes was seen as essential to maximising the number of responses. Five-point scales were used for all rating and likelihood items. This decision was supported by research showing that there is virtually no difference beyond simple linear scaling when comparing 5 and 7 item scales, that the shorter scale is easier to use while still retaining a middle-value option (Colman & Norris, 1997; Nagata, Ido, Simizu, Misao, & Matsuura, 1996), and recent use of 5-point scales by the TPB model's author (Ajzen, Joyce, Sheikh, & Gilbert, 2011).

Table 1. *Description of survey constructs and questions*

Construct	Question(s)	Rationale
Business characteristics	Types of builds provided States of operation	Basic descriptive data. Also used to screen participants to in-scope states and residential building involvement.
	Levels of prefabrication used	Previous behaviour is a known significant predictor of future behaviour **[1]**. Those already adopting some prefabrication may be more likely to adopt it in the future.
	Years of business operation	Basic descriptive data.
	Annual number of houses built	Basic descriptive data. Can also be used to assess representativeness of the sample against the distribution of firm size in Australia **[2]**
	Postcode of primary office	Basic descriptive data. Remoteness groupings derived from postcodes can be matched to external data to assess the representativeness of the sample **[3]**
	Exterior wall materials used	Types of exterior wall materials used vary by region and can be used to assess the representativeness of the sample **[4]**
Intention	Will business use a higher level of prefabrication?	Core outcome measure for the TPB **[5]**
Willingness	If market conditions were supportive, might the business use a higher level of prefabrication?	Additional TPB outcome measure: Willingness is separate to intention, referring to committing a behaviour if presented with the opportunity **[6]**
Planning	Level of future plans re: level of prefabrication used: explore options, make plans, take action, continue using, or regress to lower level.	Additional TPB outcome measure: Future plans are an intermediate towards forming intentions and committing a behaviour **[7, 8]**
Housing market condition	Housing market will improve in the next 3 years?	Innovation has been both positively and negatively linked with pressure on businesses.
TPB Direct measures	3 single item direct measures of - Attitudes, - Subjective norm, and - PBC, relating to prefabrication.	Direct measures provide a quick, overall measure of the 3 core TPB constructs, predicting that adopting prefabrication is: - worthwhile (attitudes) - supported by important people (subjective norm) - easy to do (PBC) **[9]**.
TPB Indirect measures	Indirect measures of underlying elements of the 3 TPB constructs: 9 for attitudes, 8 for subjective norm and 7 for PBC.	These items provide further detail than the direct measures, relying on an ‘expectancy-value’ model **[5, 9]**. That is, questions concern: - Attitudes: likelihood of outcome, weighted by whether outcome is positive or negative. - Subjective norm: approval of key persons/groups weighted by how much their opinion is valued. - PBC: degree of influence of contextual factors, weighted by their likelihood of occurring A single score is calculated for each of the 3 constructs for each respondent, based on the weighted values.

References:

[1] (Weinstein, 2007)
[2] (Housing Industry Association, 2012)
[3] (Australian Bureau of Statistics, 2008)
[4] (Australian Bureau of Statistics, 2008)
[5] (Francis et al., 2004)
[6] (Gibbons, Gerrard, Blanton, & Russell, 1998).
[7] (Sniehotta, 2009)
[8] (Prochaska & Diclemente, 1986)
[9] (Ajzen, 1991)

Results

The results of the study cover the characteristics of the sample; univariate analysis of individual questionnaire items and constructs; bivariate relationships between constructs; breakdown of business characteristics by previous prefabrication use; and finally multivariate model predicting future intentions to adopt a higher level of prefabrication is presented.

Sample characteristics

This section presents an overview of the basic characteristics of respondents and their businesses, with particular reference to describing the degree of representativeness of the sample. A breakdown of the types of builds provided by respondents' businesses is presented in Table 2.

Table 2. *Characteristics of respondents' businesses (N=454)*

Variable	n	%
Types of Builds (valid N=454)		
Residential		
Detached housing	421	92.7
Townhouses/terrace houses	170	37.4
Small unit blocks	150	33.0
High-rise unit blocks	54	11.9
Non-residential		
Commercial builds	155	34.1
Light industrial	127	28.0
Heavy industrial	15	3.3
Annual number of builds (valid N=445) [1]		
1 - 2	123	27.6
3 - 10	168	37.8
11 - 40	66	14.8
41 - 100	40	9.0
More than 100	48	10.8
Years Operating (valid N=451)		
Less than 1 year	15	3.3
> 1 – 2 years	18	4.0
> 2 – 5 years	76	16.9
> 5 – 10 years	71	15.7
> 10 – 20 years	110	24.4
More than 20 years	161	35.7

[1] – Differences between the total sample size and the number of valid responses is due to non-completion of these items

In line with the screening of responses, at least one form of residential building was undertaken by each respondent's business. Detached housing was offered by nearly all businesses, with roughly a third of businesses offering townhouses or small multiresidential blocks. A similar proportion also undertook commercial (e.g. offices, retail), and light industrial (e.g. factories, warehouses) builds. Approximately one in ten of respondents businesses provided high-rise units, and less than 4 percent carried out heavy industrial work such as the construction of roads and other infrastructure. In terms of annual numbers of builds, the data was clearly positively skewed. A combined 65% of the sample fell into the categories of (1-2) or (3-10) houses or units built annually. These findings are in line with the long-term predominance of small businesses in the Australian construction industry, which would be likely to devote the majority of their time to small housing projects rather than large infrastructure projects (Australian Bureau of Statistics, 2004, 2013c). The majority of businesses responding had been operating for at least 10 years, with a decreasing representation as years of operating decreased. There is no clear comparison data for these figures.

Location data was also collected through the postcode of the primary office location of respondents' businesses. Postcode data can be assigned to one of 5 remoteness categories defined by the Australian Bureau of Statistics' (ABS) Australian Statistical Geography Standard (ABS, 2013a). A minority of businesses were based outside of the Major Cities (urban areas around the capital cities), with very few in remote areas. The distribution of businesses across the remoteness categories was virtually identical to the Australian population distribution as provided by the ABS (Australian Bureau of Statistics, 2013b), as shown in Table 3.

Table 3. *Responses by remoteness of primary office*

	Sample		**Population**
Remoteness Category	**n**	**%**	**%**
Major Cities of Australia	310	70.8	71.7
Inner Regional Australia	63	14.4	13.3
Outer Regional Australia	43	9.8	9.8
Remote Australia	21	4.8	4.9
Very Remote Australia	1	0.2	0.2
Valid Total	**438**	**100.0**	**100.0**
Unspecified	16	3.5	-
Total	**454**	**100.0**	**100.0**

The level of reported prefabrication use on housing projects in the last 3 years is shown in Table 4.

Table 4. *Responses by level of prefabrication used in the last 3 years (valid N=454)*

Prefabrication levels used in the last 3 years	**n**	**%**
Level 0: None	95	20.9
Level 1: Trusses or beams	282	62.1
Level 2: Structural panels (e.g. SIPs / Precast concrete)	131	28.9
Level 3: Specialised pods (e.g. bathroom / kitchen)	39	8.6
Level 4: Modules (housing segments)	87	19.2
Level 5: Fully complete houses delivered to site	87	19.2

As the levels of prefabrication use were not mutually exclusive, meaning that a business could be involved in multiple levels of prefabrication, values in the table do not sum to the total number of respondents. While one fifth of the sample reported using no prefabrication in their housing projects, prefabricated trusses or beams were used by a 62% majority. Higher levels of prefabrication were much less frequently employed, with structural panels being the most common, followed by modules / fully complete houses, and specialised volumetric pods least frequently.

These figures show a much higher level of prefabrication use than previous estimates which suggested less than 5% of Australian construction projects involve prefabrication (Hampson & Brandon, 2004). Although the survey result may involve a response bias towards those with a personal interest in prefabrication, the prefabrication figures are so high compared to previous estimates that it is reasonable to conclude that rates of prefabrication have increased over the past decade.

State-based differences

As the survey collected data from two separate states in Australia, the differences between each of these states should also be considered to determine if they can be analysed as a single group or separately. For the purposes of these analyses, the 32 responses indicating businesses operating in both Western Australia (WA) and Queensland were excluded. The final samples to compare were thus 300 cases for WA and 122 cases for Queensland. These same groupings are used throughout this report when comparing each of the states.

Business characteristics

Table 5 presents an overview of the respondents' business characteristics by state of operation.

Table 5. *Characteristics of respondents' businesses by state of operation*

	WA (n=300)		**Qld (n=122)**	
Variable	**n**	**%**	**n**	**%**
Types of Builds				
Residential				
Detached housing	283	94.3	113	92.6
Townhouses/terrace houses	105	35.0	50	41.0
Small unit blocks	105	35.0	33	27.0
High-rise unit blocks	29	9.7	16	13.1
Non-residential				
Commercial builds	97	32.3	38	31.1
Light industrial	87	29.0	27	22.1
Heavy industrial	9	3.0	5	4.1
Annual number of builds				
1 - 2	84	28.8	36	29.8
3 - 10	120	41.1	45	37.2
11 - 40	42	14.4	16	13.2
41 - 100	23	7.9	10	8.3
More than 100	23	7.9	14	11.6
Years Operating				
Less than 1 year	12	4.0	3	2.5
> 1 – 2 years	13	4.4	3	2.5
> 2 – 5 years	57	19.1	17	14.0
> 5 – 10 years	49	16.4	20	16.5
> 10 – 20 years	78	26.2	23	19.0
More than 20 years	89	29.9	55	45.5

The patterns in terms of both types of build and annual number of builds were very similar between both states. While a higher proportion of businesses operating for more than 20 years was present in Queensland, the positive correlation between years operating and proportional representation was similar in both states. Table 6 below shows the proportion of respondents using each level of prefabrication, broken by state of operation.

Table 6. *Responses by level of prefabrication used in the last 3 years, by state of operation*

	WA		Qld	
Prefabrication levels used in last 3 years	**n**	**%**	**n**	**%**
Level 0: None	73	24.3	20	16.4
Level 1: Trusses or beams	186	62.0	81	66.4
Level 2: Structural panels (e.g. SIPs / Precast concrete)	93	31.0	26	21.3
Level 3: Specialised pods (e.g. bathroom / kitchen)	16	5.3	12	9.8
Level 4: Modules (housing segments)	53	17.7	20	16.4
Level 5: Fully complete houses delivered to site	44	14.7	23	18.9
Total	**300**	**100.0**	**122**	**100.0**

The pattern of prefabrication use was similar between the two samples, with a predominant use of prefabricated trusses or beams, a rare use of pods, and between a 15 and 20% representation of other volumetric prefabrication.

Table 7's analysis of exterior walling materials used on housing projects can also be useful in commenting on the representativeness of the sample. It should be noted that the ABS comparison data concerns the *main* material of outside walls and is mutually exclusive, while the data from the current survey allowed respondents to choose multiple options. The predominant use of double-brick among Western Australian builders, and the high use of brick veneer in Queensland aligned well with the ABS comparison data. The higher use of timber exteriors in Queensland compared to WA was also replicated. The distribution suggests the survey received responses from a relatively representative cross-section of builders in regards to material usage.

Table 7. *Responses by exterior wall materials used, by state*

	Survey Data				ABS Data	
	WA		Qld		WA	Qld
Exterior wall materials used	**n**	**%**	**n**	**%**	**%**	**%**
Brick veneer	113	37.7	69	**56.6**	15.7	**37.9**
Double brick	198	**66.0**	13	10.7	**47.2**	4.5
Timber	115	38.3	66	54.1	5.6	19.8
Concrete	70	23.3	33	27.0	2.0	21.1
Fibro cement	127	42.3	69	**56.6**	21.6	11.6
Insulated panels[1]	100	33.3	44	36.1	*N/A*	*N/A*
Other[2]	61	20.3	28	23.0	7.9	5.1
Total	**300**	**100.0**	**122**	**100.0**	**100.0**	**100.0**

[1] – The ABS data did not specify the category of 'Insulated panels'
[2] – The ABS 'Other' group includes 'Steel/Aluminium', 'Stone', 'Other' and a negligible 'Don't Know' group

Remoteness data derived from primary office postcode was also able to be compared to the remoteness indicator calculated from postcodes of company licensing data publicly available from the Queensland Building and Construction Commission and the Western Australian Building Commission. The survey data again showed a similar pattern to the comparison data, with a higher representation of businesses around the Major Cities area (i.e., the greater Perth capital city region) than for Queensland (i.e., the greater Brisbane capital city region). Respondents from locations in Outer Regional or more remote categories were slightly over-represented in the current sample, yet still a clear minority.

Table 8. *Responses by remoteness of primary office, by state*

	Survey Data				Licensing Data	
	WA		Qld		WA	Qld
Remoteness category	**n**	**%**	**n**	**%**	**%**	**%**
Major Cities of Australia	220	75.6	69	58.0	82.9	69.8
Inner Regional Australia	35	12.0	26	21.8	7.7	16.0
Outer Regional Australia	17	5.8	22	18.5	4.8	12.8
Remote Australia	18	6.2	2	1.7	3.9	0.8
Very Remote Australia	1	0.3	0	0.0	0.7	0.6
Total	**300**	**100.0**	**122**	**100.0**	**100.0**	**100.0**

In summary, these results suggest the respondents from the two states did not differ substantially in relation to types of buildings constructed, annual number of builds, years operating, or on the levels of prefabrication used in the prior 3 years. The two samples did however differ on types of walling materials used and slightly on distribution by remoteness. These differences were however generally in line with comparison data for all builders in each state.

Outcome variables

The relationship between state of operation and the other TPB predictor and outcome measures are presented throughout the following analyses to highlight differences where they exist. These results are sometimes presented separately at the end of this document in Appendix A to prevent repetition and simplify the presentation of results.

Univariate analysis

As a starting point for the analyses, comparison of the responses to each of the survey items is presented, before progressing to bivariate relationships and multivariate modelling. These descriptive analyses allow for an understanding of perceptions of the individual items which constitute the theoretical TPB and TAM constructs. Additional tables of source data are provided in Appendix B to this document in the instances of graphs being displayed.

Direct TPB measures

The direct TPB measures used in the current study provide single item measures of the three TPB predictor constructs of Attitudes, Subjective Norm and Perceived Behavioural Control by assessing whether moving to a higher level of prefabrication use would be: 1) worthwhile, 2) supported by most people important to the respondent, and 3) easy to do, as shown below in Figure 3. Responses were on a 5-point scale from Strongly Disagree (SD) to Strongly Agree (SA) with a neutral midpoint of Neither Agree Nor Disagree (N).

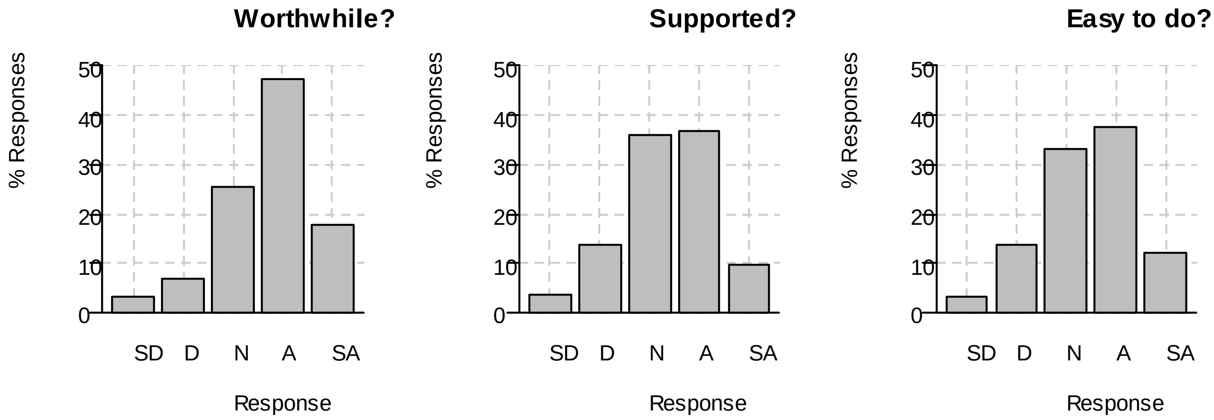


Figure 3. Distribution of responses to direct TPB measures

Responses to the questions were generally favourable, with a skew towards believing prefabrication is worthwhile, supported and easy to do. Attitudes ($\bar{x}$ = 3.69, s=0.9) were overall more favourable than both the subjective norm ($\bar{x}$ = 3.36, s=1.0) and PBC direct measures ($\bar{x}$ = 3.42, s=1.0). These differences were statistically significant as evidenced by paired t-tests (Att. > PBC.: $t(412) = 6.4$, $p < .001$), though no difference was found between the SN and PBC measures (PBC > SN.: $t(405) = 1.47$, $p = 0.14$). Figure 4 presents the distribution of these three measures by state of operation of respondents' businesses.

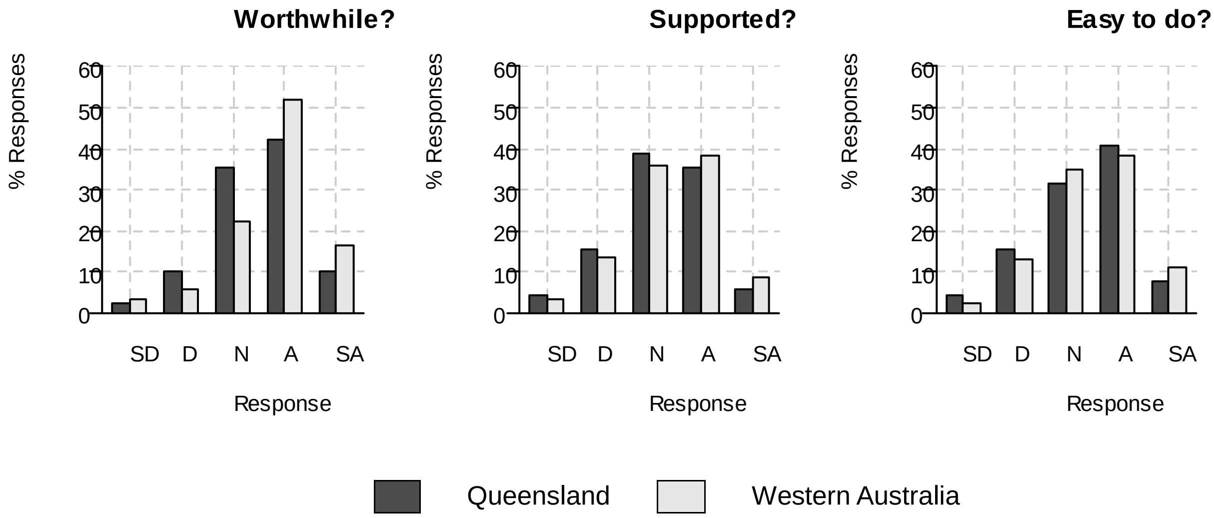


Figure 4. Distribution of responses to direct TPB measures, by state of operation

The results between comparing respondents from each state were similar, with a trend towards the same positive trends as for the combined sample. Linear by linear association tests identified a significant difference between the two states for direct Attitude ($\chi^2(1) = 6.5$, $p < .05$), indicating the Western Australian sample as believing prefabrication was more worthwhile. No differences were found comparing the direct Subjective Norm ($\chi^2(1) = 0.98$, $p = .32$) or direct PBC ($\chi^2(1) = 1.3$, $p = .25$) measures.

Indirect Attitudes Measures

Unlike the overall direct TPB measures, the indirect TPB measures rely on measuring respondents' beliefs about particular factors that make up the overall attitudes, subjective norm, and PBC measures. This data therefore addresses Aim 1 of the current study, by describing the relative importance of particular factors for builders. Each of the constructs is discussed in turn beginning firstly with the attitudes measures. The two sets of TPB attitudes questions measure the likelihood of a particular outcome occurring if the target behaviour is adopted, as well as the degree to which the impact of adopting the target behaviour is negative or positive. The likelihood items were measured on a scale from 'highly unlikely' to 'highly likely', with a neutral midpoint of 'neither likely nor unlikely.' These values were coded numerically on a scale from 1 to 5, with a midpoint of 3. Table 9 shows the relative mean rankings of these variables by the survey respondents.

Table 9. *TPB Attitudes: likelihood of outcomes if moved to a higher level of prefabrication*

	Question (Would moving to a higher level of prefabrication:)	Mean	Std.Dev
Likely	Improve the speed of your construction?	3.95	0.85
	Improve the energy efficiency of your housing products?	3.43	0.99
	Reduce the number of trades you require?	3.31	1.01
	Improve your business' image?	3.09	0.93
Unlikely	Reduce the flexibility of your housing designs?	2.98	1.16
	Increase your building costs?	2.85	0.99
	Reduce the size of your target market?	2.84	0.91
	Increase the complexity of your building?	2.80	0.97
	Reduce the quality of your building?	2.48	1.07

The majority of responses to each of these likelihood items were distributed around the neutral responses, with infrequent representation of the 'highly unlikely' and 'highly likely' groupings. The most likely outcome from adopting prefabrication was seen as improved speed of construction, while the least likely was a reduction in build quality. The corresponding value attached to each of these items is presented in Table 10, ranging from 'Very negative' (-2) to 'Very positive' (+2), with a neutral midpoint of 0.

Table 10. *TPB Attitudes: evaluation of impact of changes on business*

	Question (What would be the impact of these changes on your business?)	Mean	Std.Dev
Positive	Faster construction speed	1.03	0.64
	Improved energy efficiency of your housing products	0.69	0.81
	Improved business image	0.53	086
	Reduced number of required trades	0.43	0.86
Negative	Increased complexity of building	-0.26	0.84
	Reduced target market	-0.30	0.78
	Reduced flexibility of possible house designs	-0.39	0.89
	Increased building costs	-0.42	0.87
	Reduced quality of housing built	-0.50	0.92

Responses were in line with the coding of the questions to negative and positive outcomes. Faster construction speed was seen as the most favourable outcome, while reducing the quality of housing was the clearly least favourable outcome. The ordering of the mean responses to these two sets of attitude questions did not vary significantly between states, with this data presented separately in Appendix A.

Indirect Subjective Norm Measures

The two sets of TPB subjective norm questions measured the approval of particular key persons or groups towards a higher level prefabrication, along with the degree to which their opinion is valued by the respondent. The approval items were measured on a scale from 'strongly disapprove' to 'strongly approve', with a neutral midpoint of 'neither approve nor disapprove.' These values were coded numerically on a scale from -2 to +2, with a midpoint of 0. Table 11 shows the relative mean rankings of these variables by the survey respondents.

Table 11. *TPB Subjective norm: approval of key persons and groups*

	Question (Would the following groups approve of your business moving to a higher level of prefabrication?)	**Mean**	**Std.Dev**
Approve	Housing energy efficiency regulators	0.46	0.71
	Industry groups (HIA, MBA, Builders' networks)	0.30	0.75
	Clients/owners	0.27	0.85
	Architects and building designers	0.23	0.88
	Local planning regulators	0.17	0.75
Disapprove	Material suppliers	-0.01	0.93
	Subcontractors	-0.04	0.91
	Banks and other lenders	-0.05	0.78

The distribution of responses did not highlight an extreme approval or disapproval of prefabrication among the listed key groups. Energy efficiency regulators were seen as the most approving group, in line with the literature noting prefabrication's relationship to better environmental performance. Banks and other lenders, along with subcontractors and material suppliers, were seen as most negative towards prefabrication, though this was only a slight bias. Table 12 shows the corresponding value placed on these important groups' opinions, as rated from 1 (Not at all) to 5 (A lot).

Table 12. *TPB Subjective norm: value of key groups' opinions*

Question (How much do you value their opinions?)	**Mean**	**Std.Dev**
Clients/owners	4.42	0.74
Subcontractors	3.69	0.90
Architects and building designers	3.68	0.98
Housing energy efficiency regulators	3.56	1.01
Industry groups (HIA, MBA, Builders' networks)	3.53	0.97
Local planning regulators	3.45	1.03
Material suppliers	3.39	1.02
Banks and other lenders	3.31	1.16

The results indicated that the groups chosen for the current study were generally well valued by the respondent builders, in line with their inclusion on the basis of previously collected interview data. The stand-out result was the high value attributed to clients/owners' opinions, which was substantially higher than the next closest groups of subcontractors and architects/building designers. The ordering of the mean responses to these two sets of Subjective Norm questions did not vary significantly between states, with this data presented separately in Appendix A.

Indirect PBC Measures

The two sets of TPB PBC questions measured the likelihood of particular events supporting prefabrication uptake occurring, along with the degree to which they would influence using prefabrication. The likelihood variables were measured on a scale from 1 (Highly unlikely) to 5 (Highly likely), with a midpoint of 3 (Neither likely nor unlikely).

Table 13. *TPB PBC: likelihood of potentially supporting events occurring*

	Question (How likely are the following events?)	**Mean**	**Std.Dev**
Likely	Stricter energy efficiency requirements	3.23	1.00
	Increased demand for prefabrication	3.22	1.01
	More people trained in prefabrication	3.04	0.96
Unlikely	Lower labour costs for prefabrication	2.89	1.04
	Lower material costs for prefabrication	2.85	1.00
	Relaxation of planning rules for prefabrication	2.57	1.00
	Easier financing for prefabrication	2.55	0.92

Again, the responses were typically distributed around the central responses with low representation at the extremes of the likelihood scale. The continuation of stricter energy efficiency requirements was reported as most likely, just ahead of an increased demand for prefabrication. Along with the relatively low approval of banks and lenders towards prefabrication, easier financing for prefabrication was reported as the least likely supporting event to occur. Relaxation of planning rules was seen as similarly unlikely. Items measuring the degree of influence on prefabrication uptake were also rated on a scale from 1 (Not at all) to 5 (A lot). Table 14 below presents these mean rankings.

Table 14. *TPB PBC: encouragement to adopt prefabrication provided by potentially supporting events*

Question (How much would the following events encourage your business to move to a higher level of prefabrication?)	**Mean**	**Std.Dev**
Increased demand for prefabrication	3.91	1.05
Lower material costs for prefabrication	3.82	1.01
Lower labour costs for prefabrication	3.82	1.04
More people trained in prefabrication	3.67	1.08
Relaxation of planning rules for prefabrication	3.57	1.18
Easier financing for prefabrication	3.43	1.18
Stricter energy efficiency requirements	3.03	1.12

All of the items were generally rated as being encouraging of prefabrication, with none scoring on average below the midpoint score of 3. Increased demand was reported as the most encouraging factor across respondents, followed closely by cost reductions for materials and labour associated with prefabrication. Stricter energy efficiency requirements was clearly the lowest ranked supporting factor, highlighting that prefabrication’s purported benefits of better environmental performance may not be a strong immediate influence. The ordering of the mean responses to these two sets of PBC questions did not vary significantly between states, with this data presented separately in Appendix A.

Composite measures

Composite measures were calculated using a multiplicative expectancy-value model for each set of the indirect attitude, subjective norm and PBC items discussed above. This resulted in three sets of values for each respondent. The attitudes scale thus represented the summed combination of the likelihood of a particular outcome occurring if prefabrication was adopted, weighted by whether the outcome was seen as positive or negative. The subjective norm scale represented the summed combination of how much a key group approved of prefabrication, weighted by the value given to that group's opinion. Finally, the PBC scale represented the summed combination of how much a particular event would encourage prefabrication uptake, weighted by the likelihood of that factor occurring. The rankings of these computed composite measures for each of the three TPB constructs of attitudes, subjective norm and PBC are shown in the following tables.

Table 15. *TPB Attitudes: ranking of composite scores*

	Issue:	**Mean**	**Std.Dev**
Positive	Faster construction speed	4.41	2.89
	Improved energy efficiency of your housing products	2.85	3.26
	Improved business image	2.01	2.83
	Reduced number of required trades	1.74	3.29
Negative	Increased complexity of building	-0.64	2.63
	Reduced target market	-0.91	2.51
	Increased building costs	-1.18	2.81
	Reduced flexibility of possible house designs	-1.22	3.24
	Reduced quality of housing built	-1.31	2.87

In line with the previous results indicating that the most positive related outcomes such as faster construction speed, improved energy efficiency and a reduction in the required number of trades were also most likely to occur, these variables contributed most positively to the overall TPB attitudes composite score. Opposing these factors, the negative factors such as a reduced quality of building and an increased complexity of building were also seen as the least likely to occur. As the degree of negative opinions were generally not as strong as the degree of positive opinions, these negative variables did not contribute as much to the overall TPB attitudes score as the positive outcomes. A similar pattern was found comparing the results between Queensland and Western Australia, with these results presented in Appendix A.

Table 16. *TPB Subjective norm: ranking of composite scores*

Key Group	Mean	Std.Dev
Housing energy efficiency regulators	1.91	2.83
Clients/owners	1.27	3.94
Industry groups (HIA, MBA, Builders' networks)	1.24	2.96
Architects and building designers	1.04	3.54
Local planning regulators	0.82	2.74
Material suppliers	0.15	3.56
Subcontractors	0.00	3.69
Banks and other lenders	-0.09	2.99

The individual subjective norm items presented in the previous section generally showed that the groups chosen for the current study were well valued. Overall, housing energy efficiency regulators were the most favourable taking into account both the relatively high value placed in their opinions and their clear highest level of approval for the adoption of prefabrication. While the opinions of subcontractors and banks and other lenders were generally well regarded, they were rated as having a more neutral opinion towards prefabrication and thus were not strongly influential in the overall composite score. The ordering of these subjective norm factors was similar between the two states, with no significant differences on the basis of t-tests between the distributions. Appendix A presents these analyses by state.

Table 17. *TPB PBC: ranking of composite scores*

Event	Mean	Std.Dev
Increased demand for prefabrication	12.88	5.71
More people trained in prefabrication	11.27	5.10
Lower labour costs for prefabrication	11.11	5.25
Lower material costs for prefabrication	11.07	5.19
Relaxation of planning rules for prefabrication	9.39	5.09
Easier financing for prefabrication	8.89	4.82
Stricter energy efficiency requirements	2.84	3.26

An increased demand for prefabrication was seen as the strongest overall PBC measure, driven by its rating as both likely to occur, and the factor that would be most encouraging for adopting a higher level of prefabrication. Stricter energy efficiency requirements on the other hand were seen as most likely to occur, but were the lowest ranked factor in terms of encouraging prefabrication adoption. The composite result reflects this weakness. Comparing the results between each of the states showed little difference, with this data presented in Appendix A.

Outcome measures

Three outcome measures were utilised in the current study, namely intention and willingness to adopt a higher level of prefabrication, and a measure of what stage of planning respondents' businesses were at in regards to prefabrication. Figure 4 depicts the distribution of responses to the two statements: "*My business will…*" and "*If market conditions were supportive, my business might…*" take part in the target behaviour of: " *use a higher level of prefabrication than previously used, on at least one housing project in the next 3 years.*" Both of these measures were presented together on a 5 point scale from strongly disagree (SD) to strongly agree (SA), with a midpoint of neither agree nor disagree (N).

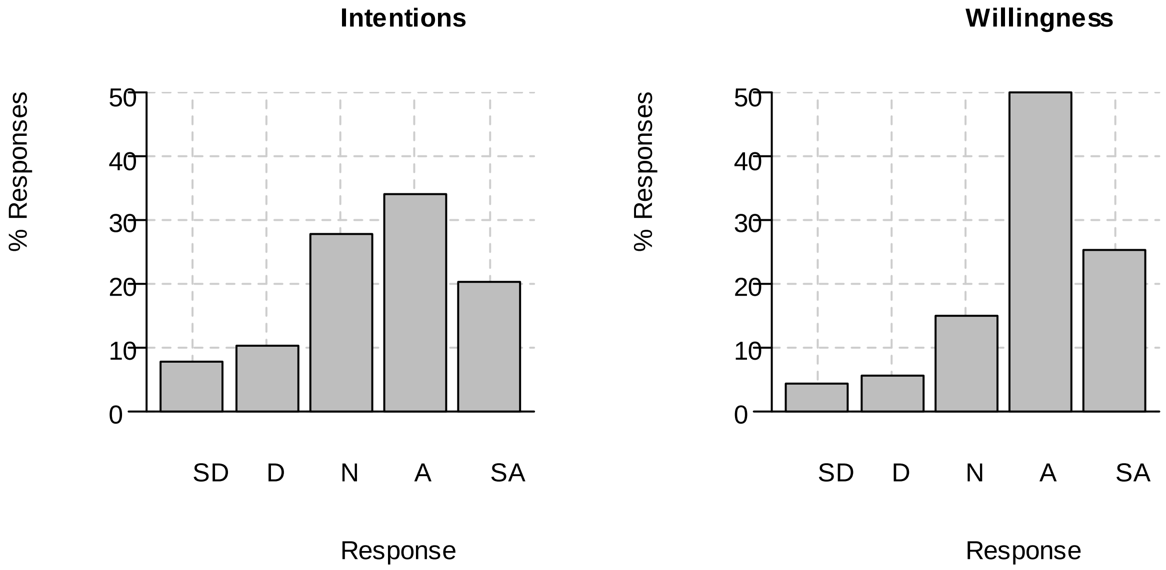


Figure 5. Distribution of responses to intention and willingness outcome measures

As a group, intentions to adopt a higher level of prefabrication were generally positive, but significantly less so than the willingness to adopt prefabrication if supportive market conditions existed (Linear by linear association test: $\chi^2(1) = 25.6$, p = < .001). No statistically significant difference was found between these two measures when compared between the two states (Linear by linear association tests, Intention: $\chi^2(1) = 3.56$, p = .06; Willingness: $\chi^2(1) = 1.19$, p = .28). The relevant graphs showing these results separately by state are included in Appendix A.

The third and final outcome measure consisted of an ordinal measure of what future steps respondents saw their business taking in regards to adopting a higher level of prefabrication. Table 18 below shows the proportion of respondents in each planning category.

Table 18. *Plans towards adopting a higher level of prefabrication*

In the next 3 years, my business will:	**n**	**%**
Not move to a higher level of prefabrication…	79	17.6
Explore how to adapt to a higher level of prefabrication…	201	44.7
Make plans to move to a higher level of prefabrication…	50	11.1
Actively move to a higher level of prefabrication…	71	15.8
Continue to use the highest level of prefabrication…	46	10.2
Move from the highest to a lower level of prefabrication…	3	0.7

The majority of the respondents fell into the group ‘exploring’ how to adopt a higher level of prefabrication. This category roughly aligns to the theoretical stage of ‘contemplation’ in the Stages of Change model (Prochaska & Diclemente, 1986), where respondents are ready to make change, but as yet have not made any firm plans as to how to change their behaviour.

Bivariate analysis

Following from the univariate analyses, bivariate analyses were undertaken to explore the relationships between the key constructs collected through the survey, along with further analyses to address Aim 2 of this study by highlighting business differences by previous prefabrication use.

Relationships between predictor and outcome measures

Table 19 below presents the correlations between each of the composite measures, direct TPB measures, and the outcome measures of intention, willingness and future planning. For the future planning measure, the 3 cases 'regressing', or moving from the highest to a lower level of prefabrication were removed to ensure an always increasing linear scale that could be validly correlated. Those respondents specifying that they would continue to use the highest level of prefabrication when they had not been using the highest level were also removed.

Table 19. *Correlation matrix of key predictor and outcome measures*

Variable[1]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. Indirect Attitude	**1.00**	-	-	-	-	-	-	-	-
2. Indirect Subjective Norm	0.51	**1.00**	-	-	-	-	-	-	-
3. Indirect PBC	0.37	0.39	**1.00**	-	-	-	-	-	-
4. Direct Attitude	0.48	0.46	0.40	**1.00**	-	-	-	-	-
5. Direct Subjective Norm	0.48	0.48	0.34	0.66	**1.00**	-	-	-	-
6. Direct PBC	0.32	0.32	0.22	0.46	0.59	**1.00**	-	-	-
7. Intention	0.40	0.35	0.40	0.71	0.59	0.39	**1.00**	-	-
8. Willingness	0.31	0.32	0.32	0.60	0.45	0.28	0.71	**1.00**	-
9. Plans	0.38	0.32	0.38	0.59	0.49	0.28	0.64	0.53	**1.00**

1 – Correlation coefficients based on Spearman's rho rank correlations

All of the predictor and outcome variables were positively and significantly correlated ($p < .001$). In line with the theoretical TPB model, Intentions, Willingness and Plans towards using a higher level of prefabrication were significantly correlated with each of the direct and indirect TPB measures. The direct and indirect TPB measures were also significantly correlated with one another. The strongest correlations identified included between the direct TPB measures (in particular direct attitude / direct subjective norm = 0.66); direct attitude to intention (0.71), and between intention and willingness (0.71).

The significant correlations between the TPB constructs are expected in line with the theoretical underpinning of the model. The particularly strong relationships between the outcome variables support their use as similar, yet nuanced constructs. Significant correlations between the predictor constructs are also likely given that attitudinal, normative and control perceptions are likely to cluster together for or against prefabrication. Significant relationships between the predictors and the outcome variables also provide initial reassurance that the choice of variables in the current study is appropriate for inclusion in a model predicting prefabrication uptake. The same pattern of positive relationships was seen in both separate sets of data relating to each state, as shown in Appendix A.

The following boxplot figures show the relationship between the distribution of the indirect TPB response scores and each level of the 'intention to adopt a higher level of prefabrication' outcome measure.

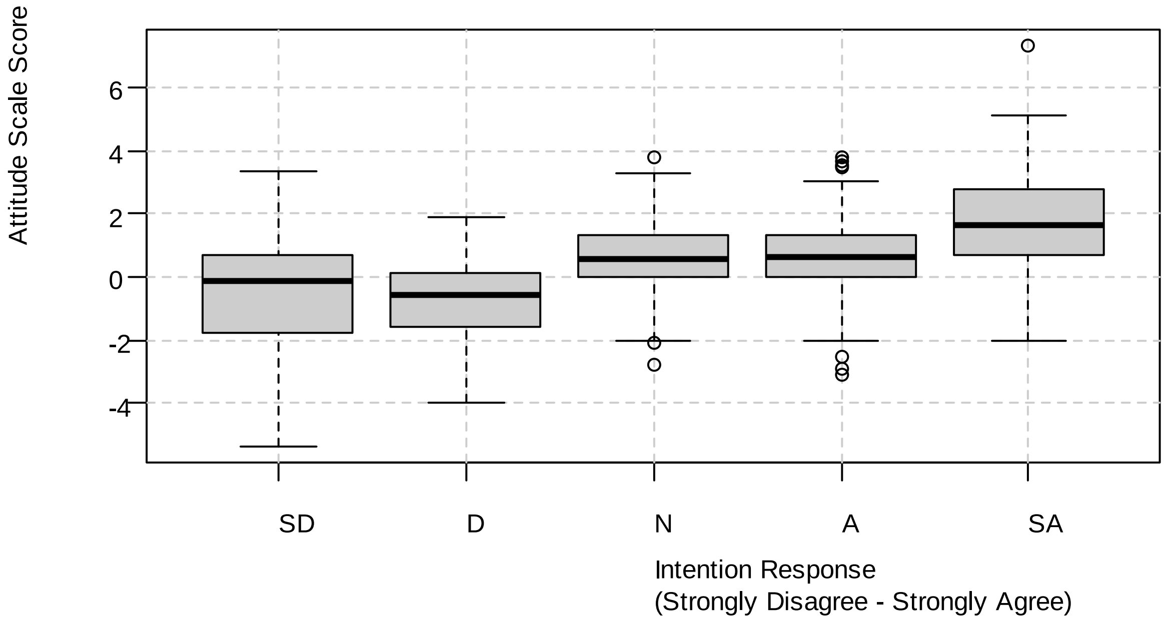


Figure 6. Boxplot of indirect TPB attitude scale score for each intention group

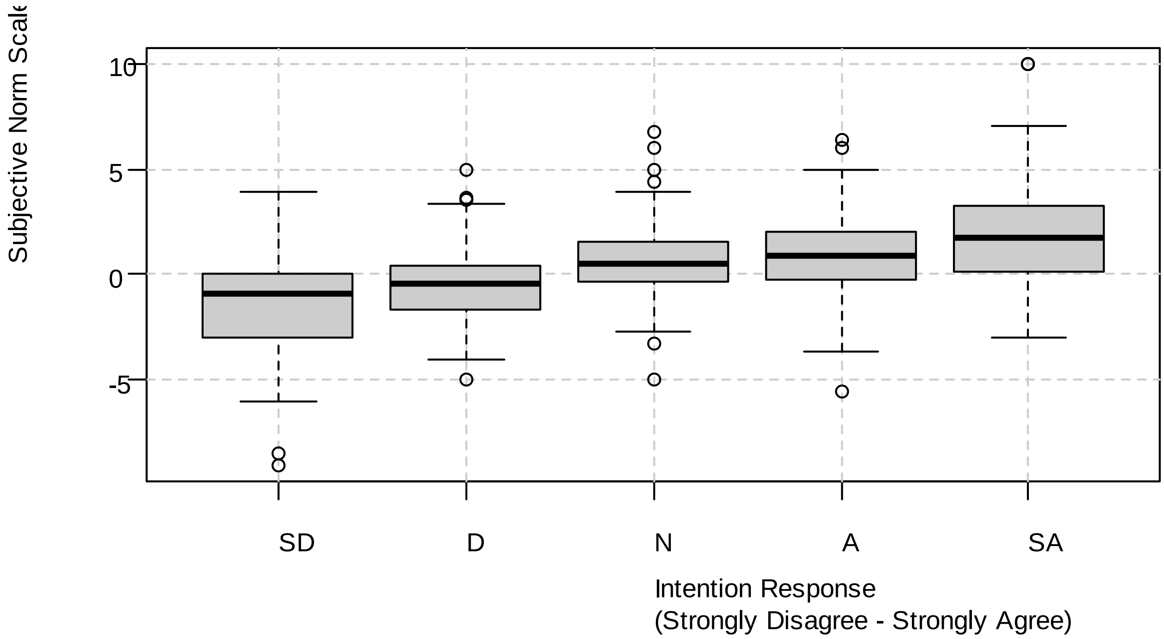


Figure 7. Boxplot of indirect TPB subjective norm scale score for each intention group

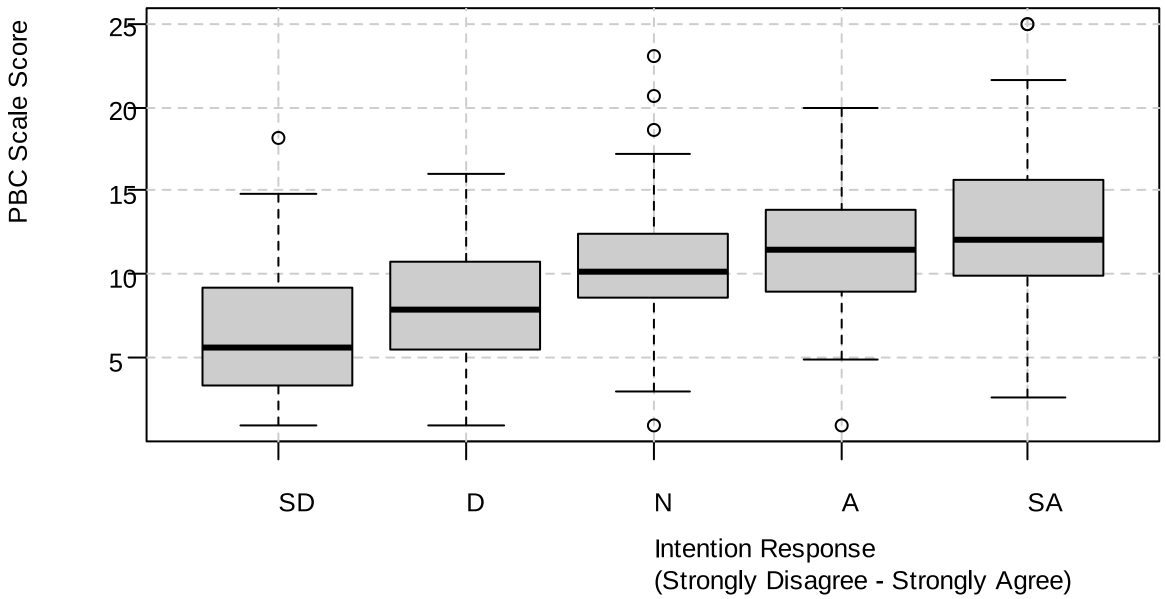


Figure 8. Boxplot of indirect TPB PBC scale score for each intention group

There was a consistent pattern of indirect TPB scale scores becoming more favourable to prefabrication as intention to adopt a higher level of prefabrication increased. A very similar pattern of responses was repeated for the Willingness measure, with these three figures included in Appendix B to this document. The results also did not differ substantially when inspecting the boxplots by state of operation, with these separate analyses included in Appendix A.

Results by level of prefabrication use

This section presents an overview of the survey's results broken by their self-reported level of prefabrication usage, addressing Aim 2 of this study. To simplify the interpretation of these analyses, 4 mutually exclusive groups were defined based on the highest level of prefabrication that respondents' reported using. The complete, modular and pod groups (Levels 3-5) were collapsed together as 'volumetric' prefabrication, while the remaining three groups of Structural Panels (Level 2), Prefabricated Trusses or Beams (Level 1), and None (Level 0) were retained. Table 20 presents the number of respondents in each of these groups.

Table 20. *Responses by highest level of prefabrication used*

Highest prefabrication level used	**n**	**%**
None	92	20.3
Trusses or beams	140	30.8
Structural panels	78	17.2
Volumetric	144	31.7
Total	**454**	**100.0**

This distribution did vary significantly on the basis of state, when comparing the categories nominally ($\chi^2(3) = 8.31$, $p < .05$), but not when considering the overall trend from None to Volumetric (Linear by linear association test: $\chi^2(1) = 0.97$, $p = .32$).

Table 21. *Responses by highest level of prefabrication used and state of operation*

	WA		Qld	
Highest prefabrication level used	**n**	**%**	**n**	**%**
None	71	23.7	19	15.6
Trusses or beams	89	29.7	48	39.3
Structural panels	60	20.0	16	13.1
Volumetric	80	26.7	39	32.0
Total	**300**	**100.0**	**122**	**100.0**

There was a higher proportion of no prefabrication use in WA compared to Queensland, and lower use of prefabricated trusses and beams and volumetric units. WA did however have a greater use of structural panels. A number of key variables are now discussed in turn, describing the relationship of prefabrication usage to business characteristics, beliefs about prefabrication, and intention to increase prefabrication usage.

Prefabrication level and business characteristics

This section presents an overview of the relationships between the characteristics of the businesses and their self-reported usage of prefabrication. Figure 9 shows the relationship between highest level of prefabrication use and remoteness of the business' primary office. The one respondent in the 'Very Remote' category was collapsed together with the 'Remote' category to simplify the figure.

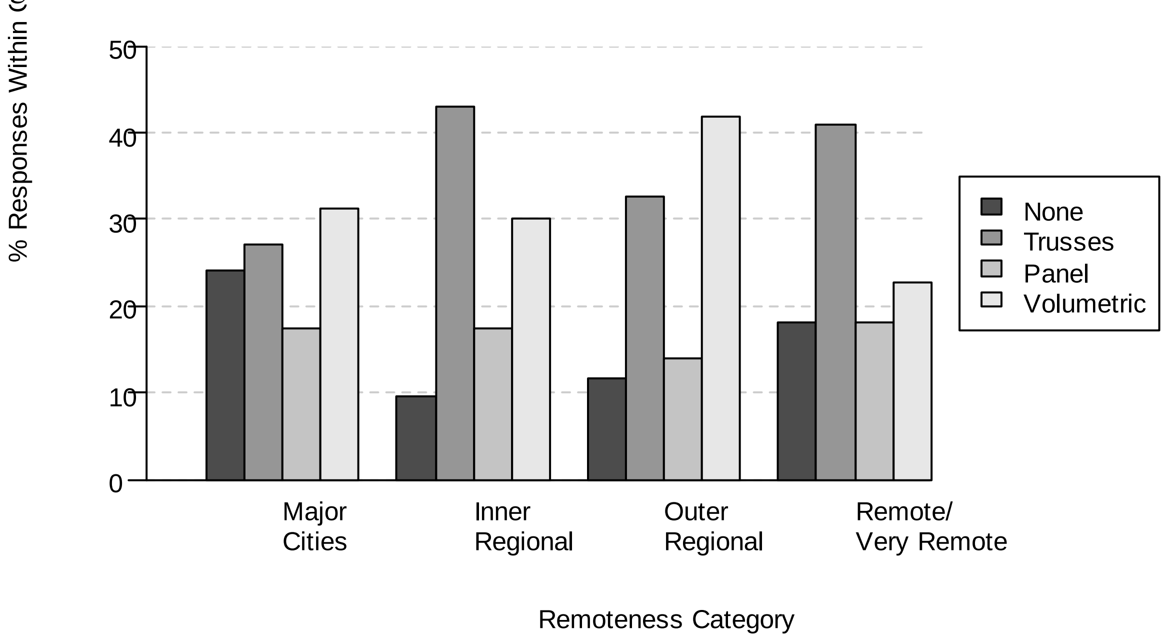


Figure 9. Distribution of highest level of prefabrication used by remoteness category

There was not a consistent linear relationship between prefabrication level and remoteness, though there was an indication that the proportion of companies using no prefabrication increased with increasing remoteness outside of the major cities areas. Comparing this distribution between Queensland and Western Australia likewise did not identify any distinct trends by state in the data, as shown in Appendix A. Figure 10 shows the distribution of these highest levels of prefabrication by the number of annual builds completed by respondents' businesses.

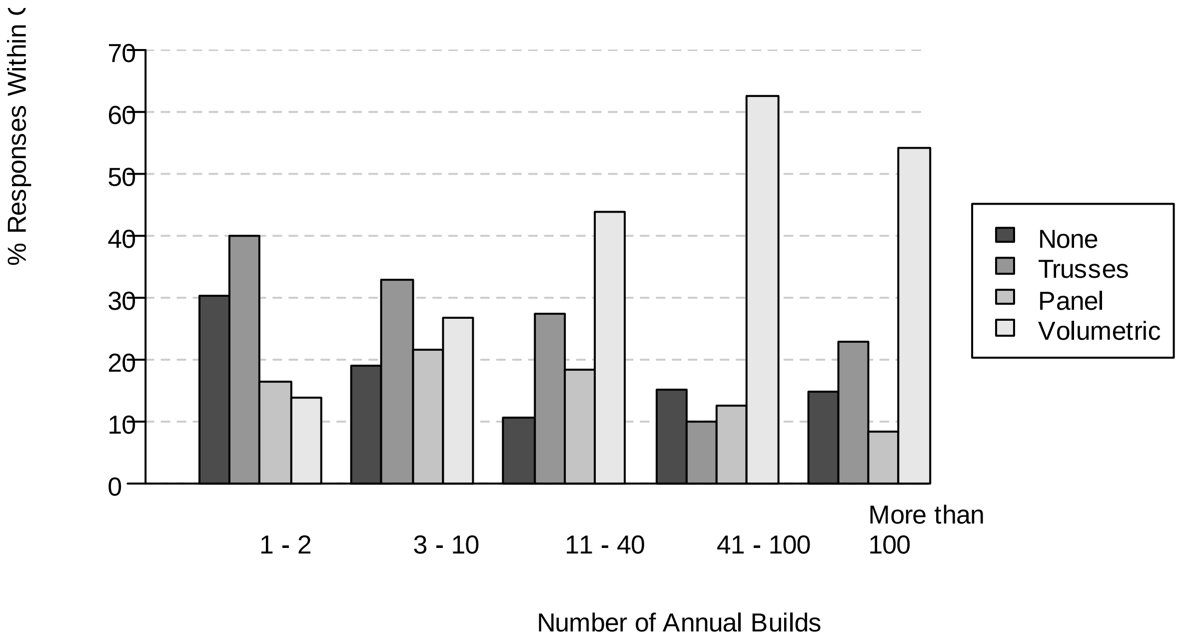


Figure 10. Distribution of highest level of prefabrication used by number of annual builds

The clearest trend evident from Figure 10 is the increase in the application of volumetric prefabrication with an increasing number of annual builds. The use of either no prefabrication or prefabricated trusses and beams as the highest level, was also highest among builders with low output. This trend persisted for both the Queensland and Western Australia respondents. Prefabrication usage by the number of years operating is highlighted in Figure 11.

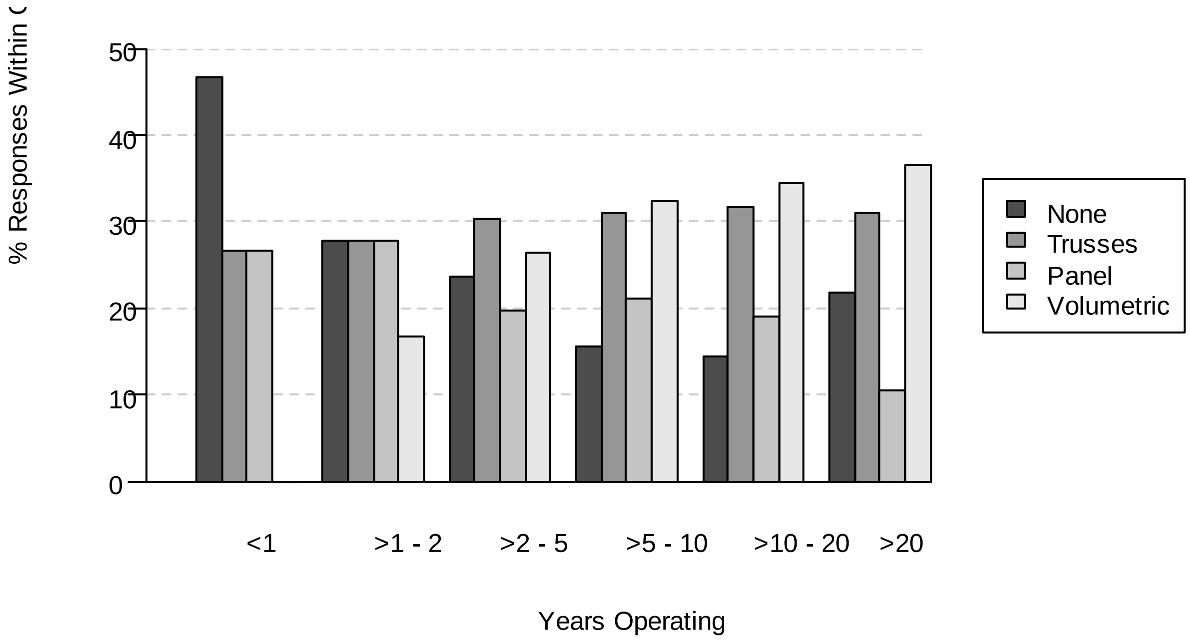


Figure 11. Distribution of highest level of prefabrication used by years operating

Again there was an overall trend towards greater use of volumetric prefabrication as years operating increased, though substantially weaker than the relationship with annual number of builds. The relationship was even less clear when considering each of the states of Queensland and Western Australia separately, as shown in Figures 12 and 13. Some of the smaller groups have been collapsed in these analyses to allow sufficient numbers for analysis.

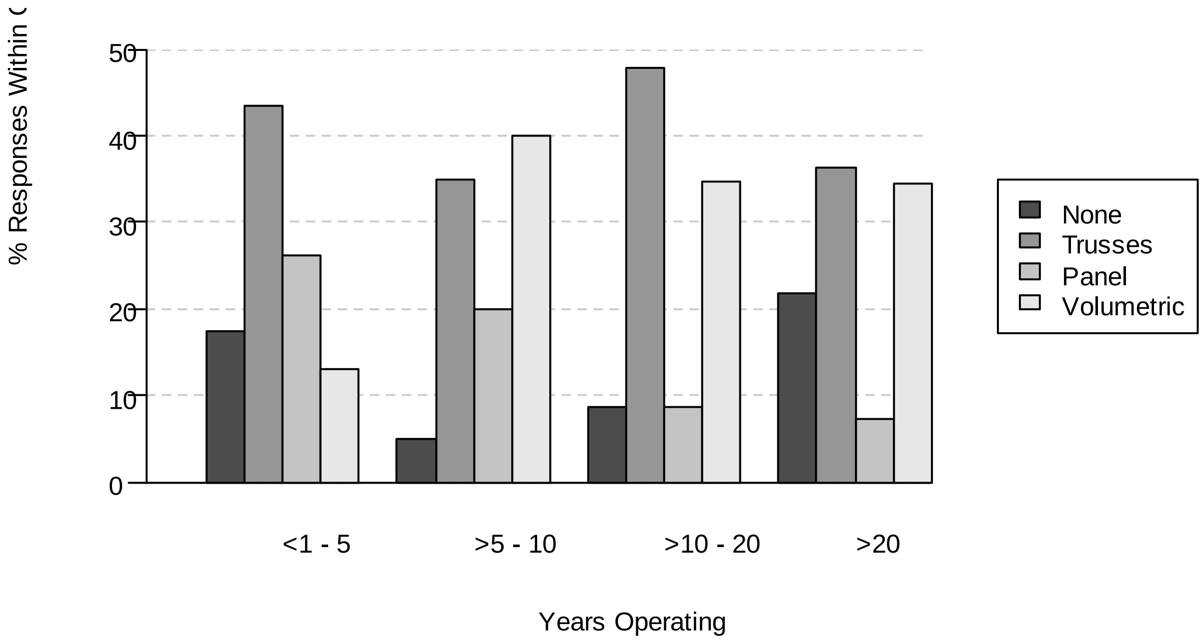


Figure 12. Distribution of highest level of prefabrication used by years operating, Queensland

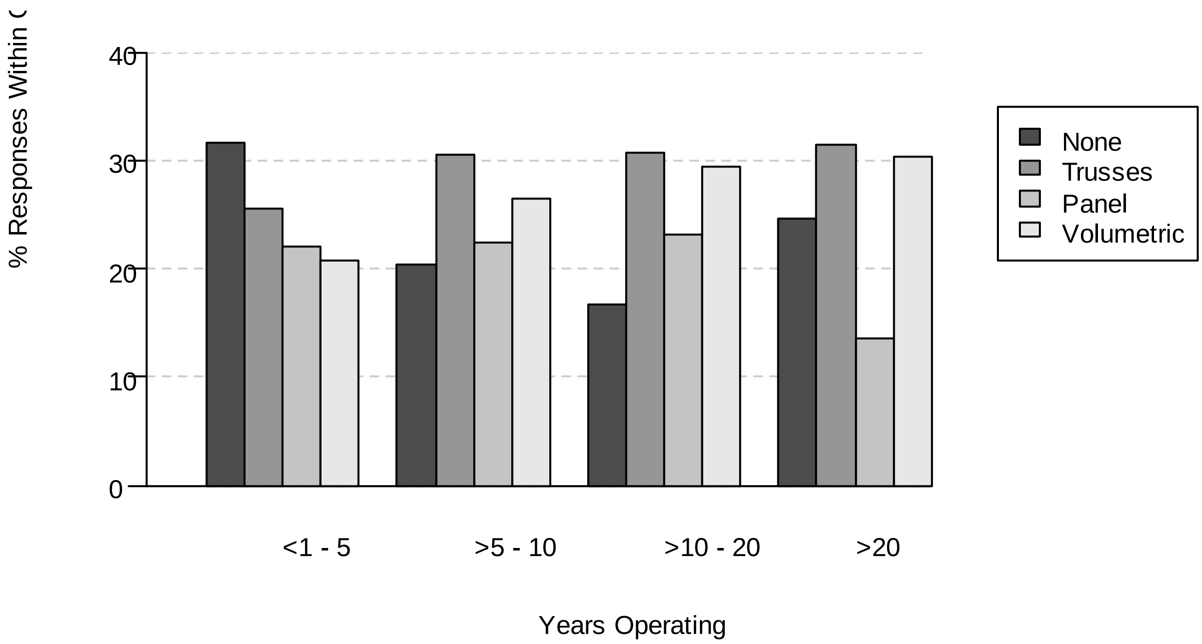


Figure 13. Distribution of highest level of prefabrication used by years operating, Western Australia

While the Queensland data indicated an increase in prefabrication for older companies (>5 years) compared to the youngest companies (<1 – 5 years), this pattern was not replicated in the Western Australian data. Finally, the relationship between prefabrication use and types of residential buildings constructed is shown in Figure 14. For the purposes of this analysis, 3 mutually exclusive groups based on the largest types of buildings constructed by respondents' businesses were derived. These were respectively: 1) Detached housing only 2) Townhouses or small multi-residential unit blocks as the highest level, and 3) Multiresidential high-rise unit blocks as the highest level.

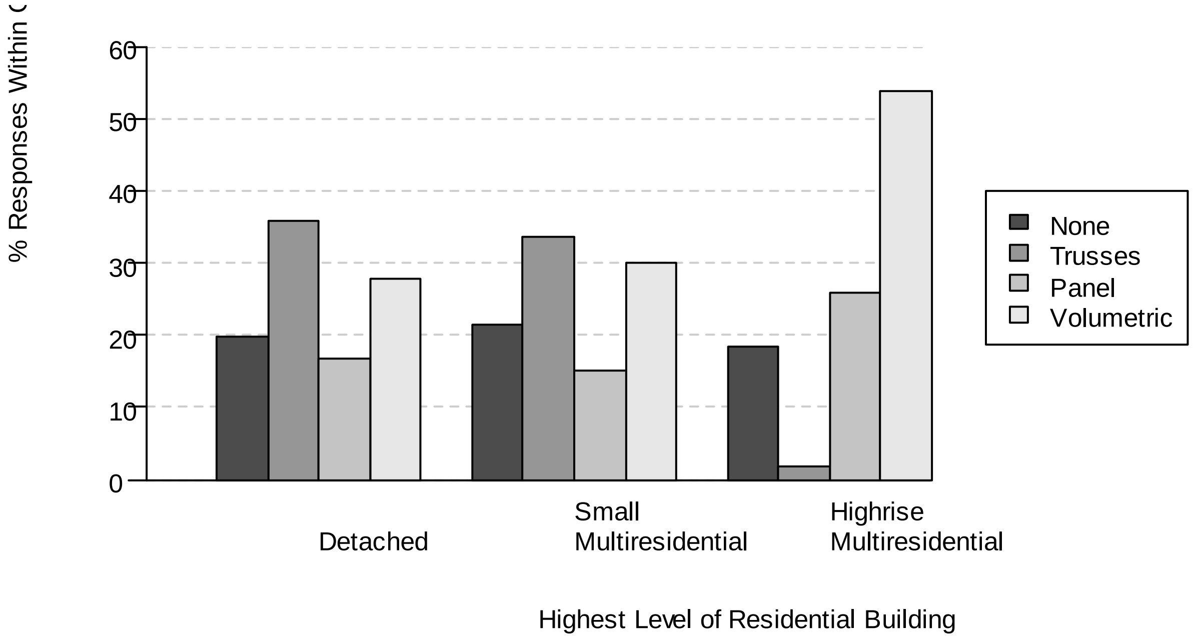


Figure 14. Distribution of highest level of prefabrication used by highest level of residential building

While there is little difference in the pattern of prefabrication usage between those businesses constructing detached or small multi-residential buildings, there was a large proportional increase in the use of volumetric prefabrication for those businesses involved in high-rise multiresidential building. There was however an interactive effect by state for this factor, as shown in Figures 15 and 16.

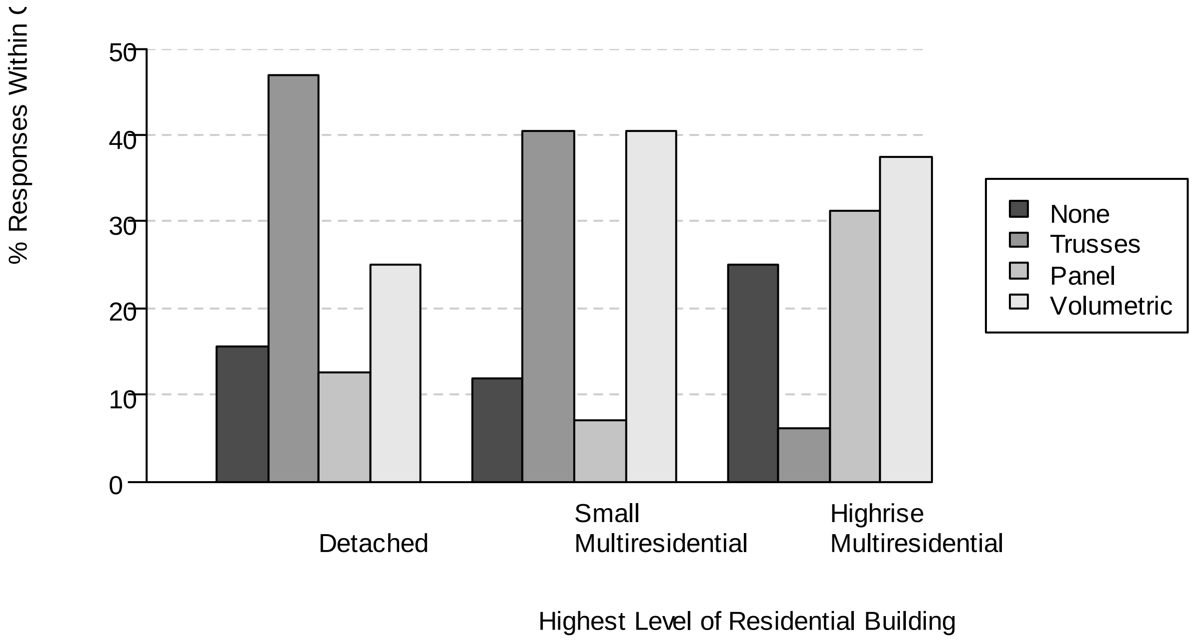


Figure 15. Distribution of highest level of prefabrication used by highest level of residential building, Queensland

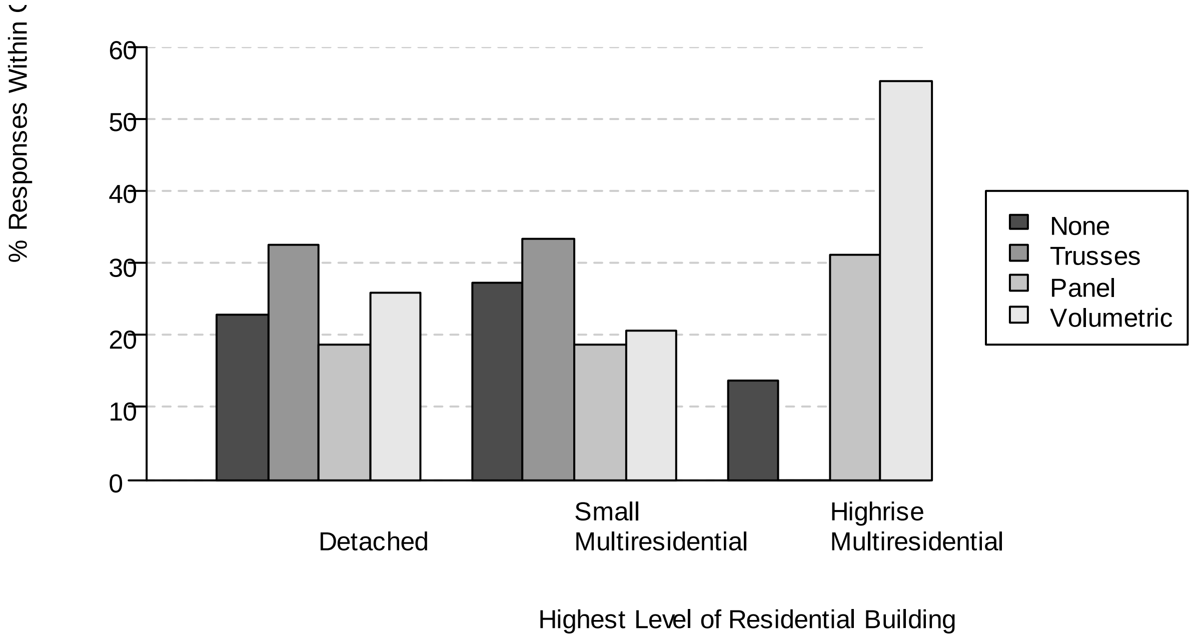


Figure 16. Distribution of highest level of prefabrication used by highest level of residential building, Western Australia

The Queensland data suggested a higher level of volumetric prefabrication generally, with this more prevalent among those building any form of multiresidential housing. Only high-rise multiresidential showed a higher use of volumetric methods in Western Australia.

Prefabrication level and beliefs about prefabrication

This section presents an overview of the relationship between reported levels of prefabrication use by respondents' businesses and their beliefs about prefabrication. The relationship to each of the TPB predictor and outcome variables are included in this analysis. Figure 17 shows the relationship between highest level of prefabrication use and intention to move to a higher level of prefabrication.

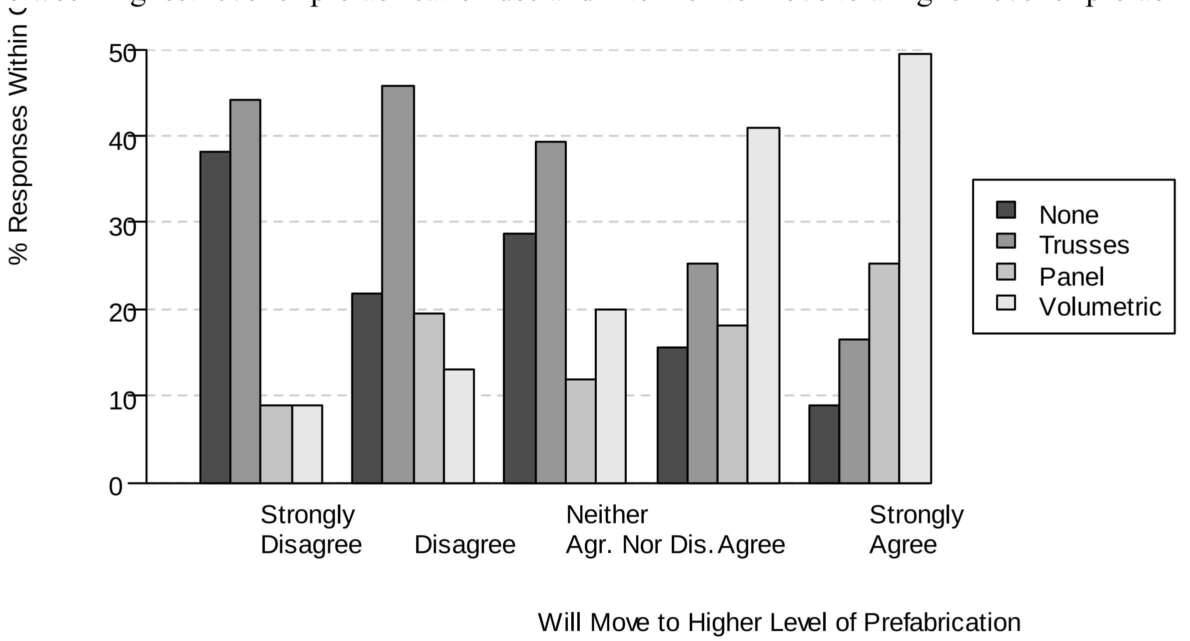


Figure 17. Distribution of highest level of prefabrication used by intention to move to a higher level of prefabrication

As intention to use a higher level of prefabrication increased, so too did the likelihood that the respondent's business had previous experience employing higher levels of prefabrication. This relationship was statistically significant (Linear-by-linear association test: $\chi^2(1) = 54.8$, $p < .001$). The relationship was very similar for both Queensland and Western Australian respondents when considered separately, as shown in Appendix A. The results for the willingness measure were similar, suggesting that respondents were not being held back by their particular circumstances (see Figure 18).

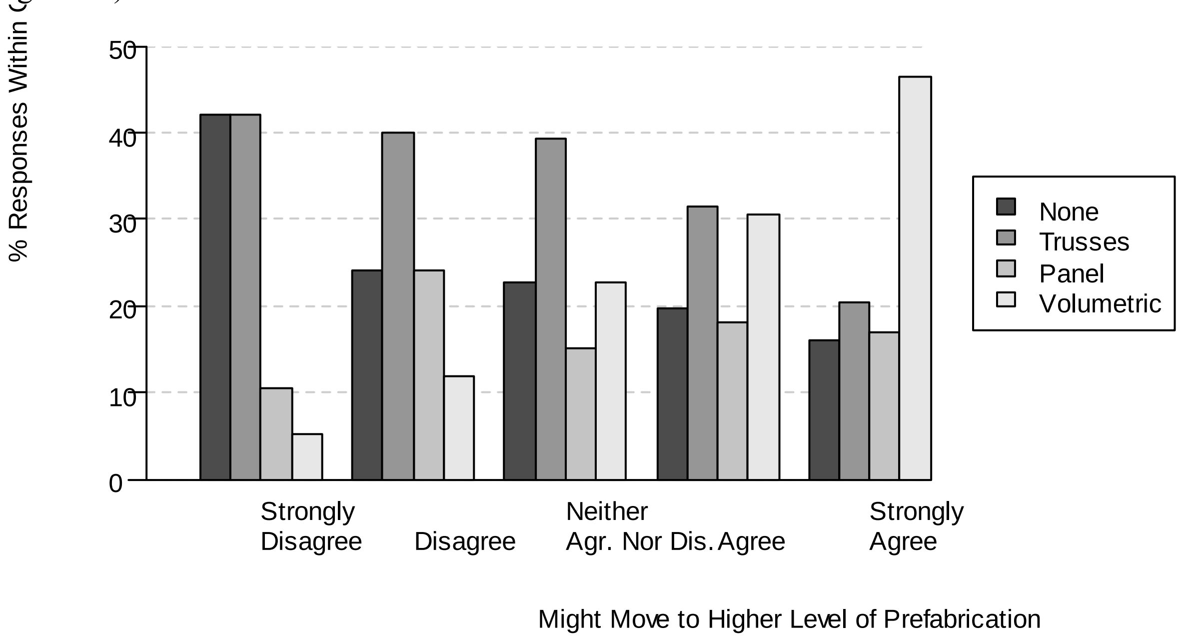


Figure 18. Distribution of highest level of prefabrication used by willingness to move to a higher level of prefabrication

As for intention, this relationship was again statistically significant (Linear-by-linear association test: $\chi^2(1) = 24.0$, $p < .001$). The relationship did not change on the basis of state, as shown in Appendix A. Finally, the relationship between respondents' future plans for prefabrication and their previous usage were explored, as shown in Figure 19.

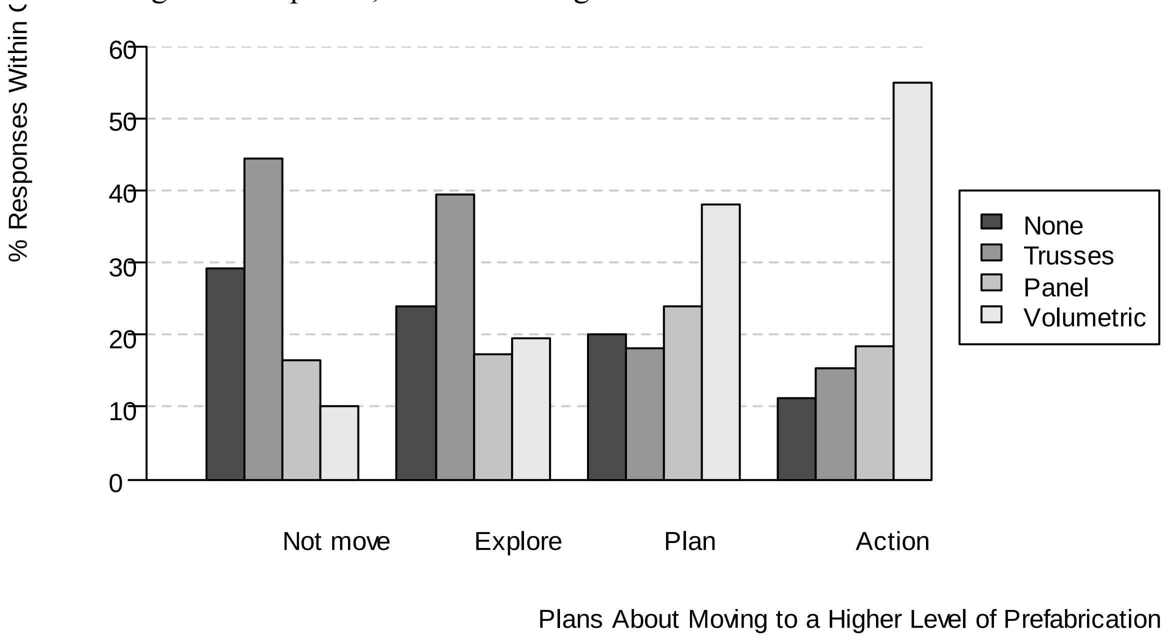


Figure 19. Distribution of highest level of prefabrication used by plans about moving to a higher level of prefabrication

As with the intention and willingness measures, those with past experience with prefabrication were significantly more likely to have made firm plans or taken action to begin moving to a higher level of prefabrication (Linear-by-linear association test: $\chi^2(1) = 91.2$, $p < .001$). This relationship did not vary dependent on state, as shown in Appendix A.

Multivariate

The previous sections have provided an analysis of individual variables either alone (univariately), or in combination with other variables (bivariately). While this provides a baseline of data that can be used for interpreting the results, more detailed multivariate models taking into account the variation between sets of variables are necessary. This section addresses Aim 3 of the current study, by formulating a model to test the predictive ability of the proposed TPB model to predict builders' future intentions towards prefabrication.

Variable selection and recoding

To assist with the interpretation of the final predictive model, a number of variables were first simplified or re-categorised on the basis of their relationship to intentions to adopt a higher level of prefabrication.

Previous level of prefabrication use
Respondents' previous level of prefabrication use was significantly correlated with intention (Linear-by-linear association test: $\chi^2(1) = 54.8$, $p < .001$). Paired Chi-square tests of independence (df = 4) were used to identify which levels of prefabrication use differed in terms of their relative intentions. A corrected critical p-value of $.008\dot{3}$ (.05/6) was used to account for the multiple tests. Each of the comparisons was significant at the $p < .001$ level with the exception of the 'None' vs. 'Trusses and Beams' comparison ($p = 0.77$); and the 'Panel' vs. 'Volumetric' comparison ($p = 0.24$). For entering into the final model, prefabrication level was thus further recoded to two groups representing the combination of 'None / Trusses and Beams' and 'Volumetric / Panellised'

Types of housing built
There was no significant relationship between the types of housing built by respondents' businesses and intention (Linear-by-linear association test: $\chi^2(1) = 2.40$, $p = .12$). The variable was thus not considered further for multivariate modelling.

Years operating
There was no significant relationship between the number of years the respondent's business had been operating and intention (Linear-by-linear association test: $\chi^2(1) = 1.60$, $p = .21$). The variable was thus not considered further for multivariate modelling.

Annual number of builds
The number of houses built annually by respondents' businesses was significantly correlated with intention (Linear-by-linear association test: $\chi^2(1) = 10.9$, $p < .001$). Follow-up paired Chi-square tests of independence (df = 4), using a corrected critical p-value of $.008\dot{3}$ (.05/6) for the multiple tests, identified no significant differences in intention between the smallest builders building 1-2 houses annually, and those building 3-10 houses annually ($p = 0.72$). Comparisons approaching significance were however found between those annually building 1-2 houses and 11-40 houses ($p = .01$); 1-2 houses and 41-100 houses ($p = .04$); 1-2 houses and >100 houses ($p = .06$); and 3-10 houses and 11-40 houses ($p = .02$). No significant differences were likewise found comparing respondents' intentions from builders with a larger turnover: 11-40 vs. 41-100 ($p = .36$), 11-40 vs. >100 ($p = 0.12$); 41-100 vs. >10 ($p = 0.96$).

A conservative decision was made to include this variable in the multivariate model, as there was some indication of differences on the basis of annual turnover. To increase the likelihood of identifying this possible effect, the two smallest groups (1-2 and 3-10 houses annually) were combined; the medium group (11-40) was retained in line with the one possible difference; and the largest two groups (41-100 and >100) were also combined in light of no identified differences.

Remoteness

The remoteness of respondents' primary business office was significantly correlated with intention (Linear-by-linear association test: $\chi^2(1) = 19.9$, $p < .001$). Follow-up paired Chi-square tests of independence (df = 4), using a corrected critical p-value of .0083• (.05/6) for the multiple tests were again used. A significant difference was found between 'Major Cities' and 'Remote/Very Remote' ($p = .002$), while a result approaching significance was found comparing 'Major Cities' and 'Outer Regional' ($p = .07$). All remaining comparisons did not reach statistical significance. The variable was thus simplified to a comparison between a combination of the 'Major Cities' and 'Inner Regional' groups, against a combination of the 'Outer Regional' and 'Remote/Very Remote' groups.

Indirect TPB variables

As noted in the bivariate relationships section of this report, each of the indirect TPB measures of attitudes, subjective norm and PBC were significantly and positively correlated with the intention measure. As such, all of these variables were included in the final model.

Ordered logit model - intention

The final multivariate model used to predict intention to use a higher level of prefabrication is described in Table 21.

Table 21. *Final ordered logit model predicting intention to use a higher level of prefabrication*

Type	**Variable**	**Categories**
Dependent	Intention	Strongly disagree Disagree Neither agree nor disagree Agree Strongly Agree
Independent	Previous use of prefabrication	None/Trusses Volumetric/Panellised
	Annual number of houses/units built	1-10 11-40 41+
	Remoteness of primary office	Major cities / Inner Regional Outer Regional / Remote / Very Remote
	Attitude	Continuous Variable
	Subjective Norm	Continuous Variable
	Perceived Behavioural Control (PBC)	Continuous Variable

Each of these variables was entered into an ordered logistic regression model. This statistical method is particularly designed for predicting an ordinal outcome, such as the steadily increasing intention measure used in the current study, from a set of continuous, ordinal or categorical predictors. The results of this analysis are shown in Table 22.

Table 22. *Results of ordered logit model predicting intention to use a higher level of prefabrication*

Variable	**Odds Ratio**	**95%CI**	***p***
Previous prefabrication level			
None/Trusses	1.00	-	-
Volumetric/Panellised	3.12	(2.10 – 4.65)	<.001
Annual number of builds			
1-10	1.00	-	-
11-40	1.22	(0.70 – 2.13)	.47
41+	1.72	(1.05 – 2.84)	.03
Remoteness			
Major cities / Inner Regional	1.00	-	-
Outer Regional / Remote / Very Remote	0.57	(0.34 – 0.98)	.04
Indirect TPB			
Attitude	1.37	(1.18 – 1.59)	<.001
Subjective Norm	1.20	(1.08 – 1.33)	<.001
Perceived Behavioural Control (PBC)	1.15	(1.09 – 1.21)	<.001

A number of interpretations can be drawn from this table of results. The odds ratio column refers to the likelihood of a respondent being in a higher category of intention compared to all the lower categories combined.

In relation to previous prefabrication level, for a one unit increase from 'None/Trusses' (0) to Volumetric (1), the odds of their intention being 'Strongly Agree' versus all lower categories combined ('Agree' – 'Strongly disagree') would be 3.12 times greater. This odds ratio would repeat comparing 'Agree' to all lower categories combined ('Neither agree nor disagree' – 'Strongly disagree' and so on until all categories are compared ordinally. Following this logic, it can be seen that previous prefabrication level was a significant predictor of intention.

The ordinal change in odds of being in intention categories was also significantly predicted by the remoteness indicator. As the odds ratio was less than 1, this indicated that the odds of being in a higher category of intention compared to all lower categories *decreased* with a shift from the 'Major cities/Inner regional' category to the 'Outer Regional / Remote / Very Remote' category. That is, increasing remoteness is related to a lower intention to adopt prefabrication.

A similar interpretation can be applied to the relationship between intention and the annual number of builds. Comparing against the reference category of 1-10 builds annually, the odds of being in a higher intention group compared to all lower categories was 1.22 times greater. This was not a significant effect though ($p = .47$). The 1.72 times greater odds moving from 1-10 to 41 or more houses built annually was however significant ($p = .03$).

The interpretation of the continuous indirect TPB measures is slightly different. For each increase of 1 unit in the TPB measures, the odds of being in a higher intention group is multiplied by the respective odds ratio. Each of the indirect TPB predictors was significantly related to increased odds of being in a higher intention category.

Ordinal logistic regression also allows for the prediction of the probability of a respondent falling into one of the 5 intention categories, based on the combination of the independent variables. This is often easier to directly interpret than the odds ratios as it returns the probabilities directly in terms of the dependent variable. To simplify the calculation of these probabilities from the calculated regression equation, the continuous TPB variables were cut into 3 values based on quartiles – the lower quartile (25th percentile), mean value (50th percentile), and upper quartile (75th percentile).

Table 23. *Highest and lowest predicted probabilities based on ordinal regression model of intention to use a higher level of prefabrication*

Predictors						Intention Group Probability[1]				
Att	**SN**	**PBC**	**Previous Prefab.**	**Annual Builds**	**Remote**	**SD**	**D**	**N**	**A**	**SA**
High	High	High	Volumetric/Panellised	41+	MC/IR	0.6	1.4	8.6	37.5	52.0
High	Med	High	Volumetric/Panellised	41+	MC/IR	0.7	1.8	10.9	41.4	45.2
Med	High	High	Volumetric/Panellised	41+	MC/IR	0.7	1.8	10.9	41.5	45.0
High	High	High	Volumetric/Panellised	11 – 40	MC/IR	0.8	1.9	11.5	42.3	43.5
High	High	Med	Volumetric/Panellised	41+	MC/IR	0.8	2.0	11.8	42.7	42.7
…										
Low	Low	Med	None/Trusses	1-10	OR/R/VR	17.4	25.1	38.9	15.7	2.8
Med	Low	Low	None/Trusses	1-10	OR/R/VR	18.2	25.7	38.4	15.1	2.7
Low	Low	Low	None/Trusses	11-40	OR/R/VR	19.4	26.4	37.6	14.2	2.5
Low	Med	Low	None/Trusses	1-10	OR/R/VR	19.7	26.6	37.3	13.9	2.4
Low	Low	Low	None/Trusses	1-10	OR/R/VR	22.7	28.1	35.2	12.0	2.0

[1] – SD = Strongly disagree, D = Disagree, N = Neither agree nor disagree, A = Agree, SA = Strongly Agree

Those in the combinations likely to have the most support had very low probabilities of ‘Disagree’ or ‘Strongly Disagree’ responses (2 – 3%). The same could not be said for those combinations providing the least support. The most negative combinations of predictors still had a 14% probability of either ‘Agree’ or ‘Strongly Agree’ responses. The intensity of feelings against prefabrication were thus not typically as strong as those in favour of prefabrication.

Ordered logit model - willingness

A second multivariate model was tested, this time substituting the willingness to adopt prefabrication as the dependent variable in place of the intention measure. The results of this analysis are shown in Table 24.

Table 24. *Results of ordered logit model predicting willingness to use a higher level of prefabrication*

Variable	**Odds Ratio**	**95%CI**	***p***
Previous prefabrication level			
None/Trusses	1.00	-	-
Volumetric/Panellised	1.47	(0.99 – 2.19)	.06
Annual number of builds			
1-10	1.00	-	-
11-40	2.06	(1.17 – 3.67)	.02
41+	1.86	(1.12 – 3.13)	.02
Remoteness			
Major cities / Inner Regional	1.00	-	-
Outer Regional / Remote / Very Remote	0.53	(0.30 – 0.93)	.03
Indirect TPB			
Attitude	1.17	(1.01 – 1.36)	.04
Subjective Norm	1.25	(1.12 – 1.39)	<.001
Perceived Behavioural Control (PBC)	1.10	(1.04 – 1.17)	<.001

While still statistically significant, there was some indication that TPB attitudes were less important in predicting willingness compared to intention. Previous usage of high levels of prefabrication was also not statistically significant in the willingness model, compared to its strong effect in the intention model. Table 25 again presents a selection of the most favourable and unfavourable predicted probabilities for the willingness model.

Table 25. *Highest and lowest predicted probabilities based on ordinal regression model*

Predictors						**Willingness Group Probability[1]**				
Att	**SN**	**PBC**	**Previous Prefab.**	**Annual Builds**	**Remote**	**SD**	**D**	**N**	**A**	**SA**
High	High	High	Volumetric/Panellised	11 – 40	MC/IR	0.7	1.1	4.1	40.9	53.2
High	High	High	Volumetric/Panellised	41+	MC/IR	0.7	1.3	4.5	42.9	50.6
Med	High	High	Volumetric/Panellised	11 – 40	MC/IR	0.8	1.3	4.6	43.6	49.7
Med	High	High	Volumetric/Panellised	41+	MC/IR	0.8	1.4	5.1	45.5	47.2
High	High	Med	Volumetric/Panellised	11 – 40	MC/IR	0.9	1.5	5.2	46.0	46.4
…										
High	Low	Low	None/Trusses	1-10	OR/R/VR	9.9	13.3	27.6	42.8	6.4
Low	Low	Med	None/Trusses	1-10	OR/R/VR	10.2	13.7	27.8	42.1	6.2
Low	Med	Low	None/Trusses	1-10	OR/R/VR	10.4	13.8	27.9	41.7	6.1
Med	Low	Low	None/Trusses	1-10	OR/R/VR	11.2	14.6	28.4	40.1	5.7
Low	Low	Low	None/Trusses	1-10	OR/R/VR	12.6	15.9	29.1	37.4	5.0

The model predicts that those respondents with the most favourable characteristics such as strongly positive beliefs about prefabrication, previous experience using prefabrication, a high number of annual builds and a base in an urban region, were almost universally willing to increase their use of prefabrication if circumstances were supportive. At the other end of the spectrum, those builders with relatively unsupportive views towards prefabrication, no previous experience using prefabrication, with a small annual number of builds, and based outside of urban areas were still reasonably willing to use prefabrication if circumstances were supportive. There was a 40% probability of such respondents stating that they would 'Agree' with increasing prefabrication use in supportive conditions.

Several key findings can be taken from these finalised multivariate models. Firstly, each of the variables included in the models had sufficient explanatory power to predict either builders' intentions or willingness. Secondly, the TPB variables specifically were able to add further explanatory power when included together in a model with a number of key control factors. This highlights the usefulness of the currently proposed theoretical model for monitoring and understanding how builders' beliefs can potentially affect their future behaviour.

Discussion

The current study has presented the results of the first large-scale survey of Australian residential builders' attitudes towards the use of prefabrication. This section provides an overview of the findings, addressing their generalisability, relationship to previous research, and implications for future policies.

Sample characteristics

There should first be a discussion of the nature of the sample used in the current study, and how this may affect the scope and validity of the conclusions that can be drawn. The current survey was publicised through contact lists which did not have any stated negative or positive viewpoint towards prefabrication, and neutral language was used throughout the recruitment text. The topic of the study was however explicitly conveyed, which may have prompted a particular subset of the total population of builders to respond. Comparison of the sample population with ABS and builder licensing authority data only showed minimal bias in terms of business characteristics. This increases the likelihood that the current results can be considered valid for the Australian builder population.

Almost all respondents built detached housing, a third built townhouses or small unit blocks, and a minor 12% constructed high-rise multiresidential blocks. The majority of respondents (64%) were small companies, building less than 10 houses (or units, or combination thereof) annually. The vast majority were also based either in capital cities or in the urban regions surrounding these cities. All of these findings align well with the known characteristics of the Australian construction industry (Australian Bureau of Statistics, 2004, 2013c). Few core differences in business characteristics were likewise identified when comparing the respondents between the Queensland and Western Australian states, which constituted the two target areas for the data collection. The types of housing constructed, annual number of builds, years' operating, and types of prefabrication previously used did not differ significantly. The differences which were identified, such as a greater use of brick in WA, and timber in Queensland, and a higher proportion of builders based in rural areas in Queensland, were in line with population data sourced from the respective licensing authorities and the Australian Bureau of Statistics. A substantial proportion of respondents had previously used relatively advanced forms of prefabrication like structural panels or volumetric sections (pods, modules or complete houses), illustrating a significant increase in use over the previous decade (Hampson & Brandon, 2004).

Most important factors

Aim 1 of the current study was to rate the relative importance of a variety of factors in influencing builders. The direct TPB predictor measures in the current study generally showed that the sample of respondents skewed towards believing that prefabrication was worthwhile, supported, and easy to do. Both negative opinions and strongly positive opinions were however rare, with the modal response being slightly positive, followed by the ambivalents who neither agreed or disagreed with a positive outlook for prefabrication. The use of the indirect TPB measures sought respondents' attitudes to a range of factors underpinning these direct measures, and allows further discussion of prefabrication's place in the Australian residential construction industry.

Attitudes

In light of the positive attitudes towards prefabrication, the responses to the TPB indirect attitude measures suggested that the positively rated changes were most likely to occur, and the most negatively rated changes were the least likely to occur. Faster construction speed was the most positively rated attitudinal factor overall, seen as a very likely outcome of a move to prefabrication, and an overall generally positive outcome for business. This is not an atypical finding, and is supported by previous research (Aburas, 2011; Bildsten, 2011). The ability to build quicker, moreso than the ability to build cheaper, was thus highlighted by the current results. On the other hand, reducing the quality of housing delivered was seen as the most negative outcome, driven primarily by its potential negative effect on business rather than a high likelihood of occurring if prefabrication use was increased. While this view is certainly not dominant, those builders that believe prefabrication would reduce their ability to produce a housing product of the same quality as traditional methods are thus a key group.

Subjective norm

Several points can be highlighted about key groups' perceived reaction to builders adopting prefabrication. Perceptions of key groups' support for prefabrication tended towards a neutral response of 'Neither approve nor disapprove', with an infrequent representation of strong opinions. Even the groups perceived to disapprove of prefabrication the most, in this case material suppliers, subcontractors, and banks and other lenders, were still mostly rated as having a neutral or evenly balanced viewpoint. There is thus no clear evidence of a groundswell of either strongly negative or strongly positive opinions towards prefabrication within the industry. This finding contradicts recent industry publications in Australia and overseas which suggest that the construction industry is not interested in innovating (Australian Industry Group, 2008; Dalton et al., 2011). Rather, it appears to point more strongly to an inertial population that could be swayed from a neutral resting point if strong arguments or facilitating factors were to be introduced.

Those groups perceived as holding negative opinions were most commonly those involved in the practical building processes, such as suppliers, subcontractors, and bankers. These groups have a direct business and financial interest in the success of building projects. Those groups involved in regulation or indirect engagement with industry processes, such as energy efficiency regulators, industry bodies, and clients, were perceived as the most supportive. This may represent a split between those who have the most to lose by risking adoption of prefabrication versus those that may be considering the issues from a broader policy or social perspective. For instance, United Kingdom policy makers have struggled to practically engage with the housing construction industry to translate the positive views of the policy makers about prefabrication into the delivery of successful example housing projects (Stansfield, 2005).

The opinions of the key groups assessed in the survey were generally valued, in line with their inclusion on the basis of pilot study focus groups. The standout result was the weight given to clients' opinions, being held in universally high regard. This highlights their potential power in driving the behaviours of builders. Clients were overall one of the most influential groups, considering both the high value placed in their opinions and their overall slightly positive perceived attitudes towards prefabrication. The high value placed in clients' opinions is in line with past research (Goulding et al., 2012; Lessing et al., 2005; Linner & Bock, 2012), but the overall perceived positive attitudes is contradictory to much research highlighting that the housing market is dismissive or actively adverse to prefabrication (Daly, 2009). This is an indication that perhaps the modern Australian market has begun to move past these historical perceptions to a more positive view.

PBC

A number of contextual events potentially affecting the likelihood of adopting prefabrication were also explored as part of the indirect PBC measures of the TPB model. As with the subjective norm variables, there was a split between the impact of immediate, builder-relevant factors and more distant, policy-directed changes. Increases in demand, reduction in material and labour costs, and more trained staff were seen as the most encouraging factors, while relaxation of planning rules, easier financing and stricter energy efficiency requirements were ranked as less influential.

This suggests that at least in the short term, encouraging the development of a market to buy prefabricated housing, and developing a supportive and cost-sensitive industry in terms of basic materials and staffing will be more strongly valued than attempting to manipulate high level policies which do not have an immediate short term benefit for those at the ‘coal face’ of the industry. Of particular note is the overall finding that introducing stricter energy efficiency requirements was not perceived as a strong encouraging factor for prefabrication, despite its high perceived likelihood of occurring. This result suggests more careful consideration should be given to communicating the links between innovative forms of building like prefabrication, and the ease with which such methods would allow compliance with efficiency regulations.

Outcome measures

About 54% of Australian builders agreed or strongly agreed with intending to adopt a higher level of prefabrication in the next three years. Indeed, 75% of builders would use more prefabrication if there were supportive conditions. These findings suggests there is no deep-seated negativity towards prefabrication that would resist it becoming an established part of the Australian housing industry.

Results by level of prefabrication use

Previous behaviour has long been recognised in social research as a significant predictor of both current and future behaviour. The second aim of the current study was to compare the characteristics of builders that had previously used prefabrication versus those that had not. For the purposes of this comparison, a gradated response on the basis of the company’s previous highest level of prefabrication use was adopted. There was no distinct trend when considering the distribution of prefabrication use by remoteness categories. While previous literature has acknowledged that the provision of prefabricated housing may particularly benefit rural locations by delivering a completed house or house-part to under-resourced locations (Blismas & Wakefield, 2009), this does not necessarily imply that the businesses serving these locations would not base themselves in a central urban location. A brief internet search of providers of Australian prefabricated, transportable housing identifies several based within major metropolitan cities. It is thus not surprising to find the direct relationship between previous prefabrication use and remoteness to be unclear.

While previous research has generally pointed to larger business size and turnover as increasing readiness and opportunities to adopt new construction methods (Gibb & Isack, 2001; Poon et al., 2003), it is also true that such businesses have the most to lose by encouraging disruptive technologies that erode their established industry positions. Yet, it seems that larger businesses are more innovative in their use of prefabrication. The simple resource-based hypothesis supported by previous research in other jurisdictions (Friedman & Cammalleri, 1993; Gibb, 2001; Poon et al., 2003) was again supported in this Australian study. The clearest trend in the current results was the continual increase in the odds of using volumetric prefabrication with an increasing number of builds annually. The largest builders may be the most well-resourced and able to adapt to the use of new methods and technologies.

The number of years for which the business had been operating was not related as clearly with past prefabrication use as the size of the business. While there was some indication from the Queensland data that the youngest companies were less likely to have previously used prefabrication, this was neither a strong or clear finding. Two further points can be inferred from this finding. Firstly, the simple existence of a company for a long time period does not appear to imply greater odds of having adopted prefabrication innovations. Secondly, this finding should be interpreted through the historical lens of prefabrication only becoming a more prominent focus of policy and research discussion in recent years in Australia (Hampson & Brandon, 2004). The Australian housing market's strong growth in the 1990's and early 2000's also may also have contributed to a lesser interest until recently in seeking innovative building methods.

Despite previous research noting that prefabrication is not common in the Australian construction industry, there have been allusions to the greater applicability of repetitive methods of construction to multiresidential structures (Blismas et al., 2010). The distinction in the current study differed on the basis of state, but pointed to a relationship between involvement in high-rise multiresidential construction and increased previous reported use of prefabrication. In many ways, the high-rise multiresidential housing sector of the house-building industry is distanced from the smaller housing projects. The scale, financial backing, experience, and size of the build team for high-rise projects are almost always larger, suggesting this finding may be in part reflective of the business' overall size and turnover.

As noted in the introduction to this section, past behaviour is a strong predictor of future behaviour. Following this logic, it is not surprising that those companies specifying that they had previously used a higher level of prefabrication had more intention to, and were more willing to, increase their prefabrication use. This finding also suggests that their previous experience using prefabrication has not resulted in negative outcomes discouraging future plans. Indeed, the group of respondents stating they 'strongly disagree' with adopting a higher level of prefabrication was almost entirely constituted of those that had never progressed beyond the use of prefabricated trusses. This group clearly should be targeted to increase the overall level of prefabrication use.

Multivariate modelling

The above discussion has centred on describing the results considering only one or two variables at a time. Aim 3 of the current study sought to determine if a model based on several control factors and the TPB variables could be developed that is predictive of intentions to use prefabrication. This model thus provides an opportunity to further consider the combined effect of several of the above discussed factors.

Two separate models were considered in this study, predicting (1) intentions and (2) willingness to adopt a higher level of prefabrication on housing projects in the next three years. Each of the models suggest that the proposed TPB constructs were all significant predictors after taking into account the core control factors of previous prefabrication use, annual number of builds, and the remoteness of the business' primary office. These constructs comprise: (1) attitudes to prefabrication; (2) subjective norm, or the degree of support key groups give to prefabrication; and (3) perceived behavioural control (PBC), or how much contextual events facilitate an individual business' ability to increase prefabrication use.

For the intentions model, there was no indication that any of the TPB predictors were uniquely strong, as evidenced by the overlapping confidence intervals of the odds ratios. This suggests that each of the TPB constructs of attitudes, subjective norm and PBC are predictive of future intentions. In terms of the combined effect of the control variables, previous prefabrication stood out as the most important factor. Interestingly, the current model also showed that this factor alone was not able to diminish the impact of the TPB variables to the extent that they were not still significant predictors. The annual number of builds was a less clear factor in the model, with the results only showing that intentions to adopt prefabrication significantly increased comparing businesses with the smallest turnover (1-10 houses annually) to the companies with the largest turnover (41+ houses annually). This suggests that subtle variation in the size of housing companies is unlikely to affect prefabrication adoption until a critical point of higher resourcing is reached. Remoteness of the business' primary office was also identified in the multivariate model as being a significant predictor of intention. The results suggest that increasing remoteness reduces the probability of having a favourable intention towards prefabrication.

The willingness model presents a slightly different message compared to the model predicting intentions. It is worth reiterating that willingness is distinct in that it refers to an openness to trying prefabrication if supportive conditions were present, as opposed to the deliberate, conscious choice represented by intentions (Gibbons et al., 1998). Several changes in the impact of the control variables were noted in this model. Previous prefabrication use dropped from its dominant position in the intentions model to not being a significant predictor of willingness. This suggests that while past experience may positively encourage builders to seek out prefabrication, it is not necessary to establish a willingness to try it, if the level of business risk was to be reduced. The annual number of builds also became a much clearer factor in this model, with both the medium sized (11-40) and larger companies (41+) being associated with an increased willingness. This suggests that if conditions were to improve in support of prefabrication, that a larger body of more receptive interested businesses would be created. The impact of remoteness however remained unchanged from the intentions model. As before, each of the TPB predictor constructs were also significantly and positively related to a greater willingness to increase prefabrication use. It was likewise inconclusive to rate any of TPB factors as being particularly stronger than another given the overlapping confidence intervals around the odds ratio estimates.

The practical implication of the results of this modelling is that many factors can be targeted to encourage further uptake of prefabrication. Several of the results from this study highlight that the housing construction industry is at a tipping point in regards to opinions towards prefabrication. It appears that many builders do not believe there is a strong negative or positive opinion towards prefabrication. This signals a great opportunity to drive the industry towards a future where prefabrication has a significant role. Those builders who already hold positive beliefs towards prefabrication may be given a particular boost to innovate if they can gain practical experience in successfully delivering a highly prefabricated housing project.

Conclusions

The current report presented the results of the first large-scale survey of Australian builders' beliefs regarding prefabrication. Drawing on a structured theoretical framework, three primary aims were addressed. Aim 1 was to identify the relative importance of factors predicting the intentions of builders to adopt a higher level of prefabrication. The current research particularly draws attention to the impact of increasing construction speed, and the potential negative effect of reducing the quality of finished products. In terms of influential groups, the central role of clients in driving builder decision making and serving as a spark for greater demand was noted. Lastly, practical considerations for builders, rather than high-level policy changes, were seen as the factors most likely to cause an immediate shift in builders' intentions towards prefabrication. Aim 2 was to describe the circumstances and business characteristics associated with the previous use of prefabrication. Business size, as measured by annual turnover, and involvement in the delivery of multiresidential housing were both strongly represented factors. Finally, the current study addressed Aim 3 by showing that a predictive model taking into account both business characteristics and previous exposure to prefabrication can be added to by the inclusion of softer social measures of attitudes including the influence of key groups, and perceptions about contextual factors. A number of recommendations for practical policy changes can be made from these findings.

(1) Provide direct funding for demonstration prefabricated housing projects, which could be used to solicit media and industry attention,

The generally positive results from the current study contradict cautious statements from construction industry groups that innovation is not a focus in Australia. A clear majority of builders are willing to try prefabrication if given greater support to do so. Prefabrication's success hinges on practical issues like increasing the cost-effectiveness of prefabricated materials, building a skilled labour force, and breaking down barriers in the consumer and banking markets. Initial momentum to achieve these aims could be realised through example prefabricated housing projects funded in part using government seeding expenditure. If barriers could be removed or financial or logistical support could be given to kick-start these exemplar projects, it would be expected that many of the largely willing group of builders would take the opportunity to be involved. This survey suggests the businesses who would be most receptive to this support would be urban-based companies with a turnover of more than 10 houses annually. The success of such projects could subsequently be used to solicit media and industry attention to further promote prefabrication's benefits.

(2) Identify local prefabricated construction businesses and facilitating their networking between one another,

The current results provide evidence of an already increasing interest in prefabrication among builders, with approximately one fifth of those surveyed reporting using volumetric prefabrication and one third reporting the use of panellised methods. This represents a significant body of expertise that should be drawn upon for future development of a prefabricated housing industry. Further support should be given to allow these businesses direct input into shaping future policies. This could be facilitated by either providing support to recently established national groups like prefabAUS and the Australasian Modular Building Codes Board (PrefabAUS, 2014), or facilitating new interest groups in areas with peak concentrations of prefabricated housing activity. An initial stage of this process should be the identification of prefabricated builders, suppliers, designers and other related businesses within the state or region of policy makers. For WA and Queensland, the identity of key players is revealed in the previous report: '*Profiling the Nature and Context of the Australian Prefabricated Housing Industry*' (Steinhardt, Manley, & Miller, 2013).

(3) Draw on the expertise of multiresidential prefabricators to (i) identify what technologies or methods could be successfully transferred to less advanced builders, (ii) assist in the transition to greater urban density

In the short term, focus should be given to identifying and capitalising on the expertise of large builders that have previously used volumetric prefabrication in multiresidential projects. Lessons learnt from the multiresidential context could be transferred to Australia's predominantly detached housing market. For instance, precast concrete has a strong position in high-rise building but has been infrequently applied to low-rise developments (Blismas et al., 2010). Further effort should be extended to profiling what multiresidential technologies and methods could be most easily and cost-effectively generalised to the entire housing market. Australian planners also predict an increase in the number of residents living in high-density, multiresidential environments. The construction of prefabricated units and high-rises could work cooperatively with these plans to address the challenges of providing affordable, liveable cities for decades to come (Randolph, 2006). Prefabrication's higher speed of construction could be used as a selling point to hasten the transition to more efficient urban environments.

(4) Develop media campaigns to highlight prefabrication's modern, high-quality image and drive growth in demand, and

With increased construction speed highlighted as both a highly likely outcome and highly valued outcome, the question remains: why has there not been a strong shift to prefabrication? The strong perceived influence of increasing demand for prefabrication may provide an answer. While increased speed allows a business to produce more units in a given time period, a matching increased demand is required to harness this advantage (Pan, Dainty, & Gibb, 2012). Efforts to publicise prefabricated housing and its benefits for clients' through mainstream media should be prioritised. As a starting point for positive messages, the current survey has shown a reduction in housing quality as the least likely outcome of a shift to prefabrication, and clients as supportive of increased prefabrication use. This would highlight the modern reality of prefabrication as a stark contrast to historical community perceptions associated with poor quality, social housing.

(5) Better educate the housing industry about how prefabrication can assist with meeting stricter energy efficiency requirements for housing.

Conversely, more work needs to be done aligning prefabrication with current community concerns about energy efficiency, sustainability and rising power costs. Improved energy efficiency was seen as a positive and likely outcome of prefabrication, and the opinions of the regulators themselves were also well valued. Stricter energy efficiency requirements were also seen as the most likely event to occur in the next 3 years. Despite these consistent findings, tightening of the efficiency requirements was the least encouraging factor for adopting prefabrication by builders, behind an increase in demand, better training, lower material and labour costs, relaxation of planning rules, and easier prefabrication financing. The energy benefits of prefabrication need to be sold to consumers, and builders who haven't already adopted prefabrication. There are many academic studies which have highlighted the waste reduction, insulation and high energy performance of prefabricated projects (Blismas et al., 2005; Dainty & Brooke, 2004; Elnaas et al., 2009; McIntosh & Guthrie, 2008; Monahan & Powell, 2011). The potential benefits of new building methods like prefabrication to meet stricter energy requirements obviously needs to be made clearer. With appropriate direction, prefabrication may even be able to reduce the administrative and technical burdens of compliance with the increasingly strict efficiency guidelines.

The significance of the TPB and TAM variables suggests that taking a multi-targeted policy approach will have a significant and interactive positive effect. This finding reinforces the value of the systems approach used as a theoretical underpinning for the current study (Gann & Salter, 2000). Such an approach should provide: (1) education and support directly to builders to change attitudes and behaviours; (2) widespread engagement with various members of the housing industry to encourage a supportive network; and (3) changes to the regulatory and contextual environment that make adopting prefabrication easier. The current policy suggestions are aligned with this model, covering the direct provision of financial support for pilot housing projects; the identification of local 'branches' of the prefabricated building industry; learning from successful multiresidential prefabrication projects; media promotion of messages about modern prefabricated houses, and further efforts to align prefabrication with the energy efficiency movement.

Limitations of the study

The current study has a number of limitations that affect the generalizability of the results. Firstly, the scope of the study was limited to builders recruited from licensing databases and contact lists in the two Australian states of WA and Queensland. Although it has been demonstrated that the results are likely to apply to the Australian population of builders nationally, generalisability overseas is less clear. The combination of factors influencing the adoption of prefabrication is likely to vary substantially dependent on both the characteristics of relevant stakeholders, the organisations in which they work, and the larger societal context in which their organisation exists (Barlow & Ozaki, 2005). Readers should thus keep in mind the characteristics of the Australian housing market compared to other jurisdictions if attempting to transfer the findings. The low historical uptake of prefabrication in the Australian market is however comparable to other regions such as the United

States and United Kingdom. This is evidenced by similar recent research particularly in the UK seeking to identify ways to increase the uptake of prefabrication and other ‘modern methods of construction’ (Gaze et al., 2007; Pan et al., 2007).

Limitations associated with the use of the survey measures should also be noted. While self-report surveys are an extremely common data collection methodology, the method is prone to response and recall biases. The current survey and recruitment methods did not however explicitly promote a viewpoint on prefabrication to reduce the encouragement of biased responses. Recall and prediction accuracy was ensured by limiting questions to a scope of 3 years before or after the current time. Finally, the completion time of the survey was kept under 10 minutes to reduce the likelihood of boredom or response sets. Regardless, surveys remain an efficient and cost-effective method of providing evidence to answer subjective, perceptual research questions. The limitations of the survey questions themselves should also be considered. In attempting to simplify the survey, the business characteristics data including remoteness, business size, age and previous prefabrication use were measured in broad categories. Future research should seek to refine these measures and clarifying their relationship to prefabrication.

Recruitment methods which can compel or encourage a higher proportion of the pool of builders to respond to the survey should also be considered. What form such a method may take was however limited by practical considerations. Ethical concerns restrict the possibility of encouraging participation or offering incentives which would strongly compel participation. One potential way of addressing this would be to use a small subset of questions included within a large, non-targeted survey, potentially through organisations that either are well respected in the housing industry, or have legislative powers to compel responses, such as the Australian Bureau of Statistics (Australian Bureau of Statistics, 2014).

Future Research

Future research using a similar methodology as the current study should be undertaken in other international jurisdictions. Both the univariate results considering the importance of individual influences and the overall modelling of intentions to adopt prefabrication should be compared and contrasted as a means to identifying consistent findings. This would also provide an opportunity to identify what international policies could be borrowed to address existing challenges in Australia. Repetition of the study with other industry groups such as architects, material suppliers or the general community would also allow assessment from new perspectives. The development of instruments and methods to collect more detailed background data on respondents’ businesses and ensure a higher response rate should be a focus of further research. Drawing closer links between researchers and industry bodies would assist in facilitating such changes. A strength of the current research however was the strong promotion of the study by government and industry backed departments to a wide cross-section of builders. Further work should seek to implement the recommendations suggested in this document and rigorously evaluate their effect on the uptake of prefabrication.

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Appendix A - State based differences on key measures

Attitude likelihood variable results:

Queensland

	Question (Would moving to a higher level of prefabrication:)	Mean	Std.Dev
Likely	Improve the speed of your construction?	3.83	0.88
	Reduce the number of trades you require?	3.27	0.97
	Improve the energy efficiency of your housing products?	3.21	0.97
	Reduce the flexibility of your housing designs?	3.05	1.12
Unlikely	Improve your business' image?	2.89	0.95
	Increase your building costs?	2.85	1.03
	Increase the complexity of your building?	2.81	1.02
	Reduce the size of your target market?	2.70	0.91
	Reduce the quality of your building?	2.65	1.10

Western Australia

	Question (Would moving to a higher level of prefabrication:)	Mean	Std.Dev
Likely	Improve the speed of your construction?	3.97	0.82
	Improve the energy efficiency of your housing products?	3.48	0.97
	Reduce the number of trades you require?	3.29	1.03
	Improve your business' image?	3.13	0.91
Unlikely	Reduce the flexibility of your housing designs?	2.96	1.17
	Reduce the size of your target market?	2.89	0.89
	Increase your building costs?	2.88	0.97
	Increase the complexity of your building?	2.80	0.95
	Reduce the quality of your building?	2.45	1.04

Attitude evaluation variable results:

Queensland

	Question (Would moving to a higher level of prefabrication:)	Mean	Std.Dev
Likely	Improve the speed of your construction?	0.83	0.88
	Reduce the number of trades you require?	0.27	0.97
	Improve the energy efficiency of your housing products?	0.21	0.97
	Reduce the flexibility of your housing designs?	0.05	1.12
Unlikely	Improve your business' image?	-0.11	0.95
	Increase your building costs?	-0.15	1.03
	Increase the complexity of your building?	-0.19	1.02
	Reduce the size of your target market?	-0.30	0.91
	Reduce the quality of your building?	-0.35	1.10

Western Australia

	Question (Would moving to a higher level of prefabrication:)	Mean	Std.Dev
Likely	Improve the speed of your construction?	0.97	0.82
	Improve the energy efficiency of your housing products?	0.48	0.97
	Reduce the number of trades you require?	0.29	1.03
	Improve your business' image?	0.13	0.91
Unlikely	Reduce the flexibility of your housing designs?	-0.04	1.17
	Reduce the size of your target market?	-0.11	0.89
	Increase your building costs?	-0.12	0.97
	Increase the complexity of your building?	-0.20	0.95
	Reduce the quality of your building?	-0.55	1.04

Subjective norm, approval of key groups, results:

Queensland

	Question (Would the following groups approve of your business moving to a higher level of prefabrication?)	Mean	Std.Dev
Approve	Housing energy efficiency regulators	0.41	0.69
	Industry groups (HIA, MBA, Builders' networks)	0.28	0.81
	Local planning regulators	0.17	0.82
	Clients/owners	0.15	0.84
	Architects and building designers	0.13	0.89
Disapprove	Banks and other lenders	-0.02	0.70
	Material suppliers	-0.13	1.01
	Subcontractors	-0.14	0.97

Western Australia

	Question (Would the following groups approve of your business moving to a higher level of prefabrication?)	Mean	Std.Dev
Approve	Housing energy efficiency regulators	0.48	0.70
	Industry groups (HIA, MBA, Builders' networks)	0.32	0.72
	Clients/owners	0.31	0.86
	Architects and building designers	0.27	0.85
	Local planning regulators	0.19	0.72
Disapprove	Material suppliers	0.00	0.88
	Subcontractors	-0.01	0.88
	Banks and other lenders	-0.02	0.76

Subjective norm, value of opinions, results:

Queensland

Question (How much do you value their opinions?)	Mean	Std.Dev
Clients/owners	4.52	0.72
Architects and building designers	3.75	1.05
Subcontractors	3.73	0.89
Industry groups (HIA, MBA, Builders' networks)	3.66	0.95
Local planning regulators	3.55	0.98
Housing energy efficiency regulators	3.53	1.00
Material suppliers	3.45	1.05
Banks and other lenders	3.41	1.20

Western Australia

Question (How much do you value their opinions?)	Mean	Std.Dev
Clients/owners	4.37	0.77
Subcontractors	3.72	0.88
Architects and building designers	3.67	0.96
Housing energy efficiency regulators	3.55	1.04
Industry groups (HIA, MBA, Builders' networks)	3.50	0.98
Local planning regulators	3.39	1.05
Material suppliers	3.37	1.00
Banks and other lenders	3.24	1.15

Perceived Behavioural Control, encouragement variables, results:

Queensland

Question (How much would the following events encourage your business to move to a higher level of prefabrication?)	Mean	Std.Dev
Lower labour costs for prefabrication	3.77	0.99
Increased demand for prefabrication	3.77	0.95
Lower material costs for prefabrication	3.75	0.97
More people trained in prefabrication	3.57	1.01
Relaxation of planning rules for prefabrication	3.41	1.11
Easier financing for prefabrication	3.32	1.16
Stricter energy efficiency requirements	2.93	1.11

Western Australia:

Question (How much would the following events encourage your business to move to a higher level of prefabrication?)	Mean	Std.Dev
Increased demand for prefabrication	3.93	0.99
Lower material costs for prefabrication	3.83	0.95
Lower labour costs for prefabrication	3.83	0.97
More people trained in prefabrication	3.68	1.01
Relaxation of planning rules for prefabrication	3.60	1.11
Easier financing for prefabrication	3.41	1.16
Stricter energy efficiency requirements	3.06	1.11

Perceived Behavioural Control, likelihood variables, results:

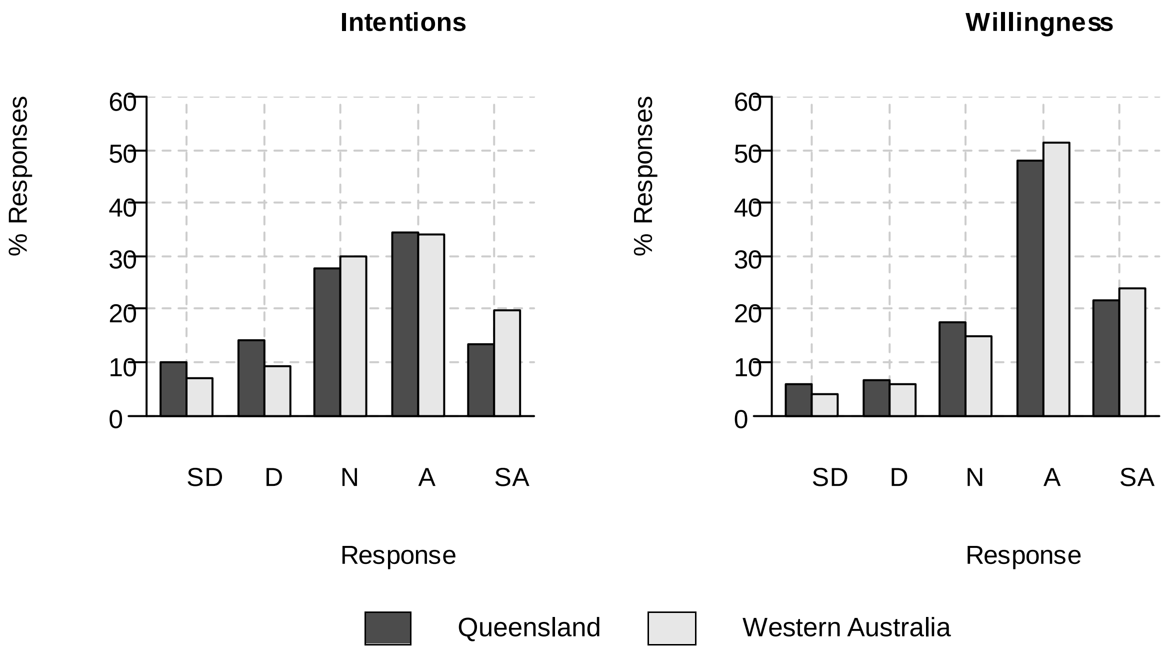
Queensland

	Question (How likely are the following events?)	Mean	Std.Dev
Likely	Increased demand for prefabrication	3.10	1.08
	More people trained in prefabrication	3.05	1.05
	Stricter energy efficiency requirements	2.98	1.06
Unlikely	Lower labour costs for prefabrication	2.97	1.10
	Lower material costs for prefabrication	2.89	1.06
	Relaxation of planning rules for prefabrication	2.52	1.09
	Easier financing for prefabrication	2.49	0.99

Western Australia

	Question (How likely are the following events?)	Mean	Std.Dev
Likely	Stricter energy efficiency requirements	3.35	0.96
	Increased demand for prefabrication	3.21	0.97
	More people trained in prefabrication	3.02	0.92
Unlikely	Lower labour costs for prefabrication	2.86	1.02
	Lower material costs for prefabrication	2.83	0.97
	Easier financing for prefabrication	2.57	0.90
	Relaxation of planning rules for prefabrication	2.57	0.98

Intentions and willingness distributions:



Attitudes, composite measure:

Queensland

	Issue:	Mean	Std.Dev
Positive	Faster construction speed	3.88	3.01
	Improved energy efficiency of your housing products	2.01	3.12
	Improved business image	1.53	2.78
	Reduced number of required trades	0.99	3.34
Negative	Increased complexity of building	-0.8	2.77
	Increased building costs	-1.14	3.20
	Reduced target market	-1.17	2.44
	Reduced flexibility of possible house designs	-1.24	3.42
	Reduced quality of housing built	-1.49	3.23

Western Australia

	Issue:	Mean	Std.Dev
Positive	Faster construction speed	4.48	2.71
	Improved energy efficiency of your housing products	3.00	3.10
	Improved business image	2.08	2.75
	Reduced number of required trades	1.96	3.22
Negative	Increased complexity of building	-0.64	2.59
	Reduced target market	-0.84	2.57
	Reduced flexibility of possible house designs	-1.30	3.19
	Increased building costs	-1.30	2.66
	Reduced quality of housing built	-1.33	2.73

Subjective norm, composite measure

Queensland

Key Group	Mean	Std.Dev
Housing energy efficiency regulators	1.66	2.80
Industry groups (HIA, MBA, Builders' networks)	1.19	3.20
Local planning regulators	0.76	3.13
Clients/owners	0.72	4.05
Architects and building designers	0.70	3.77
Material suppliers	-0.09	2.85
Subcontractors	-0.29	3.98
Banks and other lenders	-0.39	3.99

Western Australia

Key Group	Mean	Std.Dev
Housing energy efficiency regulators	1.97	2.80
Clients/owners	1.41	3.95
Industry groups (HIA, MBA, Builders' networks)	1.27	2.87
Architects and building designers	1.14	3.40
Local planning regulators	0.89	2.57
Material suppliers	0.18	3.36
Banks and other lenders	0.11	2.84
Subcontractors	0.07	3.60

Perceived Behavioural Control, composite measure

Queensland

Event	Mean	Std.Dev
Increased demand for prefabrication	12.84	5.40
More people trained in prefabrication	11.19	4.81
Lower labour costs for prefabrication	11.05	5.07
Lower material costs for prefabrication	11.01	4.92
Relaxation of planning rules for prefabrication	9.48	5.02
Easier financing for prefabrication	8.95	4.82
Stricter energy efficiency requirements	3.00	3.10

Western Australia

Event	Mean	Std.Dev
Increased demand for prefabrication	12.88	5.71
More people trained in prefabrication	11.27	5.10
Lower labour costs for prefabrication	11.11	5.25
Lower material costs for prefabrication	11.07	5.19
Relaxation of planning rules for prefabrication	9.39	5.09
Easier financing for prefabrication	8.89	4.82
Stricter energy efficiency requirements	2.85	3.26

Correlation matrix of all key measures

Queensland

Variable[1]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Indirect Attitude	**1.00**	-	-	-	-	-	-	-
2. Indirect Subjective Norm	0.58	**1.00**	-	-	-	-	-	-
3. Indirect PBC	0.34	0.47	**1.00**	-	-	-	-	-
4. Direct Attitude	0.43	0.44	0.40	**1.00**	-	-	-	-
5. Direct Subjective Norm	0.45	0.47	0.36	0.72	**1.00**	-	-	-
6. Direct PBC	0.30	0.26	0.14	0.47	0.50	**1.00**	-	-
7. Intention	0.42	0.43	0.44	0.72	0.59	0.34	**1.00**	-
8. Willingness	0.27	0.40	0.44	0.52	0.46	0.27	0.74	**1.00**

Western Australia

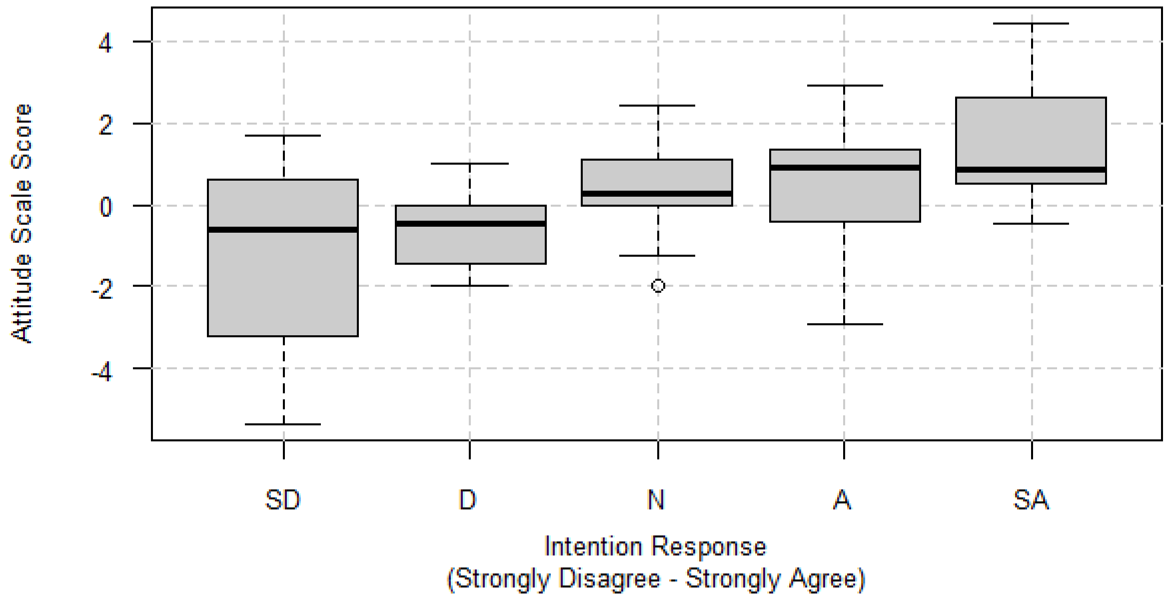
Variable[1]	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1. Indirect Attitude	**1.00**	-	-	-	-	-	-	-
2. Indirect Subjective Norm	0.49	**1.00**	-	-	-	-	-	-
3. Indirect PBC	0.40	0.36	**1.00**	-	-	-	-	-
4. Direct Attitude	0.45	0.48	0.40	**1.00**	-	-	-	-
5. Direct Subjective Norm	0.46	0.49	0.34	0.61	**1.00**	-	-	-
6. Direct PBC	0.32	0.39	0.26	0.41	0.59	**1.00**	-	-
7. Intention	0.36	0.32	0.38	0.66	0.56	0.32	**1.00**	-
8. Willingness	0.29	0.29	0.26	0.60	0.42	0.25	0.68	**1.00**

[1] – Correlation coefficients based on Spearman's rho rank correlations

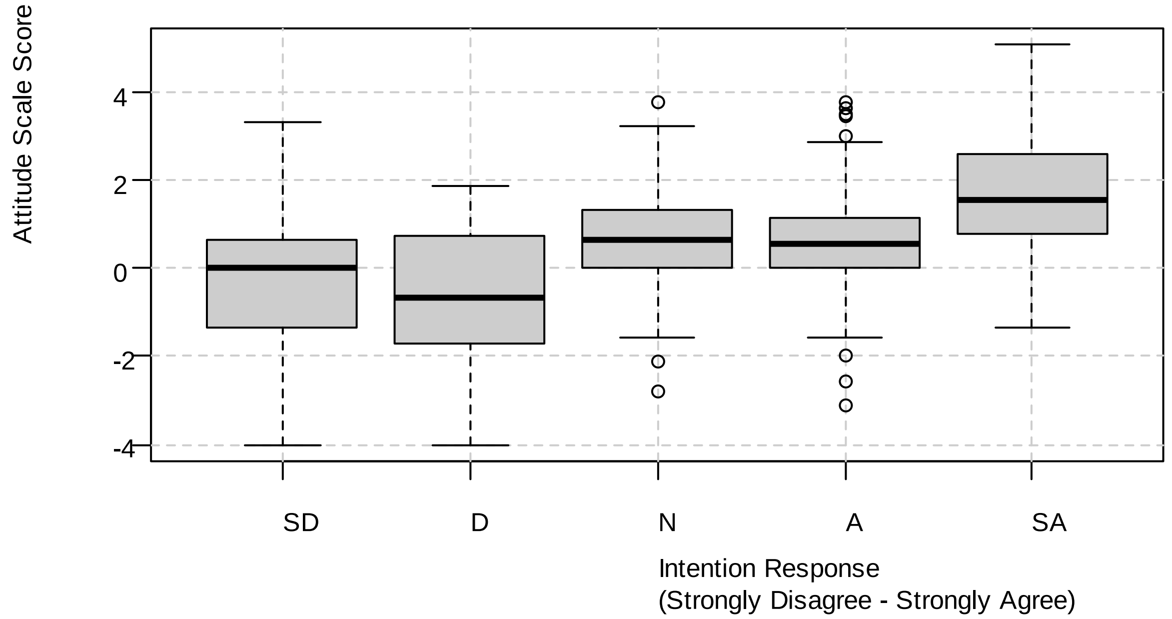
Boxplots comparing indirect TPB measures and intention:

Attitudes

Queensland

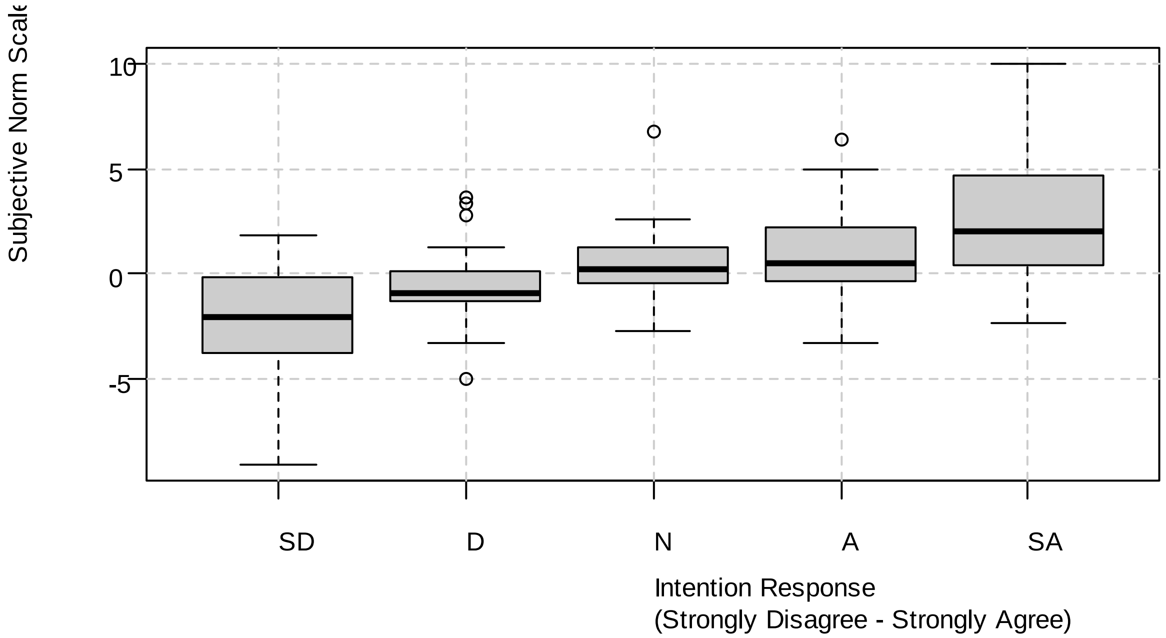


Western Australia

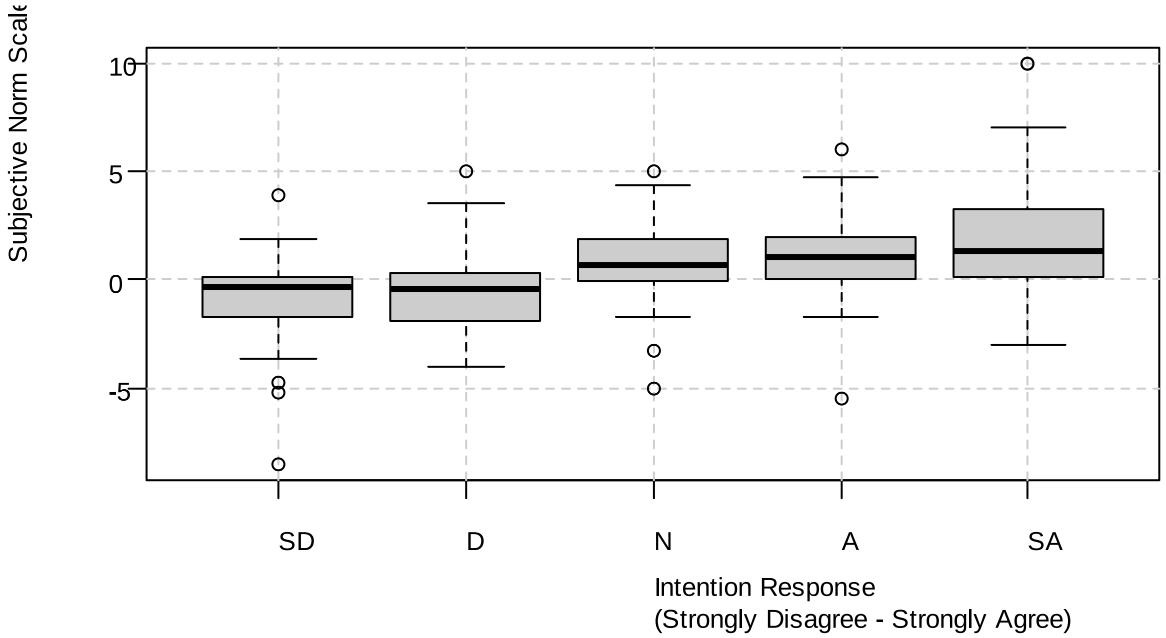


Subjective Norm

Queensland

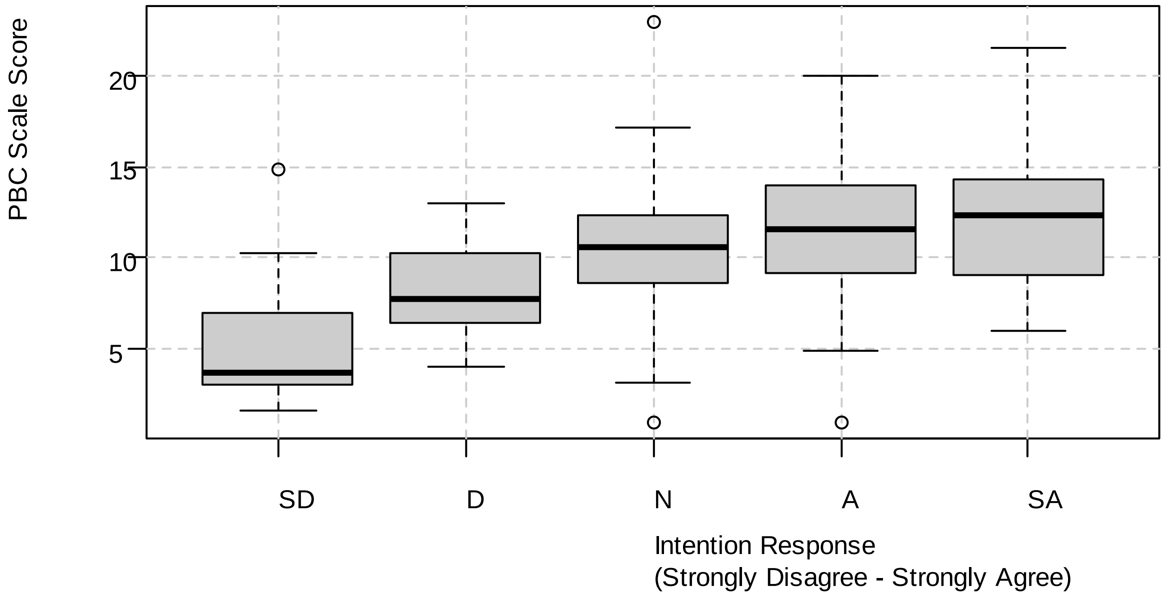


Western Australia

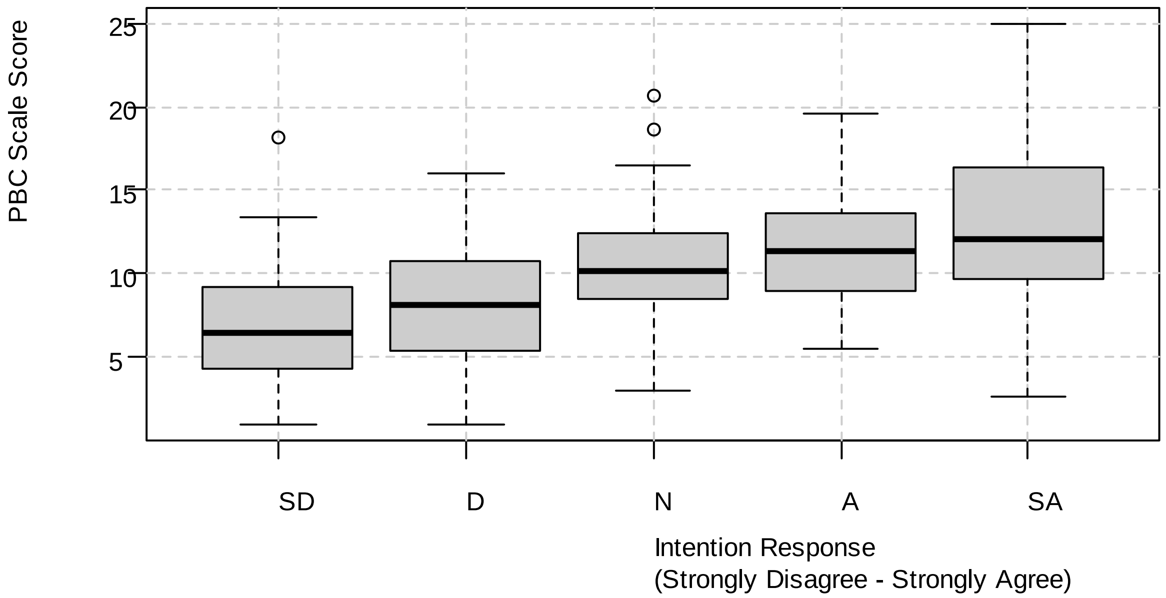


Perceived Behavioural Control

Queensland

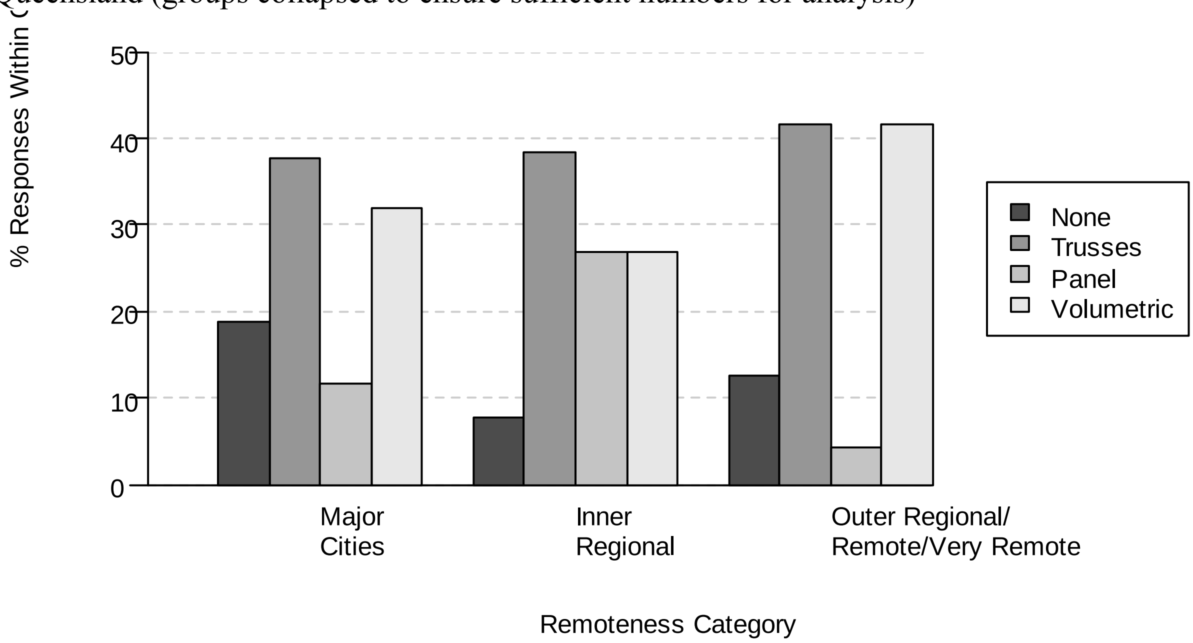


Western Australia

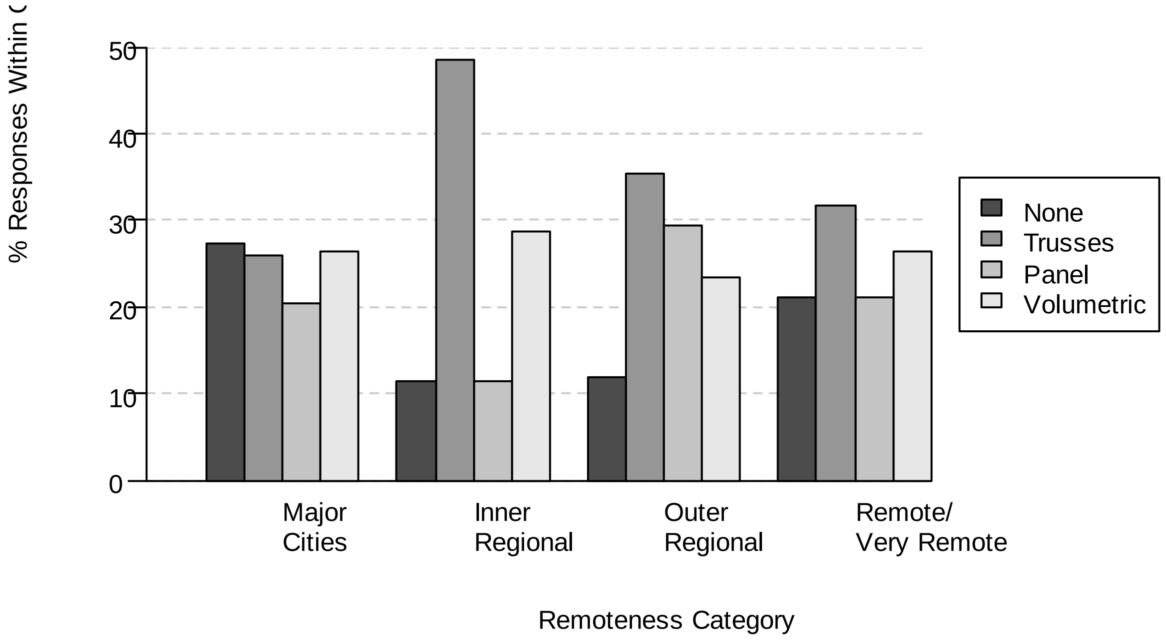


Distribution of highest level of prefabrication used by remoteness category

Queensland (groups collapsed to ensure sufficient numbers for analysis)

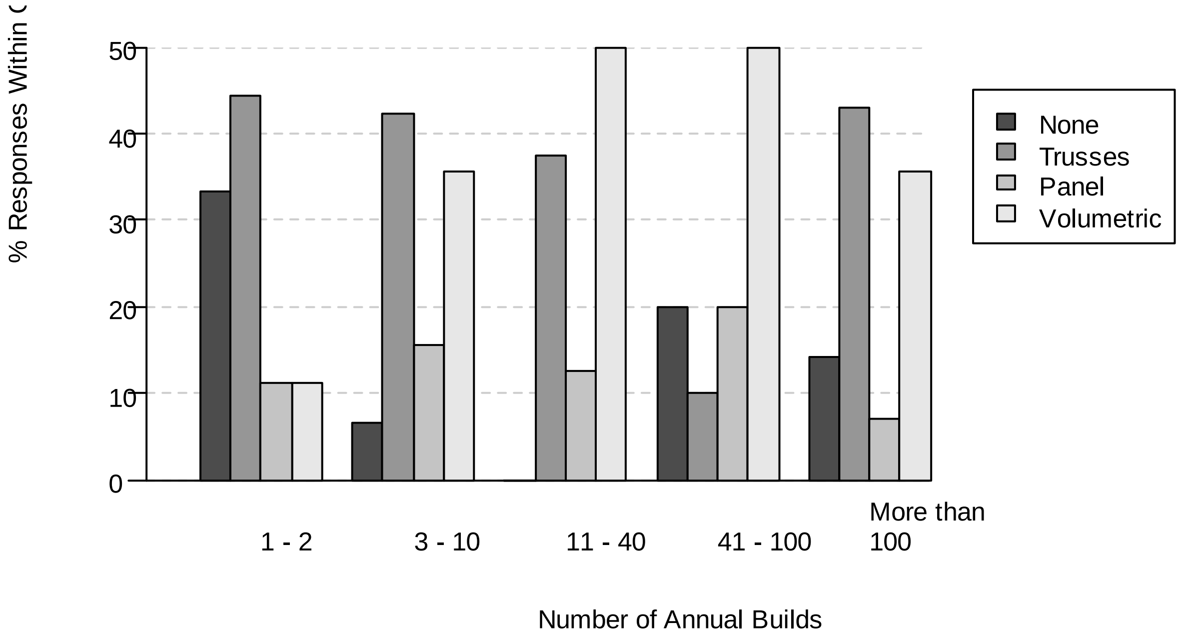


Western Australia:

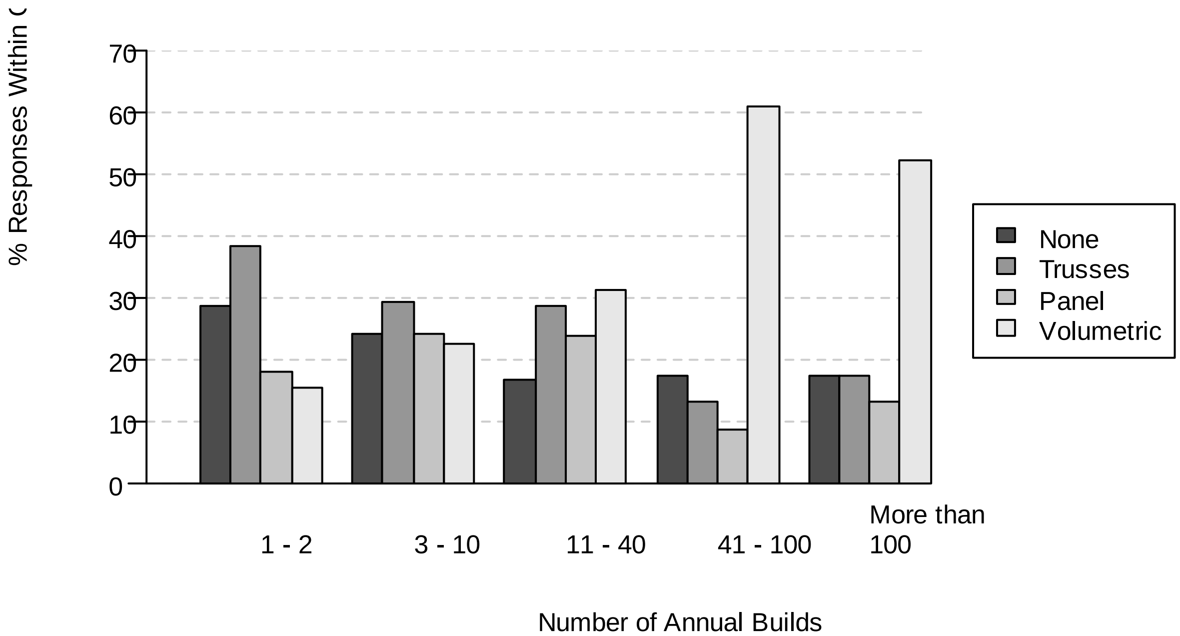


Distribution of highest level of prefabrication used by number of annual builds

Queensland

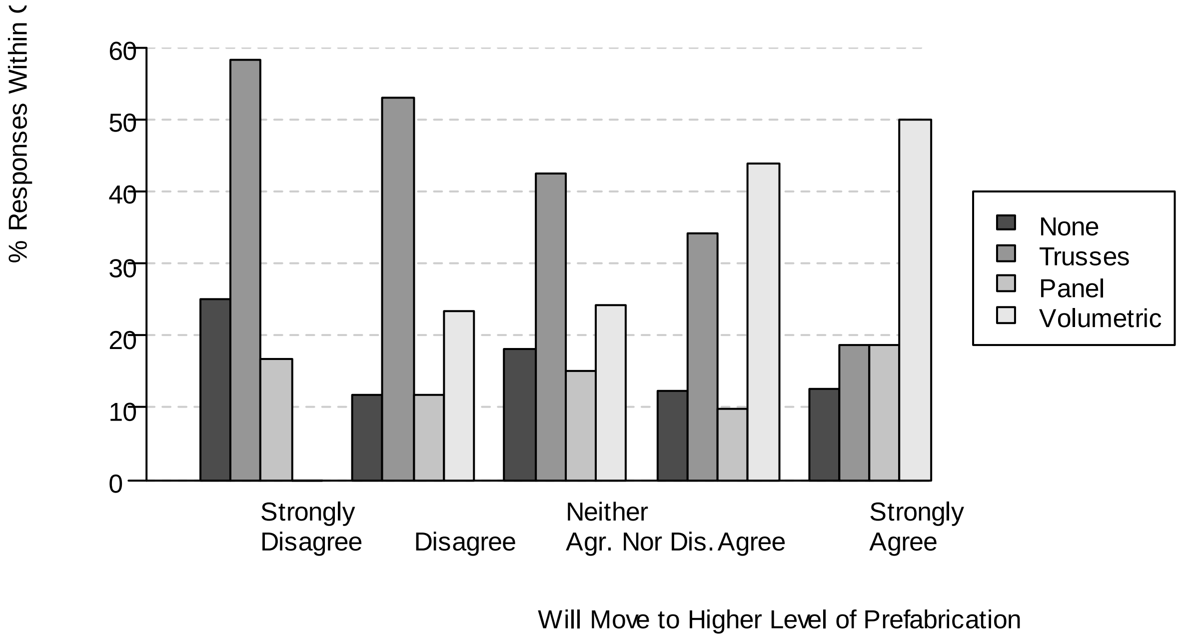


Western Australia

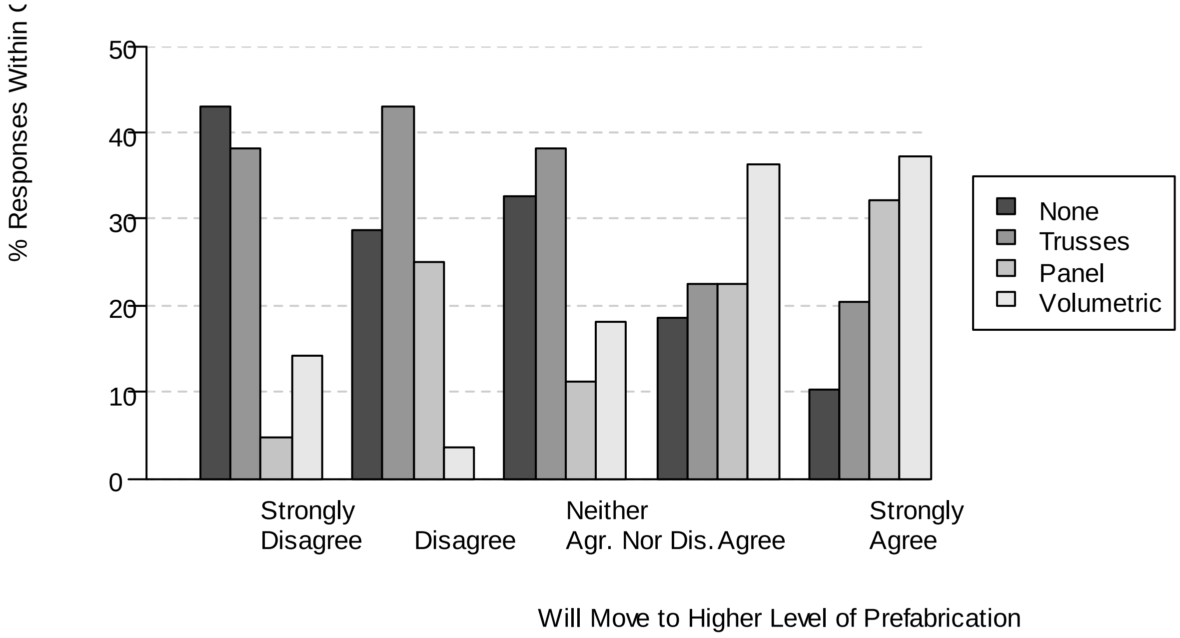


Distribution of highest level of prefabrication used by intention:

Queensland

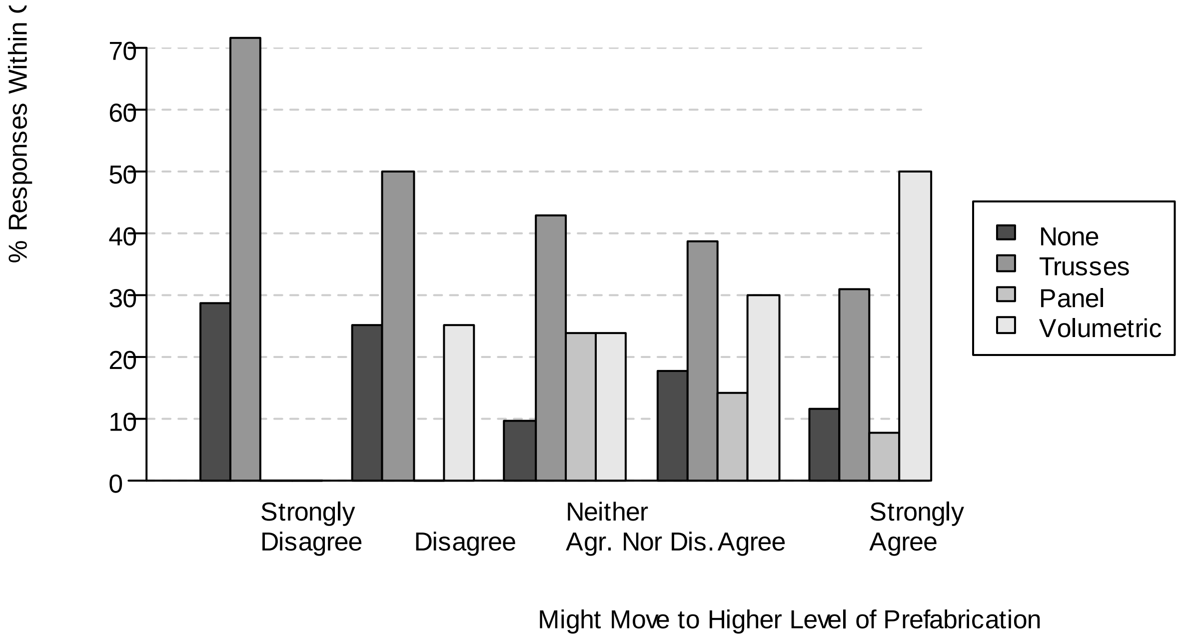


Western Australia

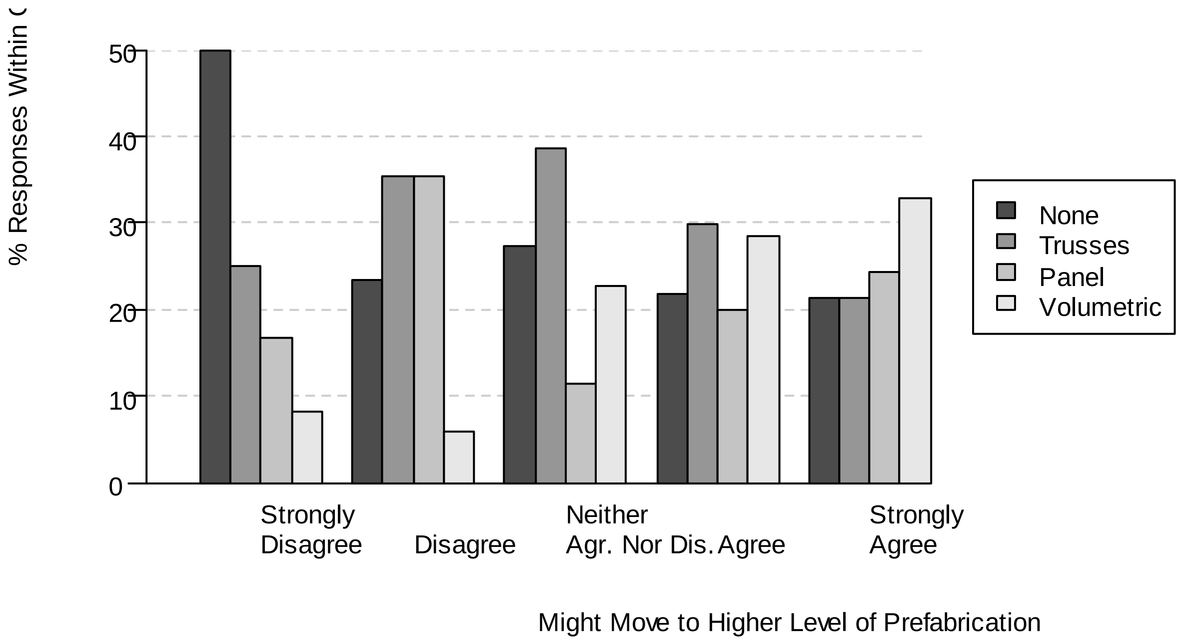


Distribution of highest level of prefabrication used by willingness:

Queensland

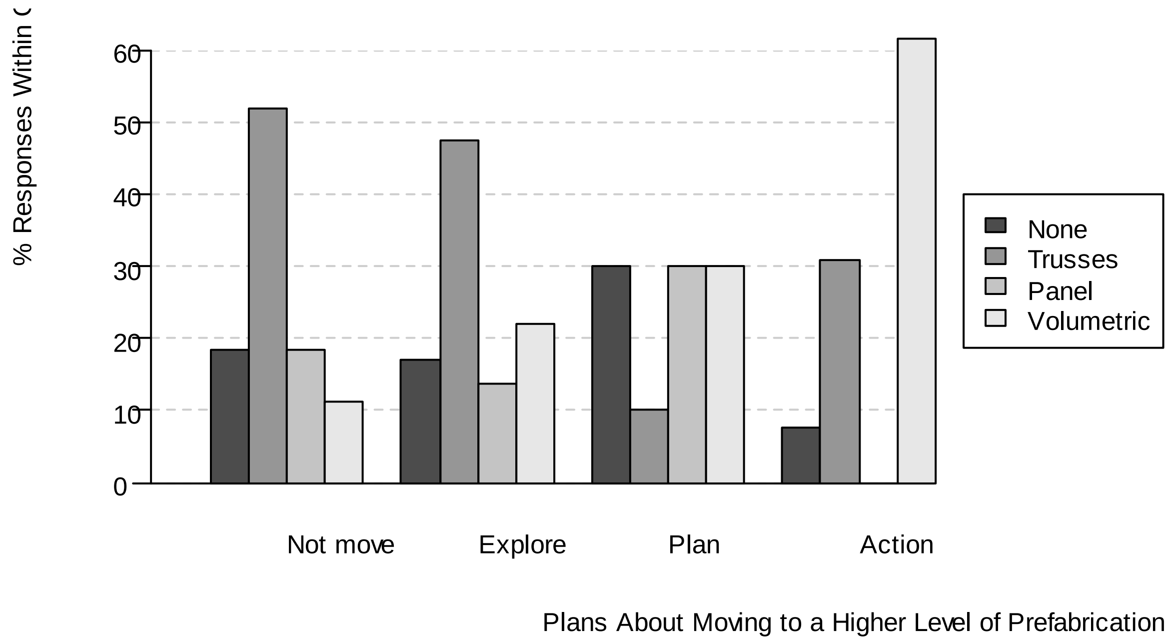


Western Australia

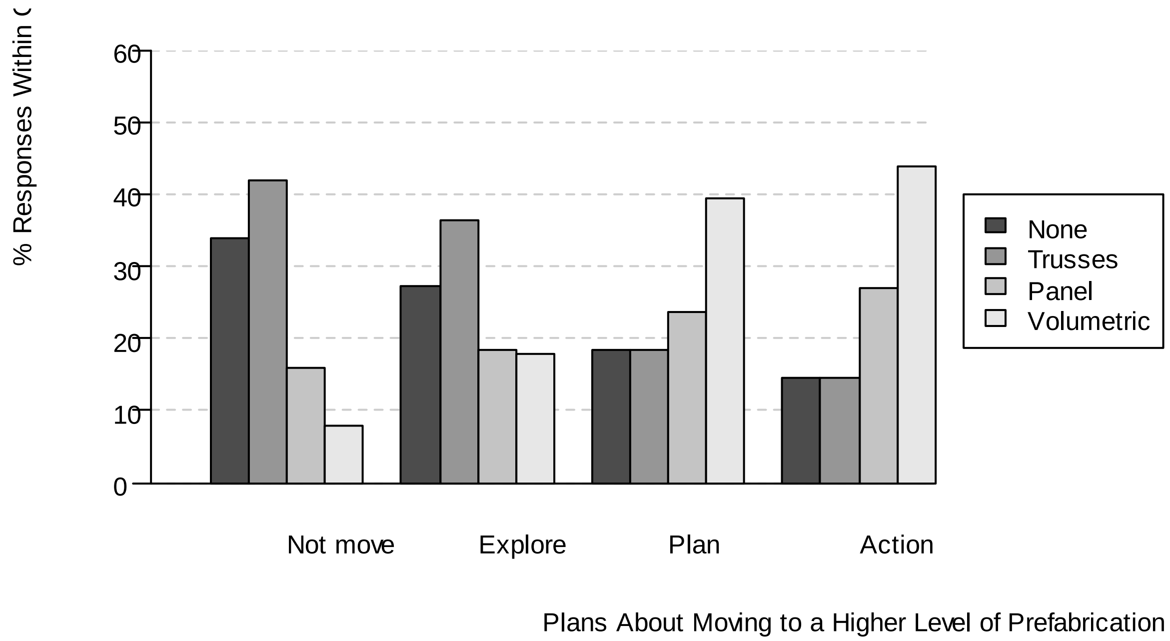


Distribution of highest level of prefabrication used by future plans:

Queensland



Western Australia



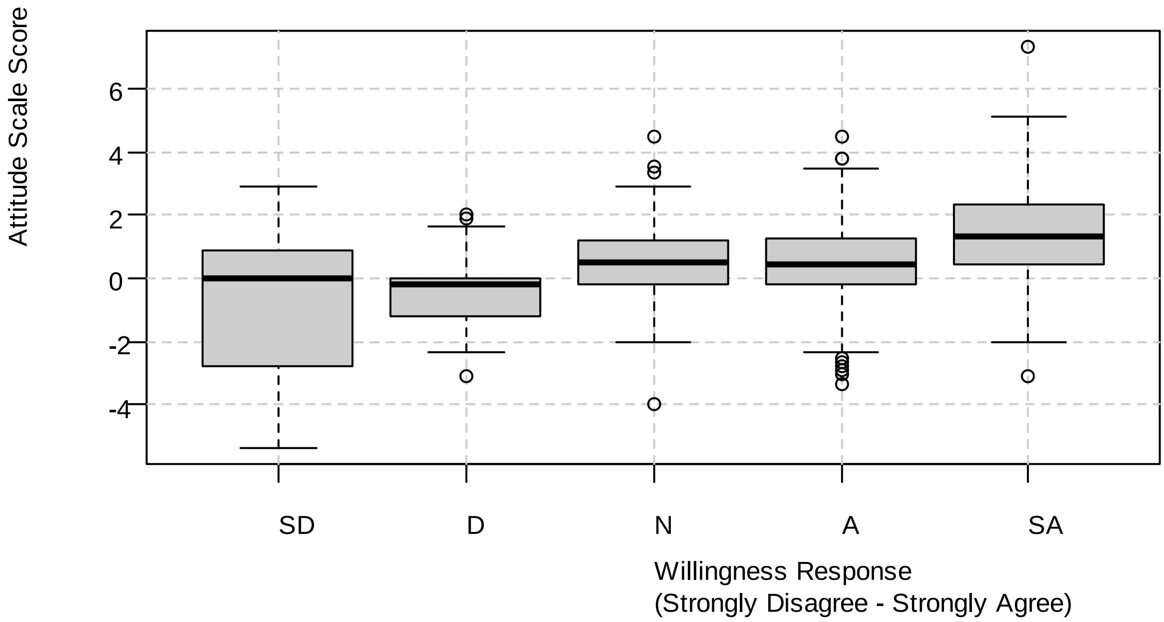
Appendix B – Full tables of results:

Distribution of responses to direct TPB measures

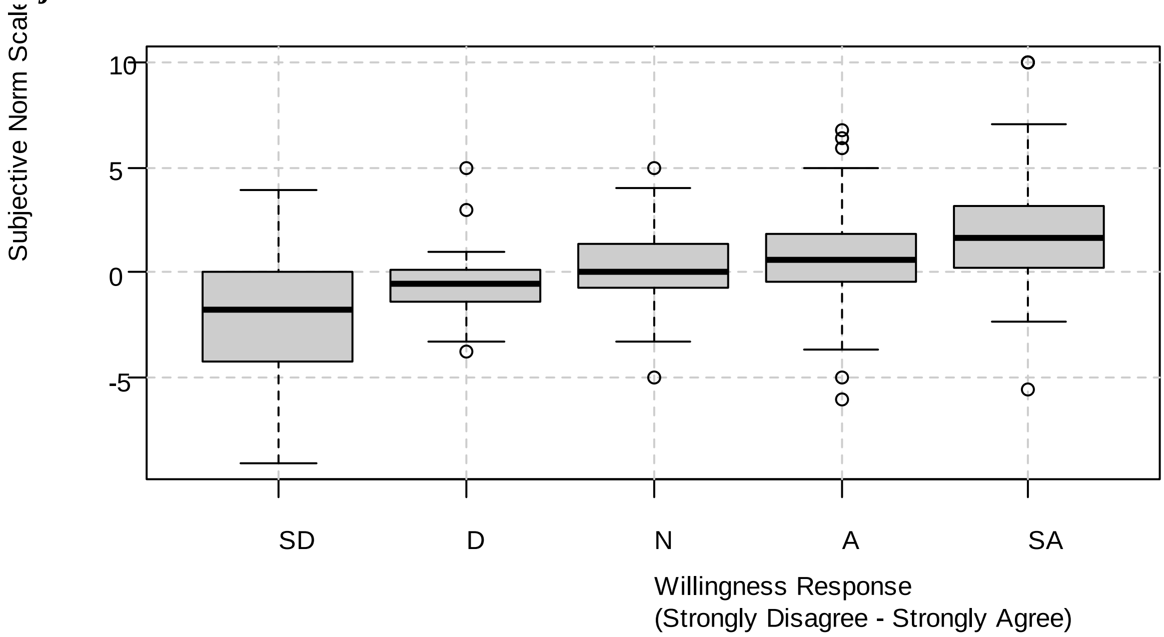
	Worthwhile?		Supported?		Easy to do?	
Response	**n**	**%**	**n**	**%**	**n**	**%**
Strongly Disagree	13	3.0	15	3.6	13	3.1
Disagree	29	6.7	57	13.7	59	13.9
Neither agree nor disagree	110	25.4	150	36.0	141	33.3
Agree	205	47.3	154	36.9	160	37.7
Strongly Agree	76	17.6	41	9.8	51	12.0
Valid Total	**433**	**100.0**	**417**	**100.0**	**424**	**100.0**
Not specified	21	4.6	37	8.1	30	6.6
Total	**454**	**100.0**	**454**	**100.0**	**454**	**100.0**

Boxplots comparing indirect TPB measures and willingness:

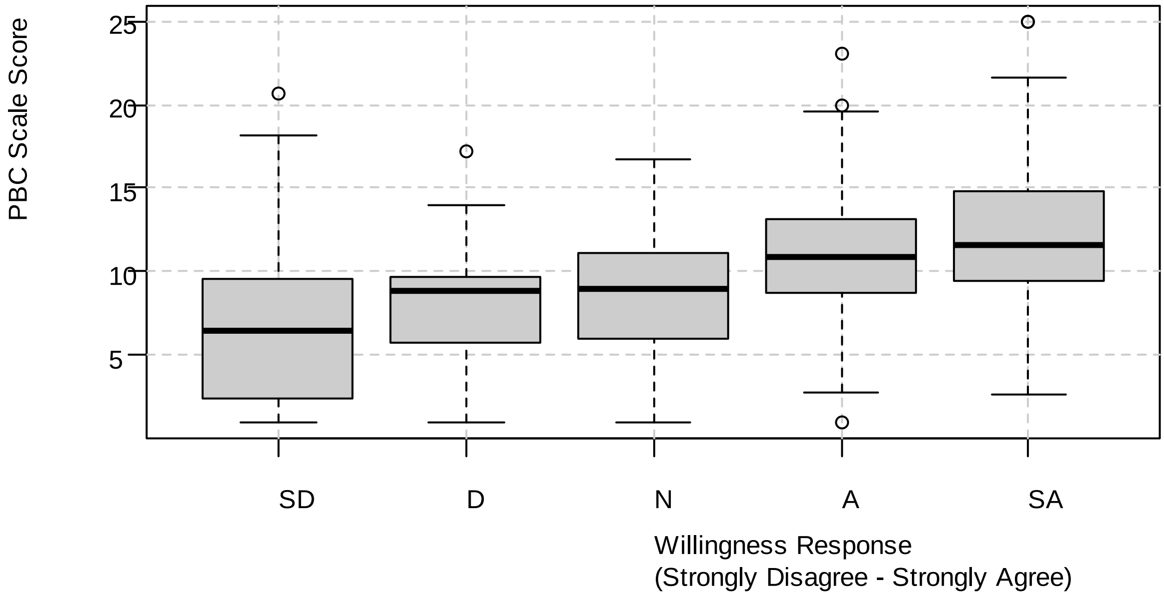
Attitudes



Subjective Norm



Perceived Behavioural Control



Appendix C – Survey Instrument

QUT

Understanding the Australian context for prefabricated housing

Research Team Contacts
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Research Leader: Assoc. Prof. Karen Manley
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Email: k.manley@qut.edu.au

QUT Ethics Approval Number: 1300000434

• **Purpose of the survey:**
This project is being undertaken as part of an Australian Research Council (ARC) Linkage project involving the Western Australian Building Commission and Building Codes Queensland as Industry Partners. The purpose of this project is to inform policy through a greater understanding of the obstacles and barriers to the use of prefabricated housing in Australia.

• **Prize draw:**
All participants are eligible to go into a draw to win an Apple iPad (16GB, Wifi + 4G).

• **Confidentiality:**
Information will be used for academic purposes only. Your answers will be confidential. Results will be aggregated and presented as summaries only, and individual respondents will not be identified. The funding bodies will not have access to completed surveys. Non-identifiable data may be used in future projects or stored in an open access database for secondary analysis.

• **Survey structure:**
You will be asked to provide your views on prefabricated housing. Participation will involve completing a 14 item survey including basic information on your business' characteristics (e.g.: annual number of houses built) and simple attitude scales (e.g.: strongly agree – strongly disagree responses).

Your participation in this project is entirely voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT or this project's Industry Partner Organisations. If you do agree to participate you can withdraw from the project without comment or penalty. However, as the questionnaire is anonymous, once it has been submitted it will not be possible to withdraw.

• **Who should complete this survey?:**
You will be a suitable respondent if you are currently a builder completing residential projects in Western Australia and/or Queensland. You do not have to be currently using prefabrication.

• **Estimated completion time:**
Approximately 10 minutes.

• **Consent to participate:**
Submitting the completed online questionnaire is accepted as an indication of your consent to participate in this project.

• **Concerns / complaints regarding the conduct of the project:**
QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 07 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project.

When you are ready to begin, click the "NEXT" button below.

NEXT

QUT

Understanding the Australian context for prefabricated housing

Business background

1. What types of builds does your business provide? (Select all that apply)

- ☐ Residential - 1 or 2 storey detached houses
- ☐ Residential - townhouses or terrace houses
- ☐ Multi-residential - small unit blocks
- ☐ Multi-residential - high-rise unit blocks
- ☐ Commercial builds (e.g. offices, retail)
- ☐ Light industrial (e.g. factories, warehouses, agricultural)
- ☐ Heavy industrial (e.g. bridges, roads, other infrastructure)

2. In what states or territories does your business operate? (Select all that apply)

- ☐ Queensland
- ☐ Western Australia
- ☐ New South Wales
- ☐ Victoria
- ☐ ACT
- ☐ Tasmania
- ☐ South Australia
- ☐ Northern Territory

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Understanding the Australian context for prefabricated housing

Prefabrication use

3. Which of the following levels of prefabrication has your business used on housing projects in the last 3 years? (Select all that apply)

- ☐ **Level 0**: None
- ☐ **Level 1**: Prefabricated trusses or beams
- ☐ **Level 2**: Prefabricated structural panels (e.g. SIPs, precast concrete)
- ☐ **Level 3**: Prefabricated specialised pods (e.g. bathroom, kitchen pods)
- ☐ **Level 4**: Prefabricated modules (housing segments delivered to site)
- ☐ **Level 5**: Fully complete prefabricated houses delivered to site

4. Rate your agreement with the following statements:

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
My business will use a higher level of prefabrication than previously used, on at least one housing project in the next 3 years.	○	○	○	○	○
If market conditions were supportive, my business might use a higher level of prefabrication than previously used, on at least one housing project in the next 3 years.	○	○	○	○	○
Market conditions for the Australian housing construction industry will improve in the next 3 years.	○	○	○	○	○

5. In the next 3 years my business will: (Choose one)

- ○ Not move to use a higher level of prefabrication than previously used.
- ○ Explore how to adapt to a higher level of prefabrication than previously used.
- ○ Make plans to move to a higher level of prefabrication than previously used.
- ○ Actively move to a higher level of prefabrication than previously used.
- ○ Continue to use the highest level of prefabrication.
- ○ Move from the highest level of prefabrication to a lower level.

Opinions on prefabrication

6. Moving to a higher level of prefabrication than your business has previously used, on at least one housing project in the next 3 years, would be:

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
worthwhile?	○	○	○	○	○
easy to do?	○	○	○	○	○
supported by most people important to you?	○	○	○	○	○

7a. Would moving to a higher level of prefabrication than your business has previously used, on at least one housing project in the next 3 years:

	Highly unlikely	Unlikely	Neither likely nor unlikely	Likely	Highly likely
increase your building costs?	○	○	○	○	○
increase the complexity of your building?	○	○	○	○	○
improve the speed of your construction?	○	○	○	○	○
improve the energy efficiency of your housing products?	○	○	○	○	○
improve your business' image?	○	○	○	○	○
reduce the size of your target market?	○	○	○	○	○
reduce the number of trades you require?	○	○	○	○	○
reduce the quality of your building?	○	○	○	○	○
reduce the flexibility of your house designs?	○	○	○	○	○

7b. What would be the impact of these changes on your business?

	Very negative	Negative	No effect	Positive	Very positive
Increased building costs	○	○	○	○	○
Increased complexity of building	○	○	○	○	○
Faster construction speed	○	○	○	○	○
Improved energy efficiency of your housing products	○	○	○	○	○
Improved business image	○	○	○	○	○
Reduced target market	○	○	○	○	○
Reduced number of required trades	○	○	○	○	○
Reduced quality of houses built	○	○	○	○	○
Reduced flexibility of possible house designs	○	○	○	○	○

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Understanding the Australian context for prefabricated housing

8a. Would the following groups approve of your business moving to a higher level of prefabrication than previously used, on at least one housing project in the next 3 years:

	Strongly disapprove	Disapprove	Neither approve nor disapprove	Approve	Strongly approve
Subcontractors					
Clients/owners					
Local planning regulators					
Housing energy efficiency regulators					
Banks and other lenders					
Material suppliers					
Architects and building designers					
Industry groups (e.g. HIA, MBA, Builders' Networks)					

8b. How much do you value their opinions?

	Not at all	Not very much	Somewhat	A fair bit	A lot
Subcontractors					
Clients/owners					
Local planning regulators					
Housing energy efficiency regulators					
Banks and other lenders					
Material suppliers					
Architects and building designers					
Industry groups (e.g. HIA, MBA, Builders' Networks)					

9a. How much would the following events encourage your business to move to a higher level of prefabrication than previously used, on at least one housing project in the next 3 years?

	Not at all	Not very much	Somewhat	A fair bit	A lot
Easier financing for prefabrication					
Relaxation of planning rules for prefabrication					
Stricter energy efficiency requirements					
Lower material costs for prefabrication					
Lower labour costs for prefabrication					
More people trained in prefabrication					
Increased demand for prefabrication					

9b. How likely are those events?

	Highly unlikely	Unlikely	Neither likely nor unlikely	Likely	Highly likely
Easier financing for prefabrication	○	○	○	○	○
Relaxation of planning rules for prefabrication	○	○	○	○	○
Stricter energy efficiency requirements	○	○	○	○	○
Lower material costs for prefabrication	○	○	○	○	○
Lower labour costs for prefabrication	○	○	○	○	○
More people trained in prefabrication	○	○	○	○	○
Increased demand for prefabrication	○	○	○	○	○

Business characteristics

10. For how many years has your business operated? (Choose one)

- ○ Less than 1 year
- ○ >1 - 2 years
- ○ >2 - 5 years
- ○ >5 - 10 years
- ○ >10 - 20 years
- ○ More than 20 years

11. On average how many new houses or individual units would your business build in a year? (Choose one)

- ○ 1 - 2
- ○ 3 - 10
- ○ 11 - 40
- ○ 41 - 100
- ○ More than 100

12. What is the postcode where your primary office is based?

13. What exterior wall materials do you use in your housing projects? (Select all that apply)

- ☐ Brick veneer
- ☐ Double brick
- ☐ Timber
- ☐ Concrete
- ☐ Fibro cement
- ☐ Insulated panels
- ☐ Other

14. If you have any other comments about the survey or prefabricated housing generally, please write them in the box below.

Thanks for completing the survey.
Please click "Next" below to finalise the survey and be taken to the competition entry page.

BACK SUBMIT