EXPLORING CONSUMERS' PERCEPTIONS AND ATTITUDES FOR OFF-SITE MANUFACTURED HOUSING IN AUSTRALIA

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Statement of Originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made.
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Edward Duc

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Contents

Glossary of terms

Affordable housing- for this thesis affordable housing is housing which meets international criteria of a house costing no more than three years income of the purchaser. It is NOT the classification of housing defined by the Australian Government as affordable, this is housing which is made available to low to medium incomes tenants at lower than market rent to enable essential services personnel to live near to their workplace.

AHURI- Acronym for the Australian Housing and Urban Research Institute. This is a nonprofit organization publishing research papers in regard housing in Australia addressing issues such as cost and housing stress.

Attitudes- related to perceptions; attitudes are informed by perceptions to take action or exhibit behavior which is measurable.

CAD/CAM- Computer Aided Drafting/Computer Aided Manufacture. This method enables use of computers to directly translate designs into manufactured components or in the case of 3D printing whole buildings.

CHCI – Acronym for Conventional Housing Construction Industry. This describes the current systems used to procure buildings by transporting components and skills to a building site and then assembly of the parts and services to complete a building.

Consumer-One that acquires goods or services for direct use or ownership rather than for resale. For this research the term applies to all consumers seeking to examine their resistance to OSM housing.

Detached residence-Housing which is standalone and not attached to another, usually occupied by a single family, comprising 70% of Australian housing stock.

Housing industry- this includes consumers, real estate agents, lawyers, finance providers and brokers, architects and designers, engineers, certifiers, councils and state government and building code management,

Housing construction industry- comprises builders, contractors and sub-contractors, services installers, services authorities for waste, water and electricity, housing and building associations, transport and materials suppliers.

OSM- Off-site Manufacture (d) (or off-site manufacturing) of housing is also described as prefabrication. OSM has various formulations including volumetric (whole parts of a house) and non-volumetric (components for assembly) to name two.

OECD- Acronym for the Organisation of Economic Co-operation and Development, an intergovernmental organization comprising 36 member countries seeking to stimulate economic progress and world trade.

Owner-for this research the term describes a consumer who has purchased a house for their own occupation.

Perception- a person's view or interpretation, intuitive recognition or appreciation as of moral, psychological, or aesthetic qualities.

Prefabricated- prefabricated buildings or objects are built from parts that have been made in a factory and can be put together quickly.

Production-the creation of value, the production of articles which have exchange value.

Supply-to furnish or provide.

Supply and demand-classic economic theory, as demand increases prices rise, as supply increases prices may fall. (subject to other factors such as regulation, marketing)

Sustainable/Sustainability- relates to the broad concepts used to describe environmental aspects such as waste, energy use and contribution to global warming. For this research *sustainability* also refers to the aspects of time, cost and quality in housing production.

System-a way of working, organizing or doing something which follows a fixed plan or set of rules.

Time cost and quality- important attributes for the current and future of housing production. Conventional systems are acknowledged as expending increasing periods of elapsed time for completion. Costs are increasing relative to incomes and defects and rework are growing.

The housing industry- for this research is defined as the market place comprising cohorts of real estate agents, financiers such as banks and mortgage providers, regulatory authorities such as councils and state governments.

The housing construction industry- is defined as the supplier to the market comprising small, medium and large enterprises providing construction management and sub-contractor trades.

Viable-able to exist, performs as intended, or succeeds.

Abstract

The systems of production currently used to construct houses in Australia are not viable, particularly in terms of time, cost and quality. As a result, detached residential housing is in short supply and is too expensive for many seeking to purchase a house. This situation is socially unacceptable. There is evidence that housing produced using off-site manufacturing (OSM) systems will mitigate the problem, however, there is market resistance to the adoption of this system.

Literature demonstrates that the housing construction industry fails to produce housing which is satisfactory in terms of time, cost and quality. The industry albeit aware of these shortcomings, resists innovation of current systems or to consider new systems. Use of OSM is considered to be an option which will satisfy goals of providing housing which reduces time and cost for production as well as suitable quality. However, consumers are perceived to have negative attitudes towards OSM systems. A conceptual framework of six perceptions was established consisting of quality, knowledge, sustainable status, customization, style and investment in relation to housing choice.

The question that this study seeks to answer is what needs to change for consumers to accept OSM systems?

Therefore, examining consumer perceptions and attitudes to systems of OSM housing currently on the market informs this study. A qualitative method was adopted to identify consumer risks, perceptions and attitudes to conventional housing and housing produced by OSM. Data from fifteen semi-structured interviews with consumers who were commissioning a new house in the near future yielded results from which findings and conclusions were developed.

The results from the study indicate that relationships between risks and perceptions can be shifted from conventional housing's style and lifestyle to knowledge and understanding of OSM systems.
The significance of this research is twofold: it informs the housing industry as to potential perceptions and attitudes of consumers to current OSM systems of housing and provides a reliable basis for further investigation to assuage consumers' reluctance to accept OSM systems. Recommendations made by the research include communication with industry and consumers demonstrating the benefits of OSM through promotion and a presence in housing demonstration villages, and inform government of favorable perceptions and attitudes of consumers to OSM systems. Key findings were consumers determine OSM systems as attractive for cost, time and quality when they are given knowledge of the genre.

Key words: viable housing construction industry, OSM systems, consumer perceptions and attitudes.

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1. Chapter 1- Introduction

This research has explored the phenomenon of consumers' attitudes to conventional housing and specifically housing produced by OSM systems. The focus is for the research is the detached residential, a typology which represents 70% of Australian housing stock (ABS, 2017). Medium and high density housing are not addressed. This social constructivist study explored the perceptions of consumers in Australia in regard to housing produced by OSM. The study seeks to identify barriers experienced by consumers to accepting OSM housing in lieu of conventionally produced housing. For this research, a consumer is a person who acquires goods or services for direct use or ownership rather than for resale. This definition applies to all consumers seeking to examine their perceptions and attitudes to conventional and OSM housing.

The research employed a phenomenological methodology to investigate the phenomenon which is the focus of the study. This chapter starts with an overview of the background and context that frames the study and then defines the problem. Following this is an explanation of the purpose of the research as well as the research questions it addresses through aims and objectives. Also included in this chapter is a discussion of the research approach, the researcher's propositions and perspectives as well as the limitations of the study. This chapter concludes with the significance and rationale of this research study.

1.1. Background and context

Housing is essential to the well-being and health of people's lives (S. Smith, 1994). Without suitable housing some important aspects of human life are in jeopardy, including aspects such as health, education and security (Clapham, 2011). However, serious long standing and current problems are being experienced by the housing industry and the housing construction industry. The focus for this research is the detached residence which comprises 70% of housing stock in Australia (ABS, 2017). These problems create outcomes which

are not viable. Since the year 2000 there has been a severe deficit of housing supply in Australia, for purchase and rental (ABS, 2017; Donald, 2013). Gurran et al. (2018) in their report for AHURI state that in 2018 there is a deficit of more than 200,000 houses in Australia.

Further, the cost of housing in Australia has continually increased since the early 1980s (Payne, 2008). The Organisation for Economic Co-operation and Development (OECD) argues an affordable index of housing price to average disposable income should ideally be 3:1. The OECD however states there was a 78% increase in the cost of housing in Australia between 1980 and 2015 (OECD, 2017). Australian Parliamentary Library calculations indicate that the ratio of average disposable household income to median house prices has increased from approximately 3.3:1 in June 1981, to just over 7:1 in June 2015 (M Thomas & Hall, 2016). In 2017 the ratio was reported as greater than 10:1 in two Australian capital cities (ABS, 2017).

The housing construction industry also exhibits poor levels of productivity and therefore has difficulty in matching demand, a problem which exacerbates both issues of increased cost of housing and redressing the deficit (T Dalton, Horne, Hurley, Gharaie, & Wakefield, 2015). Further, the construction industry demonstrates poor standards of sustainability in areas such as waste, site safety for workers, time for construction, cost overruns and poor quality as stated in various industry reports, in Australia and other countries (BEIIC, 2012; COAG, 2014; Egan, 1998; Latham, 1994).

Despite these issues the systems used by the housing construction industry remain stagnant and fails to adopt systems to improve aspects of time, cost and quality (Manley, McFallen, & Kajewski, 2009; Manley & Miller, 2014). Further the industry must reduce waste and therefore cost (Osmani, Glass, & Price, 2008). Options currently in use by commercial construction groups include building information modelling, lean and agile management, and design for manufacture and assembly, options which can improve viable outcomes for housing

production. However these options are rejected by builders producing detached houses (Gale, 2015; Koebel, 2008).

Another alternative for producing housing which is affordable and efficient compared to conventional systems, is the use of OSM systems (Elnaas, Ashton, & Gidado, 2009; Hampson & Brandon, 2004). In contrast to Australia, use of OSM in Sweden for housing is stated as 80% of housing stock (Thanoon, Peng, Kadir, Jaafar, & Salit, 2003) whilst in Germany and Japan the uptake is between 13% and 15% (Gann, 1996; Venables, Courtney, & Stockerl, 2004). Currently no other countries were found to have extensive use of OSM for housing provision (Steinhardt, Manley, & Miller, 2013a). In Australia the uptake of OSM housing is less than 3% (Steinhardt & Manley, 2016a). This minimal use of OSM matches the UK and the US and is often attributed to considerable consumer resistance to the use of OSM. Resistance is also noted in the housing industry (comprising real estate agents, financiers and authorities) and the housing construction industry (Greig, 1995). The resistance by consumers to accept OSM housing Steinhardt and Manley (2015) argue, is in part due to the housing industries making propositions that consumers resist choosing OSM housing systems over conventional systems. As a result, the industry has made commercial decisions to avoid OSM of housing (Pan, Dainty, & Gibb, 2012; Steinhardt & Manley, 2015). Investigation into consumer perceptions and attitudes to housing produced by OSM systems will inform this research. Perception is the manner in which something is regarded, understood, or interpreted a belief or opinion based upon how things seem. Perceptions can be altered by informing consumers using credible information, for example case studies. With this learning a consumer can form a balanced attitude to better inform their decision making (Marzano et al., 1992) The question that this study seeks to answer is what needs to change for consumers to accept OSM systems?

Part of the solution identifies any barriers to the consumers' acceptance of OSM systems when free of industry considerations.

1.1.1. Propositions for consideration in regard to OSM

The researcher for this study has practised in the profession of architecture since registration in 1970 designing and seeing construction through to completion on many houses. Other projects in which the researcher was involved included health and education typologies as well as high and medium rise apartment buildings. While these experiences have educated the researcher in contrasting clients' wants and needs through countless meetings and briefings, the experiences have also informed the interpretive methods and findings. These skills have invariably been aligned to a pragmatic attitude disciplined by a mantra to not create solutions which do not function to suit the brief.

By way of mitigating any bias, the researcher has continually undertaken critical self-examination and engagement with supervisors to test the research process (Bloomberg & Volpe, 2012).

In order to fully explore the phenomena at the centre of this research, certain propositions were developed based on the researcher's experiences as a practicing architect and urban designer.

Firstly, financially houses represent a large investment and often provide a stepping stone to a secure lifestyle. This proposition is based on the fact that owning a house (with or without a mortgage) often provides security for loans and other financial transactions (Yanotti, 2017). In regard to finance will an OSM house provide this security?

Secondly, houses are often regarded as a measure of status in the community. This proposition is guided by attitudes of home dwellers who insist on customising individual features for their houses (Schoenwitz, Gosling, Naim, & Potter, 2014). Will an OSM house attract the desired status?

The third proposition is that people's emotions of self-worth are affected by the house in which they live. This proposition is guided by many references to this phenomenon by psychologists describing mental health and housing stress (S. Smith, 1994). Will an OSM house afford consumers the level of self-worth they require?

Fourthly, people prefer “solid” houses. This proposition is based on the preference people have, for example, brick houses (Edge et al., 2002; Greig, 1995). Will an OSM house engender the confidence that the product has quality and solidity, to last and provide security for a long tenure?

Following completion of the collection of the data and interpretation, these propositions will be revisited to assess whether they are valid and relevant.

1.2. Problem statement

Conventional systems for the construction of houses are not viable (Altomonte, 2008; Wiesel et al., 2012). In Australia housing production is not satisfying market demand leading to poor housing outcomes and, as a result this negatively affects the health and wellbeing many people (S. Smith, 1994; Willison, 2017). Further, housing in Australia has been described as too expensive (Payne, 2008; Phillips, 2011) . There is sufficient evidence that the production of housing using OSM could satisfy the aspects of cost, time and quality (Gibb, 1999; Gorgolewski, 2004; Nadim & Goulding, 2011; Page, 2014). However, according to Craig, Laing, and Edge (2000) and Edge et al. (2002) there is significant consumer resistance to OSM housing evidenced by the small uptake to this approach. If consumers’ resistance can be assuaged and greater acceptance of OSM for housing created, production of housing should be more viable in terms of time, cost and quality (N. Blismas, 2007). The employment of OSM to a greater extent than is currently the case will arguably result in housing being more readily available and the shortfall in supply addressed for Australian house seekers.

1.3. Research gap and research questions

This study examines key perceptions and attitudes of consumers for OSM housing in Australia along with an exploration of the perceived risks, key

perceptions and attitudes for consumers when considering the commissioning of a new house. The systems of conventional housing production have been described as unviable particularly in terms of time, cost and quality. Will consumers consider purchasing a house which demonstrates sustainable characteristics albeit produced by OSM? For this research the focus is on the aspects of cost and productivity (capacity) and minimal defects (quality). Assisting consumers to make better informed choices and consider purchasing OSM housing could contribute to the identification of a solution to the current dilemma of unaffordable housing and the shortage of suitable supply.
In order to obtain the desired results, the following research questions, aims and objectives were developed.

1.3.1. Research questions, aims and objectives

Figure 1.1 below summarizes the relationships between the research problem, research questions, aims and objectives.

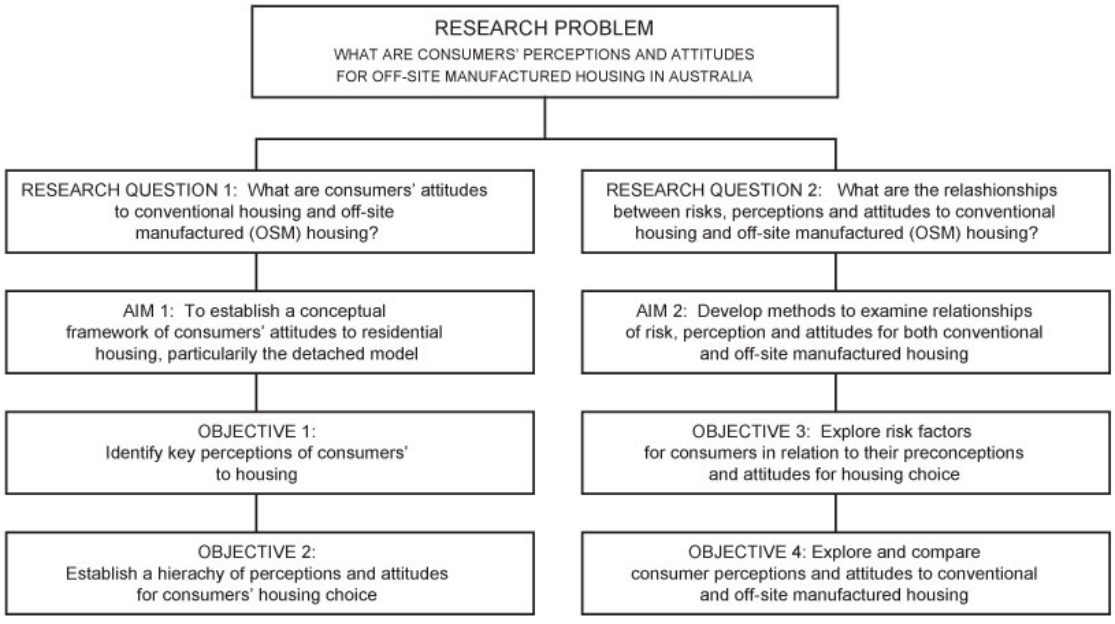

Figure 1.1 Graphical representation of the link between the research problem, questions, aims and the objectives.

Research question 1: What are consumers' attitudes to conventional housing and OSM housing?

This study sought to ascertain attitudes of consumers to OSM housing. Uncovering attitudes to conventional housing and then comparing those with attitudes to off-site housing systems informed this study. This knowledge is important if options to improve housing supply in Australia are to be addressed. The housing construction industry in Australia demonstrates poor performance for time cost and quality. Further the industry resists innovation to better perform, often described as an industry comprising silos of actors whose actions are dysfunctional and adversarial. In the literature the OSM of housing is regarded as a superior performer for time, cost and quality, and implementing this option would assist in the mitigation of unacceptable housing outcomes. However the literature argues that consumers have negative attitudes to OSM housing.

Aim 1: To establish a conceptual framework of consumers' attitudes to residential housing, particularly the detached model.

Developing a conceptual framework from a literature review will guide the research. The framework seeks important perceptions of consumers for housing, which then facilitated the finding and interpretation of their attitudes. The aim is to provide a benchmark of perceptions and attitudes for conventional detached housing. Hence it was possible to compare consumers' attitudes for conventional and OSM housing.

Objective 1: To identify key perceptions of consumers' to housing.

Finding perceptions held by consumers for conventional housing provides a background for the examination of issues concerning consumer housing choices. A literature review is distilled from major perceptions of consumers for housing.

This foundation informed the second objective by contrasting perceptions and attitudes for housing choice.

Objective 2: To establish a hierarchy of key perceptions and attitudes for consumers' housing choice.

It was essential to find the relative importance of perceptions and attitudes for housing choice if meaningful analysis of data was to be realized from this research. Codes and themes were developed from the data, and then tables were used comparing consumers' frequency of response to each code within each risk category.

Research Question 2: What are the relationships between risks, perceptions and attitudes to conventional housing and OSM housing?

The literature indicates that consumers regard OSM housing as having inherent risks. Using categories of risk such as the social perceptions of peers, financial uncertainty, physical harm, performance uncertainty, time lost and psychological issues of self-worth informed this research. Assessing risk in relation to perceptions and attitudes for both conventional and OSM houses enables this study to interpret consumer reactions to housing innovation.

Aim 2: To develop methods to examine relationships of perceived risk, key perception and attitudes for both conventional and OSM housing.

A research methodology using the Theory of Perceived Risk was developed to find relationships between risk, perceptions and attitudes to housing. Hence matrices are established to examine the importance of various risks and how they related to perceptions of both conventional and OSM housing.

Objective 3: To explore perceived risk factors for consumers in relation to their key perceptions and attitudes for housing choice.

Perceptions of risk permeate all aspects of choice. Perceptions form our attitudes and the link between risk and attitudes guides our actions in making a choice. For housing this is an important factor. Houses are generally the most expensive item consumers will purchase. Finding, interpreting and concluding which perceptions are most frequently exhibited from the data informed Objective 4.

Objective 4: To explore and compare consumer key perceptions and attitudes to conventional and OSM housing.

The collation of the most frequent consumer perceptions of housing for both conventional and OSM housing informs this study as to consumers' hierarchy of attitudes to housing. The results provide answers about consumer preferences for housing options.

1.4. Overview of the research methodology

The research questions developed from the literature review sought to examine the perceptions and attitudes of consumers to housing in Australia. It was found that there are undesirable aspects of viability for housing and that the use of OSM could assuage some of those undesirable characteristics. However, it was also found that there is consumer resistance to housing produced by OSM: in order to examine these perceptions, a qualitative methodology was selected to collect the data (Creswell, 2014). This was accomplished by conducting interviews with a purposive sample of consumers. The following is a description of the steps taken to carry out the study.

The Human Ethics Research Committee of the University of Newcastle granted approval H-2017-0003 for the interviewing of participants to ascertain their perceptions and experiences in regard to housing choice. Participants needed to be people who intended to purchase a house in the near future. This investigation used in depth interviews and a phenomenological methodology combined with a social constructivist interpretive philosophy, to understand social and cultural realities in relation to the procurement of housing. Neubauer, Witkop, and Varpio (2019) argue phenomenology is a form of qualitative research that focuses on the study of an individual's lived experiences within the world. The use of the Theory of Perceived Risk (TPR) enabled an exploration of consumer's views through their own eyes, which according to V. Mitchell (1999) results in valid and reliable research data. Importantly this theory examines aspects of possibility and consequences of risk, thereby simplifying complex issues.

The use of TPR was deemed appropriate when searching for relevant data. The TPR is regarded as being particularly suited to research inquiring into consumer attitudes for purchases which are expensive and infrequent, a category into which housing fits (Bruce & Kelly, 2013; M. Koklic, 2011).

The interviews were the primary source of data.

Only participants who were commissioning a new house in the near future but had not yet decided on the type of new housing were selected. Throughout the interview they were prompted to directly compare current housing systems with OSM housing, using sustainable principles as a filter. This approach made it possible for their reactions to be differentiated and so informed the study. The analysis of the interview data resulted in new knowledge about consumers' attitudes to OSM housing.

Each participant was interviewed individually at a location of their choice. There are six risks identified by the TPR social, financial, physical, performance, time and psychological. Questions for each of the risks were asked in regard to the participants perceptions of the housing for what they understood was currently available. They were then shown a PowerPoint (PP) presentation. Harper (2002) argues the use of tools such as PP enriches responses to and facilitates the use

of probing questions. The PP presented three OSM houses from each of three suppliers of OSM housing in Australia. These companies were selected against set criteria of sustainable factors and are discussed in detail in Chapter 2. The participants were then asked a further set of questions developed from the six TPR factors. Fifteen people participated in the study; the interviews were digitally recorded and then transcribed verbatim. The interviews were coded and themes developed using NVivo 12 computer software and the interpretive techniques of the researcher. The data was such that the weighting of the comparative responses to the risks could be carried out, adding depth to the study.

1.5. Rationale and significance

The study contributes new knowledge to the debate about housing provision in Australia. It applies the TPR to consumers, the housing industry and housing construction industry to understand the relationship between the risks for and perceptions of consumers in conventional and OSM housing.

The study investigated consumers' attitudes to conventional and OSM housing seeking to address the unviable housing provision in Australia and the resulting stress this causes a community. This problem is compounded due to the inability of the housing construction industry to improve productivity and to constrain the rising cost of housing construction thereby exacerbating the poor aspects of housing cost and availability (T Dalton, Hurley, Gharaie, Wakefield, & Horne, 2013).

There is sufficient evidence that OSM systems for housing could address issues of time, cost and quality and improve the provision of housing. However, there is considerable reluctance on the part of the housing industry to accept these systems for housing supply (Kenley, 2012). The housing industry is comprised of consumers, real estate agents, financial institutions and authorities. Consumers are the group the housing industry relies upon for commercial success. Using the Theory of Perceived Risk informs this research by seeking their impressions of current systems of OSM housing and consumer perceptions and attitudes to the

acceptance of the OSM system. Having identified the perceptions and attitudes, making these findings available to the housing industry may encourage change. This should enable improved viable systems of housing in Australia and therefore obtain better outcomes for the health and well-being of the community.
In order to inform the research a literature review was undertaken in Chapter 2.

1.6. Limitations of the study

This study recognises that certain limitations need to be acknowledged and addressed. Firstly, there are the common critiques of the accuracy and reliability of qualitative research methodologies. Secondly are the limitations of subjectivity on the part of the researcher and thirdly there are limits imposed by the design of the research.
In relation to these restrictions, the research design adopted a phenomenological qualitative methodology as most appropriate to develop suitable data. However, in the design of the research two tools were adopted to ensure the methodology demonstrated rigour; those measures included the use of the TPR and an acutely focussed group of participants. These tools provided a discipline for the research affording a measure of repeatability and confirmability. Morse, Barrett, Mayan, Olson, and Spiers (2002) argue that qualitative researchers should reclaim responsibility for reliability and validity by implementing verification strategies integral and self-correcting during the conduct of inquiry itself.

For qualitative methods aspects of subjectivity and researcher bias were reduced by ensuring the research actually reveals more about the subject than about the researcher. Further, in the process of interviewing a mindset which regards the participants as the expert and the researcher as a receiver of knowledge assists to reduce researcher bias.
The findings of the study are limited to the Australian context.

2. Chapter 2 – Literature Review

2.1. Introduction

This research arose from consideration and concern for the viable status of the Australian housing industry, particularly for the aspects of time, cost and quality. In Australia detached residences represents 70% of the housing stock and it is this typology which is the focus of this research. The study did not include medium and high density housing. Importantly, two separate but inter-dependent parts of the housing industry can be identified, the housing industry and the housing construction industry. The housing industry for this research is defined as the market place comprising cohorts of real estate agents, financiers such as banks and mortgage providers, regulatory authorities such as councils and state governments. The housing construction industry is defined as the supplier to the market comprising small, medium and large enterprises providing construction management and sub-contractor trades. The most important stakeholder in the housing market is the consumer, without which no industry would exist and is therefore the focus of this research.

The literature reviewed in this chapter focused on material relevant to conventional and OSM housing production. For this research the use of the term OSM is used in lieu of prefabrication. The literature selected included the following sources:

- Peer reviewed papers in journals and conference proceedings.
- Reports from government agencies such as the Australian Bureaux of Statistics and Commonwealth Scientific and Industrial Research Organisation.
- Books both contemporaneous and historical written by academics recognised in the genre of the building and construction industry.
- Databases of academic literature such as Scopus and Google Scholar.
- Relevant theses by Research Higher Degree candidates.

This review commences with a description of the current state of the Australian construction industry, particularly for aspects of viable practices for construction of time, cost and quality. Also addressed are availability of trade skills and waste of both labour and materials. Various systems to improve the productivity and cost effectiveness of the construction industry are mentioned for possible integration into the industry, such as BIM, 3D printing and lean and agile principles. OSM of housing is examined for its viable attributes as an alternative to current on-site systems. The review then examines historical and contemporary drivers for and obstacles to the use of OSM to address housing supply. Finally consumers' perceptions and attitudes are investigated for the Australian housing industry in regard to the supply and consumer acceptance of housing using OSM.

2.2. Background to the research

Traditional systems for housing production are not meeting desirable targets for time, cost and quality resulting in housing stress for the community (N Blismas, Pasquire, & Gibb, 2007; Robinson & Adams, 2008). Housing is arguably one of the most important needs of mankind. In a modern society such as Australia housing as well as providing shelter, represents a need fundamental to social and economic wellbeing (Steinhardt, Manley, & Miller, 2013b). There is evidence that an inadequate housing supply has been developing over time and this has resulted in a deficit for a growing population (Daley, Coates, & Wiltshire, 2018; Donald, 2013; Heaton, 2016; Yates, 2015). Although the problem of inadequate housing supply exists in many countries, the focus of this research is Australia. Maclennan, Crommelin, Van den Nouwelant, and Randolph (2018) argue insufficient supply contributes to increased housing cost through reduced availability of product to satisfy the housing industry markets. Thorpe (2013) argues there is sufficient evidence to indicate that the housing construction industry cannot or will not innovate to improve its productivity or viability. For Australia this reluctance to innovate is argued by Manley and Miller (2014) who

propose change could be encouraged through embracing sustainable principles, for example, simply reducing waste. In many countries including Australia, the housing industry retains an adherence to craft systems. In contrast the production of most consumer goods has transitioned to a manufacturing system (Elnaas, Gidado, & Ashton, 2014). The manufacturing system when compared to craft systems produces items of high quality, lower cost and timely supply (J Barlow & Ozaki, 2004; Gann, 2000). Until systems of housing production meet desirable standards of time, cost and quality, the supply of housing will fail to satisfy past and future demand, further exacerbating unacceptable social outcomes (Maclennan et al., 2018). Not only is the industry reluctant to accept off-site systems, it is argued that consumers resist choosing OSM housing systems (B Bengtsson & Ruonavaara, 2010; M Koklic & Vida, 2011; Marsh & Gibb, 2011). This resistance in turn acts to deter innovation by the industry in housing production (Blayse, Manley, Hardie, & Kajewski, 2004).Further, Loosemore (2015) argues that clients (consumers) resist paying for innovation and suggests the lead for innovation and change should come from authorities to create regulations and policy to incentivize innovation in the industry . Another factor to consider is the growing concern of communities in regard to aspects of sustainability such as waste, unwanted emissions and excessive energy use (Leviston, Price, Malkin, & McCrea, 2014). Society is seeking a reduction of negative and harmful actions which adversely affect the amenities of future generations (Leviston et al., 2014). Arguably this concern for sustainability could affect consumers' choice of housing.

2.3. The current state of the housing construction industry

Construction is an important industry in Australia contributing over $200 billion per annum (p.a.) to the national economy of which the housing industry contributes $110 billion (pa). This translates into construction being the fourth largest industry representing 7% of gross domestic product (GDP) and employing nearly 10% of the workforce (ABS, 2016; ACIF, 2016).

However, this important industry is widely criticised as being averse to innovation by continuing with inefficient practices and poor profitability (BEIIC, 2012; De Valence, 2010). The industry, particularly for building construction (as distinct from engineering) has a reputation for delivering projects which have unacceptable levels of defects and cost overruns as well as increasing times for completion of projects (BEIIC, 2012); N. Blismas (2007). Lambert (2016) made 150 recommendations to the NSW Government addressing the certification of building professionals seeking higher standards in the construction industry. In a recent report for the Building Ministers' Forum organization, Shergold and Weir (2018) recommended important reforms for compliance and the enforcement of the National Construction Codes seeking to improve the public trust in the safety and health of buildings. These reports have been timely for consumer protection, however, as recent events have transpired, without satisfactory results. In Sydney NSW there have been two major failures in apartment buildings providing evidence that major changes are still required to improve quality in housing (Hanmer, 2019). Significantly these factors contribute to housing undersupply (Lovering, 2014).

2.3.1. Background issues for the construction industry

The problems of the overall construction industry as outlined above are not a recent phenomenon nor are they unique to Australia. N Blismas and Wakefield (2009) suggest important precedents from the United Kingdom (UK) can inform the industry in Australia. Sir Michael Latham was appointed by the British government and industry organisations to examine the state of the construction industry in the UK (Latham, 1994). The report reviewed procurement and contractual arrangements and considered aspects such as time and cost overruns as well as poor build quality resulting in customer dissatisfaction. Latham concluded that the industry needed to work more closely as a team and those contractual arrangements in use at that time, should be revised to reduce adversarial and fragmented practices. Further, selection of consultants and contractors should be assessed on the quality of service and end product as well as price criteria. Latham identified the industry fragmentation as a key dilemma,

comprising silos of participants such as consultant architects and engineers, project and construction managers, and head contractors and subcontractors (Woudhuysen & Abley, 2004). Further examination of issues for the construction industry was implemented by Sir John Egan (Egan, 1998) , as chair of a "Construction Task Force", they produced a report titled "Rethinking Construction" for the UK government. The Egan Report, whilst reinforcing fragmentation as a serious problem (leading to adversarial outcomes) also addressed aspects such as unnecessary waste and poor working conditions as well as factors which compromise safety, productivity and quality. Importantly this report also identified poor levels of profitability and potentially fatal exposure to economic fluctuations, factors which create instability for clients, companies and workers. The Egan Report also mentioned two subjects important to this research. Firstly, comparison of construction to other industries, which have innovated and thereby achieved radical change, such as improvements in quality and efficiency. Secondly, the report suggested establishing a housebuilding industry forum seeking improved performance through UK social housing programs, a sector that can be specifically influenced by government through policy and financial incentives.

A recent McKinsey Global Report on productivity in the construction industry confirms the historical deficiencies that continue to afflict world economies. The authors of the report Barbosa et al. (2017) identify a number of factors for reconsideration and examination to mitigate poor productivity. The factors include extensive regulations; an industry which is opaque and fragmented; contractual structures and incentives which are misaligned; poor project management; skills shortages and an industry which underinvests in innovation and digitization.

2.3.1.1. ***Australian housing supply***

Housing is an important commodity worldwide and the current shortages have undesirable social consequences (Barker, 2004; Donald, 2013).

Barker (2004) argues that housing is a need fundamental to social and economic wellbeing and any decrease in availability creates a division between those who have housing and those who do not. It is therefore useful to examine the state of

housing supply in Australia. The Australian Senate used data provided by the Housing Industry Association indicating yearly housing supply deficits as follows; 2006-2007 new housing starts of 151,600 and underlying demand of 167,400, for 2007-2008 new starts 154300 and underlying demand 169,900, for 2008-2009 new starts 154,100 and underlying demand 172,500, for 2009-2010 new starts 163,200 and underlying demand 174,200 (HIA., 2008) and according to the Grattan Institute reports underlying deficits continue to adversely affect housing supply (Grattan Institute, 2018).

Donald (2013) cites the research of the National Housing Supply Council (NHSC) which concluded that Australia has experienced worsening housing shortages since March 2005. The NHSC projected the gap in housing supply would reach a shortage of 430,000 units by 2028.The gap is arguably a product of inadequate productivity in the construction industry to satisfy growing demand, demand generated by natural population growth together with higher levels of immigration. Housing in Australia has historically comprised mostly free-standing detached houses and today still represents nearly 70% of new housing stock. (ABS, 2016; J. Kelly, Breadon, & Reichl, 2011). Therefore the focus of this research is on the detached housing model. This research notes that although aspects of time, cost and quality in the detached housing sector are unsatisfactory, improvements to the status quo have proved elusive (M. Luther, 2012.).

2.3.2. Ongoing problems for a viable Australian construction industry

The literature identifies a number of factors constraining the construction industry from being more viable than it is at present.

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2.3.2.1. ***Shortages of skills***

Lovering (2014) in his report for the Australian Housing and Urban Research Institute (AHURI) describes build durations over the period 1993 to 2010 to be 40% longer than in preceding years. He argues that this factor contributes to housing undersupply. Lovering (2014) also argues that while issues such as increased house size and more choices for customisation have contributed to longer build durations, there was also an increasing lack of skilled workers. According to Thorpe (2013) the introduction of new technologies which require the reskilling of existing staff and other industries such as mining industries thus attracting construction workers, also contributed to skills shortages. Apart from the dangerous working conditions, Lovering (2014) describes conditions for apprentices as lacking adequate supervision, problems with poor training, abuse in the workplace, and poor wages. For apprentices, poor training regimes are currently being exacerbated by changes in the training of apprentices due to certain actions by state governments outlined below (Noonan, 2016). Noonan (2016) reports a 50% decline in completion of apprenticeships for construction trades in Australia. This has been attributed to the introduction of professionally questionable trade training centres failing to offer satisfactory education and training (Moodie, 2015). There is a lack of interest by new recruits in undertaking trades training, attributed in part to increasing and expensive levels of fees charged by teaching establishments. Lovering (2014) argues that poor site working conditions compromises the retention of skilled workers. According to the Department of Employment (Department of Employment, 2016) all construction trades at a national level (except for carpenters) are in short supply in the Australian industry. The Federal Government (2019) reports for all trades In 2018, show the proportion of vacancies filled fell to a historically low level. This situation is in contrast to 2012 when only one trade experienced skilled shortages. Clearly a lack of skilled workers has serious implications for the housing construction industry, a situation which can only be solved by implementing effective training programs in greater numbers than currently exist (Noonan, 2016). However it is obvious the on-site construction activity of

enduring poor work conditions cannot be improved without changing the systems currently in use. Skills shortages in the housing construction industry result in longer build durations and therefore declining productivity, described in the next section.

2.3.2.2. ***Poor productivity in the industry***

Increasing completion times for housing is further evidence of reduced productivity. T Dalton et al. (2015) agreed with Lovering (2014) in their report for the Australian Housing and Urban Research Institute (AHURI) which noted the quantum of increased completion times for houses from 6 to 10 months over a period of 7 years to 2010. Some reasons for this time blowout for completion are suggested by T Dalton et al. (2015) to be the rectification of faults and poor project management. These factors could be explained as a natural outcome of the industry, described by De Valence (2010) as made up of small businesses representing 94% of the industry and employing less than 5 workers. While this enables flexibility to deal with an extremely variable demand regime, it also potentially precludes efficient management of projects due to a fragmentation of the process. Fragmentation and the silos of process are at the core of poor productivity as per both the Latham and Egan reports described in section 2.3.1. In order to address unsatisfactory issues of project management, Gharaie, Wakefield, and Blismas (2010) suggested work-flow planning (where work items are noted, started, assigned, tracked, and verified to completion) rather than activity-based planning (where activities are matched against cost) could be a basis for improvement. The former approach provides the foundation for production planning systems common in manufacturing, whilst the latter is the basis for most of the conventional planning systems used in housing construction. For the housing construction industry to improve they should adopt the manufacturing system.

Thorpe (2013) describes the importance and scale of better productivity in the construction industry stating that a 1% increase in labour productivity would increase real gross domestic product (GDP) by $1.25bn. Thorpe also argues increased productivity will actually reduce the need for labour thereby further

reducing costs for construction, including housing. Cost of housing has become more critical in Australia in recent times; housing has become less affordable creating an even greater gap in supply. Gharaie et al. (2010) argue there are serious implications for increased completion times and that delays create both severe emotional and financial concerns for clients awaiting completion of their houses.

Elongated construction times impact on the cost of housing through additional interest on loans and an increasing purchase price due to additional site overheads, including in some cases penalties imposed by a contract (Gharaie et al., 2010). In the next section costs of construction and housing are examined.

2.3.2.3. ***Housing costs***

Australia, according to Neal and Rawlinson (2014), has the 6th highest level of cost of construction behind countries such as UK and Hong Kong. Up until the year 2008 the cost of house building in Australia had risen fourfold in 20 years (ABS, 2009). This increase was in part due to the average house size increasing by 32.7%. However as the ABS (2009) states, inflation for the same period doubled, it is therefore clear other influences were at play. Some of those influences were listed for consideration by a special review panel of the Council of Australian Governments (COAG) in 2012. These included market structure, regulations and compliance, taxation and other authority charges, labour costs, skills and workplace relations (COAG, 2014). The confusing regional and local building regulations and compliance factors identified by COAG were also identified by the Australian Senate Economic References Committee (ASERC). They found that local government variations to the standard National Building Code increased construction costs by $300 million a year (Australian Federal Senate, 2015). Further ASERC found there was poor compliance by the industry with the National Construction Code (NCC). The outcomes are increased costs due to rectification and reworking of non-compliant workmanship or installations. It is important to note the NCC is administered by the Australian Building Codes Board (ABCB) and requires compliance of building design and implementation deemed to satisfy provisions. Compliance can also be achieved by performance

based approvals (ABCB, 2018). Performance based approvals are usually undertaken to reduce costs and time. However this action usually results in delays for approvals and expenses for both testing and consultants fees. These costs and delays act to deter innovation, deemed essential if industry efficiencies are to be realised (Manley & Miller, 2014).

While recognising land content as a significant expense for housing procurement, the expense applies to both conventional and OSM housing, this research will not address that factor. It would therefore serve little purpose to investigate further in this study. The size of the housing site nor accessibility have not been factored in for either conventional or OSM systems. Further, whilst boom and recession plays an important part for building costs and productivity, this factor is regarded as affecting all housing systems equally.

A measure of housing affordability is the ratio of the median cost of housing compared to median household income. In Australia it is important to note that continued growth in median housing costs exceeds the growth rate of median household income (M Thomas & Hall, 2016). The ratio of house price to income has risen from 3:1 (regarded as affordable) in 1995 to 6:1 (regarded as not affordable) in 2012 (R. Fox & Finlay, 2012). The ratio has continued to deteriorate such that in 2017 it was in the order of 10:1 in two major Australian cities (ABS, 2017). Recently from 2017 into 2019 the cost of housing in Australia has fluctuated creating more uncertainty (Holden, 2019). This situation has made it difficult for an increasing number of Australians to afford housing that is safe, secure and appropriate to their needs. As well as the general increase in housing cost, and compounding the trend, the stock of affordable housing has failed to keep pace with demand in recent decades (Payne, 2008). Phillips (2011) supports this view arguing that the greater the gap in housing supply the more the pressure on the availability of housing, therefore the more expensive housing will become.

However the industry is reluctant to change and innovate and address issues of rising costs (BEIIC, 2012).

One of the important areas to examine in order to achieve a reduction in the costs of housing is the ubiquitous aspect of waste, of both materials and labour. These aspects are considered in the next section.

2.3.2.4. ***Waste in construction***

There is considerable concern about the levels of waste in the world's economies, including Australia (Beeton et al., 2006). Focusing on the Australian construction industry, Newton (2001) states in the 2001 Human Settlement Report that prior to 2001 the Australian construction and demolition industry accounted for 30-40% of all solid waste disposed of into land fill. Similarly V. Tam and Hao (2014) argue that construction alone generates 20% to 30% of all wastes sent to land fill. In a report to the Australian Government in 2012, Hyder Consulting (2012) provides more detail of the waste from residential construction sites stating the volume of waste from an average residential block during construction of a house is in the order of between 18 to 23 cubic metres (Hyder Consulting, 2012). V. Tam and Chandler (2016) state the accumulated cost of removal and payment of tipping fees for an average house is approximately $750 a cubic metre representing a cost of $13,500 to $17,250, adding significantly to the total cost of a house. This expense imposes additional and unnecessary costs which are difficult to recoup over relatively long construction periods for housing and the difficult co-ordination of the sequential nature of house building. Due to site constraints for the average suburban housing construction, the waste from construction is difficult to separate into streams for recovery (Hyder Consulting, 2012). The Hyder Report also argues that builders have little control over their supply chain and the waste from numerous on-site activities due to the standard sub-contractual systems in use on most projects. Sub-contractors are employed on a supply and install basis devolving responsibilities and risks for the builders exacerbating the accumulation of waste (Hyder Consulting, 2012). De Valence (2010a) supports this criticism arguing that the use of standard head contractor contracts, supported by clients, while designed to reduce risk also precludes innovation and opportunities for the reduction of waste. Keys, Baldwin, and Austin (2000), suggest that innovations such as pre-assembly and

standardisation in the industry will reduce waste. However the industry is not addressing opportunities for innovation. The link between waste and emissions is made by Hammond and Jones (2008) they state that construction waste is typically in the order of 22% of embodied construction energy which translates into 19% of embodied carbon. Koskela (1992) also argues that waste could be significantly reduced through innovation and change. For Koskela (1992), change would be based upon lean principles of *just in time* (JIT) *and total quality management* (TQM), concepts derived from his study of production management in the construction industry. JIT reduces cost through production volumes closely aligning with demand thereby, reducing investment in stock and warehousing. TQM is a management system that focusses on efficient and timely actions potentially reducing construction times and costs and the need for reworking due to improved quality management. Vrijhoef and Koskela (2005) argue that the issue of waste is often regarded as an operational problem and as such the social status of construction continuing as a craft industry is seen as having a higher value than waste reduction. Construction waste and related issues of sustainability in high impact products such as aluminium and steel, remains at unacceptable levels producing undesirable outcomes for the community (Baynes et al., 2018).

It is clear that conventional systems of construction, particularly single detached housing is responsible for unacceptable levels of waste. Waste of both labour and materials results in higher costs than necessary and inefficient uses of resources, as well as reduced productivity (R Smith, Kersey, & Griffiths, 2009). While change is needed to address waste, the on-site construction industry is reluctant to innovate (Blayse et al., 2004; Kieran & Timberlake, 2004; Manley & Miller, 2014).

According to Barrett and Wiedmann (2007), without making major changes the on-site construction industry will be incapable of addressing unacceptable levels of waste.

Therefore the housing industry (an on-site construction industry) must improve its performance to become viable, particularly for the aspects of time, cost and

quality; however there is evidence the industry resists change regardless of various options available to improve efficiencies and productivity. This is explored in the next section.

2.3.2.5. ***Reluctance of the construction industry to change***

The construction industry is criticised internationally for its reluctance to innovate and seek efficiencies (J. Barlow, 1999; Gann, 2000; Manley et al., 2009). Woudhuysen and Ableу (2004) argue the industry not only displays characteristics of poor performance, but that industry performance continues to decline, thus further exacerbating undesirable outcomes in regard to cost, quality and time. Hampson and Brandon (2004) argue the Australian construction industry appears to have a “natural conservatism” and a lack of open flexible systems. Perhaps a key to going forward is to address the three peculiarities Vrijhoef and Koskela (2005) identified as leading to better production in construction on site. Those peculiarities are firstly, site production which in most projects requires the majority of work to be performed on an exposed work-site. Secondly, the use of temporary production organisations consisting mostly of unrelated contractors individually adding their contribution to a project resulting in fragmentation of the process (Egan, 1998; Latham, 1994). The third peculiarity is bespoke projects and designs which, due to their individual nature, produce uncertain results with the attendant problems of designing out failure. Vrijhoef and Koskela (2005) claim the three peculiarities support each other interactively making individual changes to any of the three difficult.

The Built Environment Industry Innovation Council (BEIIC, 2012), describes the construction industry as demonstrating “Ostrich like” behaviour which will hasten the further decline of productivity unless change occurs. BEIIC (2012) found characteristics in the industry such as silos of innovation and a lack of co-operation, exposure to economic exigency and fluctuations, ad hoc training and skills development to meet future demands, all of which act against innovation. It is argued resistance to change is predominantly the influence of the client on the process of production of housing. Both Loosemore (2015) and De Valence

(2010a) argue that the client is reluctant to accept innovation due to additional risk. The system of tenders and contracts historically and contemporaneously used by the construction industry hinders change and innovation (Blayse et al., 2004; Kenley, 2012). Further, Ivory (2005) describes an industry focused on the client rather than the process, compounding resistance to changing the conventional systems of production.

Gann (2000) argues that innovation is evolutionary; more often shaped by institutions and society, thereby suggesting these could provide a key to addressing the established conventions of the construction industry and change. Gann (2000) also suggests that change usually occurs when there are significant events, for example wars or economic crises. The current dilemma facing the Australian community of severe housing shortages could be a catalyst for change.

Therefore, whilst serious issues for the construction industry persist, in particular housing production, finding another method to produce housing is an imperative. Use of OSM systems is one such approach. However there appears to be community resistance, both industry and consumers, to adoption of that system.

2.4. Off-site manufacture (OSM) of housing

There are many who argue the route to improvement in the Australian housing industry, particularly for time, cost and quality, is to adopt an OSM system (BEIIC, 2012; Hampson & Brandon, 2004; Khalfan & Maqsood, 2014; Steinhardt & Manley, 2016b). Importantly Gibb (1999) argues off-site manufacture should develop its own genre for manufacture of buildings and avoid copying conventional on-site built forms.

2.4.1. Definitions of OSM of housing

Gibb (1999) defines off-site fabrication;

“Off-site fabrication is a process which incorporates prefabrication and preassembly. The process involves the design and manufacture of units or modules usually remote from the work site, and their installation to form the

permanent works *at the work site. In its fullest sense, off-site fabrication requires a project strategy that will change the orientation of the project process from construction to* ***manufacture and installation****."* (Gibb, 1999, page 1.1.1)

A further definition by Gibb in consultation with Goodier is;
"….off-site is defined as the ***manufacture*** *and preassembly of components, elements or modules* ***before installation*** *into their final location."* (Goodier and Gibb, 2007 p586).

Other terms frequently used by the construction and prefabricated industry include;
OSF (off-site fabrication) and OSP (off-site production). These terms include both volumetric and non-volumetric systems. Another descriptor is modular which comprises volumetric forms of whole units or service pods as part of a complete building. Gibb (2001) developed a concept of S (standardized) & P (preassembly), where components are standardized for an accurate fit and interchangeability, and components are used to create sub-assemblies.
For this study, OSM of housing is defined as;
OSM has various formulations including volumetric (whole parts of a house) and non-volumetric (components for assembly) to name two. Other characteristics are;

- being for permanent housing not mobile but can be disassembled,
- on-site activities for assembly to resident occupation do not exceed 12 weeks,
- all services are installed in the process of manufacture i.e. male and female parts enabling dry connections in the factory and on site.
- wet trades are eliminated on-site,
- all components are manufactured (There is a general perception that foundations and wet trades are difficult to manufacture however fig 2.11 demonstrates an alternative foundation system currently available in Australia which is manufactured).

2.4.2. History of OSM housing (prefabrication)

This section reviews the major influences on the development of OSM housing in the Australian context. The influences have evolved over a period from the 1700s through to the present day. Whilst most countries have developed forms of OSM houses, certain countries have been more active than others and their actions have informed less active countries. For this study countries minimally active in developing OSM housing include Australia, United Kingdom and the United States of America. Germany and Japan are moderately active. Waern (2008) also describes the evolution of OSM in Sweden as developing from the abundance of timber suitable for housing construction and often used in the industry in preference to other materials. The same issues were observed by the researcher in Germany. However, many suppliers of OSM in Germany do fit the criteria for this study.

Bergdoll (2008) the curator of MoMA's "Home Delivery Fabricating the Modern Dwelling", argues "prefab" can be traced back to antiquity and was used to build ancient temples and timber structures. Conversely Bergdoll also states "prefab" is a modernist discourse of architecture and industry. For the purposes of this study the focus for the history of OSM is to describe examples of housing per se rather than for example, OSM hospitals and warehouses.

The time frame below sets out the evolution and history of prefabrication of housing developed by R. Smith (2011).

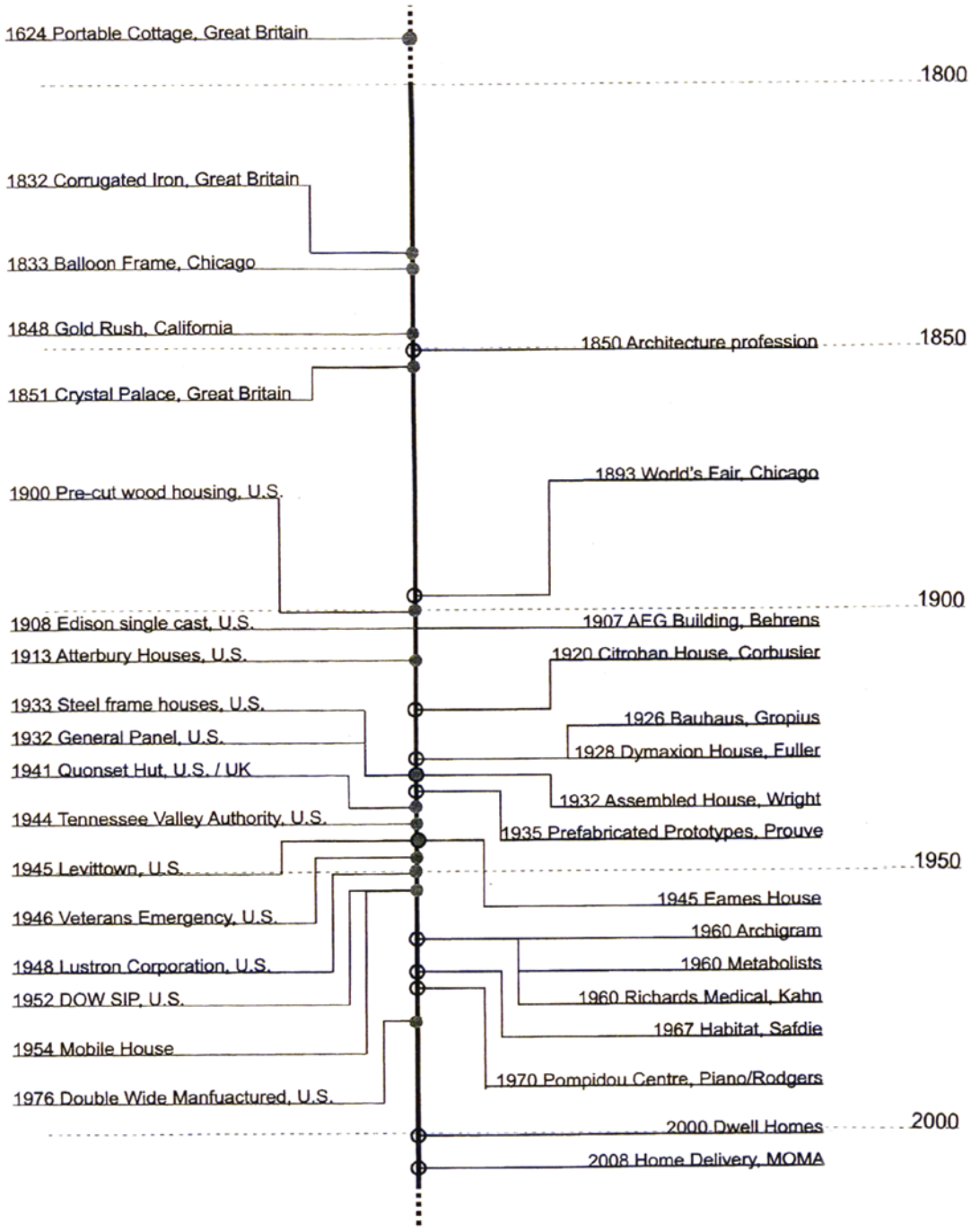

Figure 2.1. adapted from Prefab Architecture (R. Smith, 2011) Prefab Architecture p22.

This timeline places significant OSM events against historical ones including significant architectural interventions by architects such as Corbusier and Gropius. Beyond this time frame OSM of housing has evolved demonstrating innovative systems and techniques. Many OSM production companies have

used volumetric systems to produce housing. These vary in scale from major apartment buildings to single detached houses. Major projects for apartments usually involve concrete or steel frames and large manufactured complete rooms (or apartments) craned into the frames. Examples of major projects include Brooklyn NY (2013) comprising 32 stories with 166 apartments, Murray Grove in London (1998) 5 stories and 30 apartments and Melbourne (2014) 7 stories and 57 apartments. The faster uptake of OSM by commercialized construction organisations is argued by Boyd, Khalfan, and Maqsood (2012). Further developments include the use of cross laminated timber (CLT) for housing and apartments. CLT enables precutting large sheets of timber for wall panels and floors for site assembly. Further discussion of current international developments of OSM houses is covered in this review in Section 2.4.2.6.

2.4.2.1. ***First examples of OSM***

R. Smith (2011) states the first examples of prefabricated houses emanated from Great Britain for their colonial settlements as early as 1624. The houses comprised precut timber for walls, floors and roof and were delivered to America, South Africa and Australia. The use of these systems overcame concerns for suitable locally available materials and also saved time on site and reduced the need for skilled labour, examples of addressing time, cost and quality for housing.

In the 1830s the “Manning Cottage” was imported initially to house Manning’s son as an immigrant to Australia. Later it became known as “the Manning Portable Colonial Cottage for Immigrants” (R. Smith, 2011). Herbert (1978) described the Manning product as foreshadowing the essential concepts of prefabrication, using principles of standardization and dimensional co-ordination. The design was timber framed with all components fabricated in a carpenter’s shop, predrilled and joints premade. Designs for windows, doors and wall panels were based on a module of 3 feet and in such manner that assembly could be completed without error. The whole unit could be assembled within a matter of hours (R. Smith, 2011).

Herbert (1978) describes the importation to Australia of corrugated iron houses manufactured by Hemming in Great Britain in the early 1850s. Herbert cites a report stating 30,329 packages of iron houses were imported to Victoria in 1854.

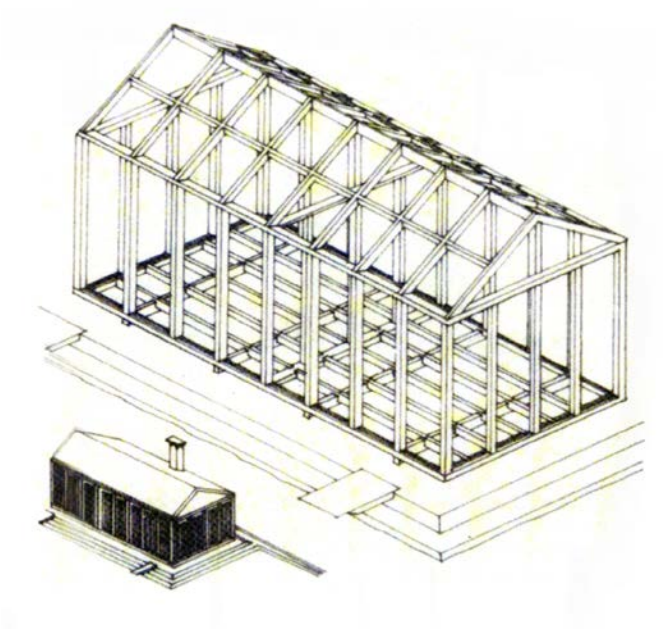

Figure 2.2 .Drawing of a Manning portable cottage from an advertisement in the South Australian record 1837 (Davies, 2005).

According to Davies (2005) after 1860 colonies developed their own construction industries which could provide on-site bespoke housing and as a result, the demand for imported portable cottages ceased. Importantly as B. Kelly (1951) argues, local industries in the late 1800s developed supply chains of materials and components for building construction. High shipping costs of prefabricated houses was another factor which resulted in the portable houses becoming more expensive than on-site constructed systems.

2.4.2.2. ***Mass production***

Bergdoll (2008) describes the development of the timber balloon frame around the end of the 1800s as facilitating the move of the housing industry to prefabrication and standardized mass production. The timber stud systems enabled a move away from the heavy conventional masonry systems inherited

from England (Bergdoll, 2008). The term “balloon frame” according to Bergdoll was coined by carpenters who suggested the frame was so light it would blow away. The system has been popular in countries with abundant timber resources including Scandinavia, Canada and Australia. The balloon frame enabled the wave of “catalogue” houses in the US by Sears and Aladdin during the 1900s.

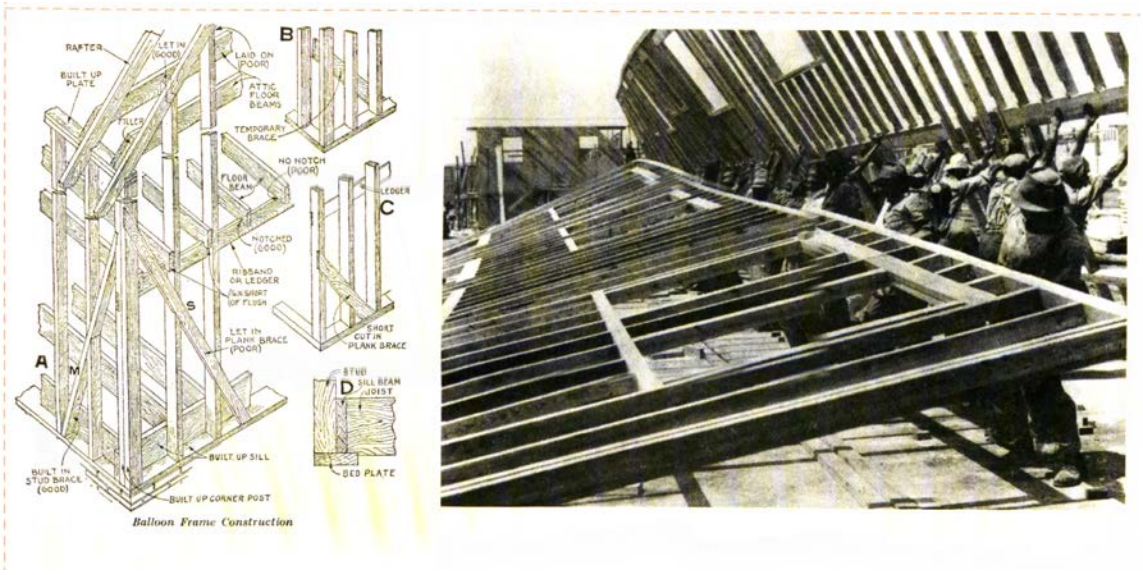

Figure 2.3. Balloon frame scanned from “Home Delivery”(Bergdoll, 2008)

Significantly the “balloon frame” heralded the first prefabricated systems for the housing industry including Australia. The method remains the most utilized form of house construction in Australia (Ximenes, Kapambwe, & Keenan, 2008).

In the United States various companies developed designs for catalogues using pattern books. Two of those companies were Aladdin and Sears Roebuck. Aladdin first utilized the balloon frame to create the kit home system, delivering to site complete houses comprised of timber frames for floors, walls and roof trusses for site assembly. Expansion of the US to the west and development of the railways not only established a market but facilitated transport of the kits. The system developed by Aladdin according to R. Smith (2011) removed waste associated with site built houses and improved the efficiency of assembly. Sears with their established mail order business were able to quickly market a housing

offer of varied designs, which spanned from 1900 to the depression in the 1930s selling over 100,000 houses. Significantly the designs used components to emulate conventional style. Importantly Sears claimed that labour required for their kit house was 40% less than conventional systems (Davies, 2005). It is significant that the systems described in this chapter have the goals of reduction in waste and labour to achieve the optimum results for time, cost and quality.

*2.4.2.3. **Modern OSM of housing, post-world war 2***

Following World War 2 (WW2), there was an upsurge of examples of OSM housing in the UK, US and Australia.

A major initiative by the UK Government was “The Temporary Housing Programme”, a policy seeking to mass produce housing to both replace housing lost in World War 2 due to bombing and to fulfill an undertaking to returning service personnel for access to independent housing. A shortage of both skills and materials restricted the use of conventional systems. Gay (1987) describes the execution of the policy as one condemned to failure by the Government whose mindset regarded factory produced housing as inferior to site built housing. The government decreed the OSM housing should be modest and temporary and have a life expectancy of 10 to 15 years. Further, as Vale (1995) found, the task of producing the houses was awarded to more than 20 manufacturers each of whom developed an individual solution, thereby reducing their options to achieve economies of scale and profit from those economies. The result was that the final cost of the OSM houses exceeded that of a conventionally constructed house. The houses were funded by the government and leased to the occupiers. It is noteworthy that there are several of the temporary UK houses still in use today despite the short lifespan dictated by the government. Interestingly the occupants in many cases preferred those factory-produced houses over the conventional systems available at that time. The temporary houses had indoor toilets, they were new and were enhanced with gardens (Vale, 1995).

In the United States around the same time as The Temporary Housing Program in the UK, the Government encouraged the production of houses in factories to

house returning service personnel and to fill the gap created by constrained housing production during WW2, a gap which could not be satisfied by conventional systems for the same reasons as the UK (Davies, 2005). Manufacturers such as Lustron and the General Panel Company produced housing which enjoyed a level of acceptance by consumers, evidenced by the fact that the factory houses were purchased and owned (Fetters, 2001). This ownership was in contrast to the UK model where the houses were leased from housing corporations. Both Lustron and the General Panel Company failed financially due to overcapitalization and their inability to produce houses at less cost than conventional builds (Davies, 2005). B. Kelly (1951) in his research for the Albert Farwell Bemis Foundation argued that innovation in housing was not common and therefore new markets were rarely established. Kelly contrasts this with the motor car industry at that time creating new markets through continuous innovation, a characteristic which continues in that industry today.

In Australia issues similar to the UK and US evolved. Housing shortages were caused by a construction lull during WW2 and a shortage of both skills and materials at that time. Following the end of WW2 Greig (1995), described the Government's action to address severe shortages of housing by endorsing and encouraging the concept of prefabrication of housing. The results closely followed the failures in the UK and US with the resultant prefabricated housing being more expensive than conventional systems, and at the same time experiencing poor market acceptance. Greig (1995) suggested the poor acceptance of the prefabricated housing was more pronounced by the government than consumers. These failures contributed to the consumers' negative perceptions of OSM housing we observe today. There are numerous references to the negative perceptions of the consumer for prefabricated housing generated during the post war period (Arif & Egbu, 2010; J. Barlow, 1999; Gibb & Isack, 2003; Nadim & Goulding, 2011). These perceptions continue today to obstruct and influence acceptance of OSM housing. These negative perceptions have been perpetuated by recent examples of prefabrication such as housing for miners and demountable classrooms, both of poor design and insubstantial

construction (M Luther, Moreschini, & Pallot, 2007.; Steinhardt, Manley, & Miller, 2014).

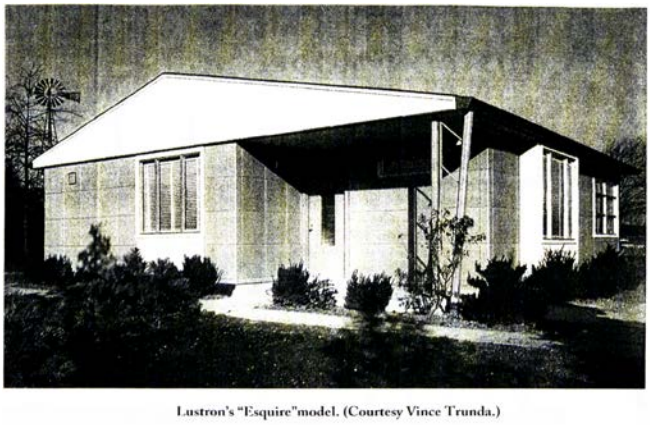

Figure 2.4. Lustron prefabricated house. Source Fetters (2001) The Lustron House.

The house comprised steel framing with metal sheeted wall panels. Lustron sold 2500 houses (Davies, 2005)

Figure 2.5 .Typical prefabricated housing developed in the UK post WW2. Photos obtained from www.atlasobscura.com.

*2.4.2.4. **Further historical examples of prefabricated housing systems***

There has been continued interest in the production of housing using prefabrication, evident in various actions by developers and architects.
In 1914 Corbusier patented the dom-ino building system of concrete structures using principles of open planning (P. Bell, 2009).

P. Bell (2009) also described Frank Lloyd Wright's design in 1917 for a system which offered a ready-cut series of houses which demonstrated mass customization. However both Corbusier's and Wright's systems failed to proceed due to the consumer's lack of interest. Later in 1937 Wright designed his "Usonian" series which utilised modular planning of off-site fabricated wall panels. The system enjoyed the modest success of a further 50 houses.
Bergdoll (2008) described the "Dymaxion House" designed by Buckminster Fuller around 1927 as a most influential example of system housing production to the industry and architecture. The failure of the system was attributed to its inflexibility in its adaption to households requiring varying needs, as well as its spaceship form and aluminium cladding. Later Fuller developed the "Wichita" house again using a circular plan with a dome roof and metal cladding. The house did not proceed beyond the prototype.
Charles and Ray Eames designed their own house based on a strict grid, incorporating wall panels of glass and asbestos fixed to a steel frame of columns and trusses. According to Bergdoll (2008) the Eames house inspired many concepts for modular prefabricated houses..

2.4.2.5. ***Current status and technologies***

Gibb (1999) described typologies of off-site fabrication (OSM) as non-volumetric, i.e. not enclosing usable space and volumetric, i.e. enclosing usable space. Non-volumetric systems typically utilize components such as wall panels, floor and roof cassettes (somewhat similar to balloon framing principles).

Figure 2.6. Wall panels scanned from Habitech Systems web site. For Habitech the panels are manufactured with a polystyrene core with sheet metal skins. Photo from Habitech website.

These components are manufactured using concrete or steel and timber as a structural element and can be clad and finished off-site or on-site. The components are transported to site and assembled into the final built form. This genre is also described as design for manufacture and assembly. Services are installed in the factory or on-site, depending on the system.

Volumetric systems are typically whole houses manufactured in a factory delivered to site in transportable sections and re-joined on site. Volumetric also includes pod-like facilities such as bathrooms and kitchens completely serviced and finished off-site in the factory and delivered to the building site. Volumetric also includes the typology of “modular” comprising whole sections of a house finished in the factory and delivered to site and joined to form a completed house (P. Bell, 2009; Kieran & Timberlake, 2004). The modular portions are often the same size to enjoy repetitious tasks and are often a standard shipping container

size to facilitate compliance with road transport to the site (P Bell & Southcombe, 2012).

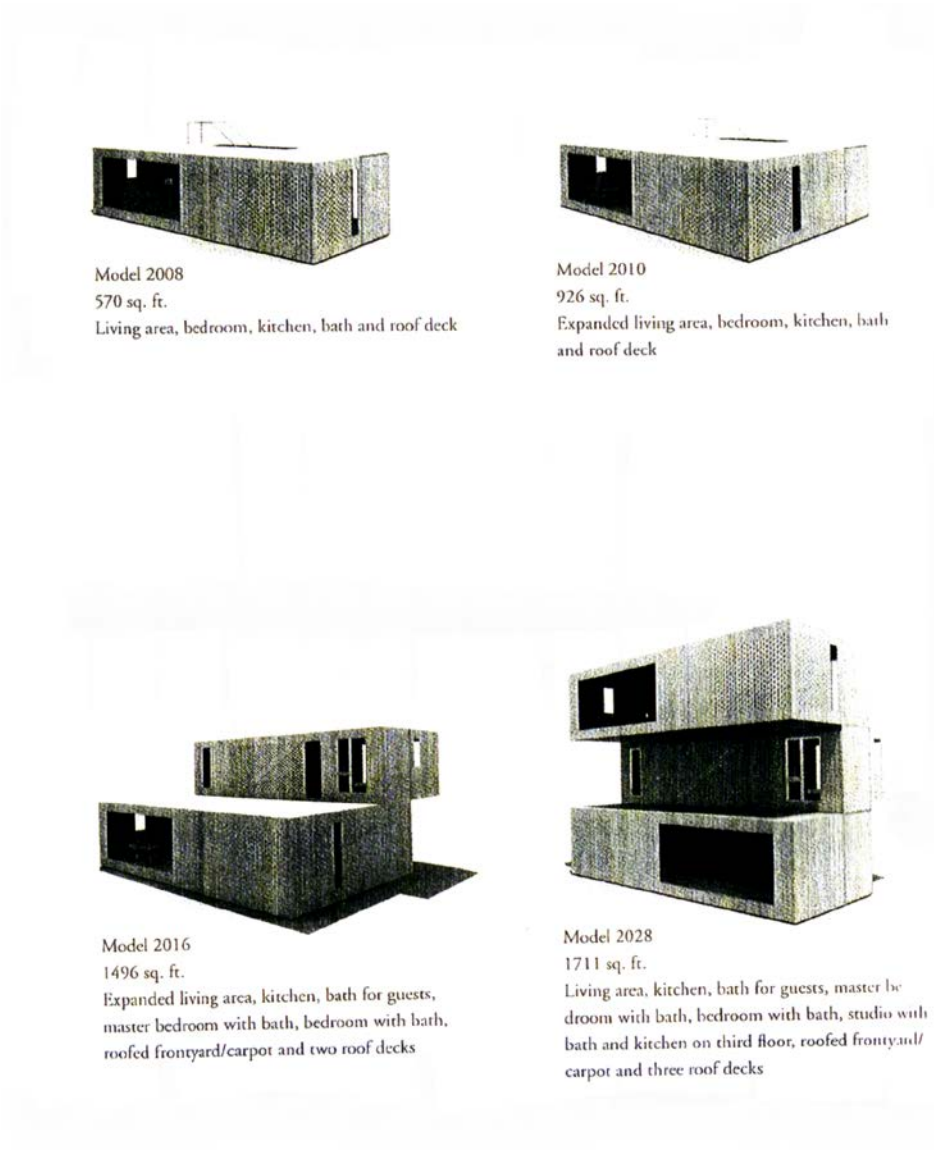

Figure 2.7. Modular components designed by Oskar Leo Kaufmann indicating flexibility of layouts and configuration. . R. Smith (2011) Prefab Architecture.

Figure 2.7 illustrates container sized modules as a single unit or combined with other units adjacent or stacked to obtain variable and flexible solutions for housing. This technology enables consumers to stage their housing needs. For example, stage one a single bedroom with bath room, kitchen and living room,

stage two one or two additional bedrooms or an additional living space (R. Smith, 2011).

The literature defines a further typology; Gorgolewski (2008) and Davis Langdon (2004) describe the hybrid system as having the potential to deliver the best results for OSM. The hybrid concept combines non-volumetric with volumetric systems using components of wall panels and floor and roof cassettes together with bathroom and kitchen pods.

Figure 2.8. Bathroom pods assembly line. Photo obtained from Interpod website. Interpod is located on the Central Coast NSW Australia.

The use of components simplifies transport to the site and enables flexible planning. The inclusion of pods allows sections of a house with the services and finishes intensive portions to be delivered completely finished and locked up for security and exclusion from damage on-site see Figure 2.8 and 2.9 (Kieran & Timberlake, 2008).

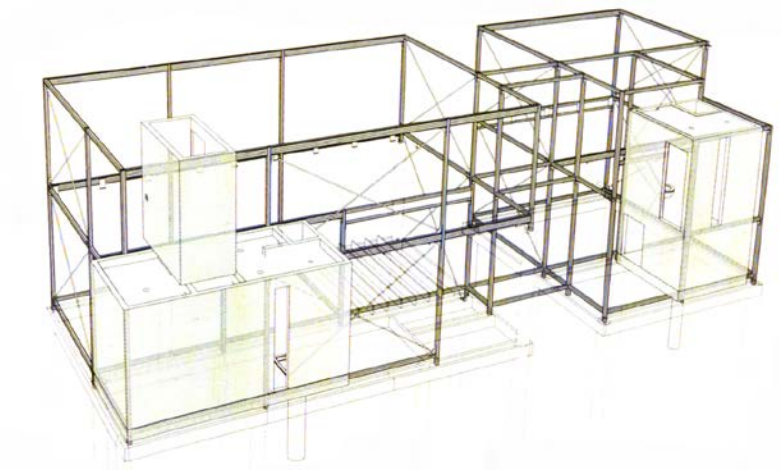

Figure 2.9. Scan from Kieran and Timberlake (2008) Loblolly House. This diagram demonstrates framing components combined with volumetric pods of kitchens and bathrooms.

Fawcett, Allison, and Corner (2005) describe another concept “modern methods of construction” e.g. wiring looms and floor and roof cassettes as also creating efficiencies for conventional systems. However there is little evidence of uptake by the industry, particularly housing. There are significant volumes of literature endorsing OSM as a method for satisfying aspects of viable housing production (Arashpour, Wakefield, Blismas, & Minas, 2015; J. Barlow, 1999; Gann, 1996; Pan & Goodier, 2011; Steinhardt & Manley, 2016b).

2.4.2.6. ***Example of an OSM hybrid house manufacture and assembly***

As previously argued, there is support for pursuing the hybrid method. This method enables customization, high quality factory finishes, controlled cost and reduced time for procurement. It is therefore relevant to this thesis to describe such a system. The process for a hybrid OSM house described here does not cover the design and documentation phases or approvals from authorities and finance providers however these processes are no different from those required for conventional systems. This description is based upon a hybrid system developed by domus AU and has been successfully used in a number of housing

projects. domus AU has an Australian patent number 2018100859 and the description of that system accords with that patent.

Manufacture of components

The system relies on walls panels, floor and roof cassettes and glazing panels. The manufacturers utilize existing businesses whose current operation produces premade steel wall and roof frames for the conventional housing industry using CAD/CAM systems. This precludes the need to establish new factories and machinery. The concept does not preclude setting up a complete in-house operation.

The wall panels are 1200mm x 2700mm x 100mm thick using 90mm steel stud frames. The frame is assembled to accept door frames and doors or window frames and glazing. All panels are the same size. The frame is then fitted with required insulation and vapour permeable membrane. External and internal wall linings have a sheet size of 1200x2700 ensuring little or no waste. The wall linings internally and externally are 10mm thick sheets of magnesium oxide, (MgO) a material which is dense, damage resistant and waterproof. Other materials can be selected. The wall panels are painted in the factory. Electric cables are installed in the factory. The addition of elements to the frames constitute added value to the CAD/CAM company (see Figure 2.13).

The floor and roof cassettes are all 1800mm x 3600mm manufactured by the CAD/CAM operators comprising steel joists or open web trusses 200mm deep. The floor cassettes are installed with insulation, vapour barrier and 20mm MgO board. The roof cassettes are fitted with insulation vapour permeable membrane, ceiling lining comprising 10mm MgO board. Graded battens are fixed to the top of the cassette and steel roof sheeting is fixed to the battens.

The system relies on 90mm x 90mm steel square posts placed directly over the footing anchors to serve as columns for a two level typology and providing nodes for identical panel end conditions.

The bath-rooms and kitchens are manufactured as pods on the standard floor cassettes by companies who specialize in those components. The pods are completely finished in the factory and all services and fittings installed. All services are of the male/female plug connectors so that all connections can be made by non-trades people. The service installation is finally checked on completion by qualified trades and connections to the mains completed. The components including the pods are delivered by truck to site for assembly. A small mobile trailer crane handles the pods and palettes of wall panels and cassettes. Assemblers comprise a licensed builder and four unskilled workers.

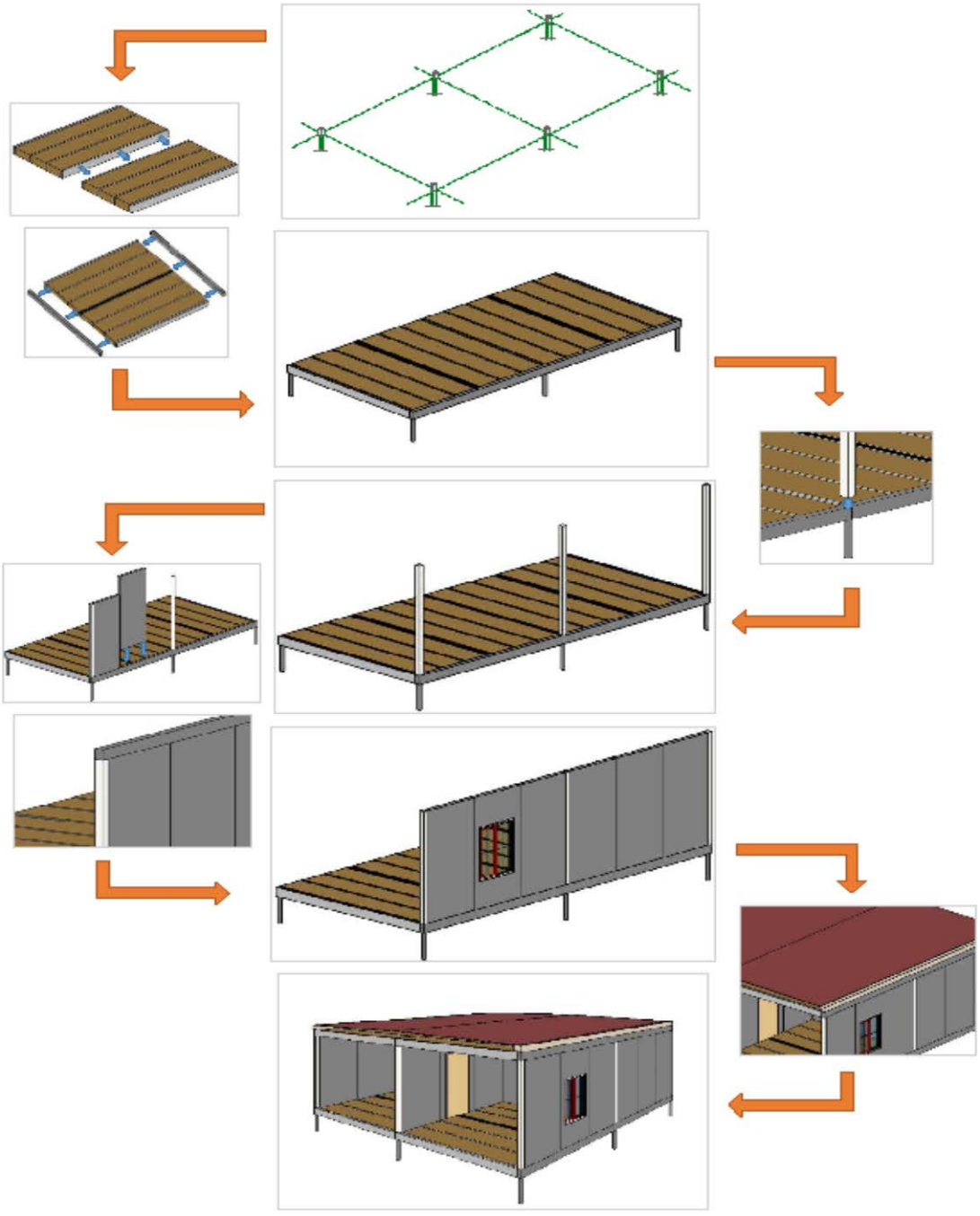

Figure 2.10. Diagram of assembly of a domus AU house. Reproduced with permission from domus AU.

Sequence of assembly and installation

Day 1 on site: the site is prepared by clearing loose materials and vegetation from the building footprint. Footings such as Mega Anchor or Sure-foot are then mechanically installed to suit the building module at 3.7M grid. See Figure 2.11. Average sized houses require one day for footing installation.

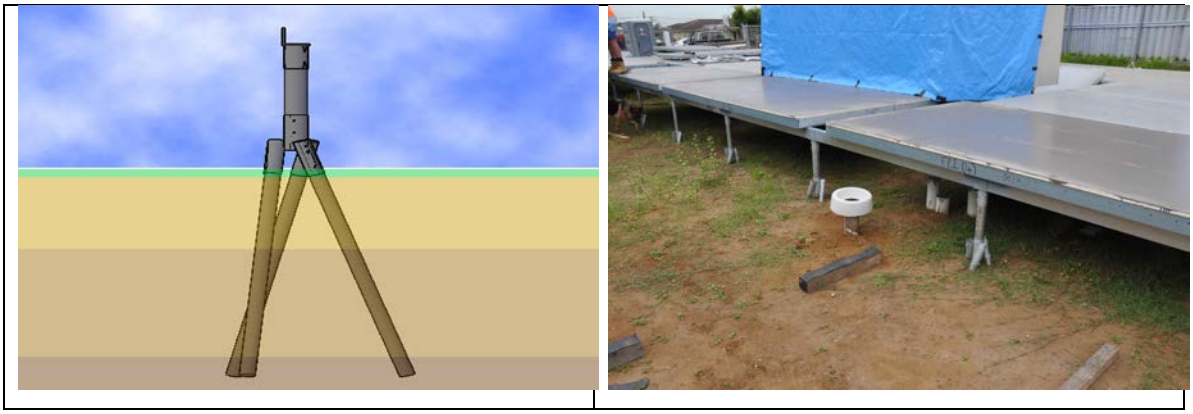

Figure 2.11 Mega Anchor showing adjustable frame support and the three steel guides for driving steel rods (anchors) into the site foundation. Photo supplied by domus AU.

Additionally a photo of Mega Anchor and floor cassettes installed. The anchor can be loaded immediately, there are no wet trades and anchors can be used in all soils as well as rock. Image supplied by Mega Anchor.
Plumbers and electricians connect the sewer, mains water and electric mains to service pits set on the perimeter of the building footprint. The electrical installation if possible has its own supply pole and cables underground to the pit.

Day 2: components delivered to site and placed on site for efficient installation.

Day 3: main Beams to support the floor cassettes are fixed to the top of the Mega Anchors. The beams are 200mmx100mm steel rectangular hollow sections and all beams run in the same direction to suit the orientation of the pods. Fixing of the beam to the anchor is mechanical.

Day 4 and 5: a typical three bedroom house requires two days to install the floor cassettes. The cassettes are mechanically fixed to main beams. Electric, water supply, sewerage and storm-water service harnesses are installed under the cassette floors. Figure 2.12 the kitchen pod is installed with the floor cassettes.

Figure 2.12 Kitchen pod mounted on standard floor cassette ready for transport and installation after plastic wrapping. Photo supplied by domus AU.

Day 5 and 6: wall panels and posts (nodes) are located and mechanically fixed on top of the cassettes. Joints between panels are expressed and sealed with Illbruck Compriband tape. This tape is an impregnated joint sealing tape which once installed expands to fill the joint. There is tape on the inside and outside of the wall panels providing an air gap to the joint.

Figure 2.13 Wall panels loaded into a vertical palette for transport to site. The vertical palette prevents damage to panels and glazing. Photo provided by domus AU.

Day 7 and 8: the roof level main beams are installed in the same orientation as the floor beams and mechanically fixed to the top of the columns. The roof cassettes are fixed to the main beams and a roof ridge fixed over and between two roof cassettes. Finally the PVC gutter supplied in one length ordered in modules of 3.7M complete with stop ends is loosely installed. The gutter is locked in place by the single length fascia. Rainwater from the gutter is collected using a siphon system and drained into a bladder placed under the floor cassettes. Services in the pods are connected to the harnesses under the house as well as wiring in the wall panels.

Day 9 and 10: the house is complete for cleaning and checking of services by the plumber and electrician (see Figure 2.10).

2.4.2.7. ***Overview of OSM housing production internationally***

A paper by Steinhardt and Manley (2016a) developed an overview of the use of prefabrication of housing in developed countries such as Australia, USA, UK, Japan, Sweden, Germany and the Netherlands. No other countries were assessed in their paper. The research by Steinhardt and Manley (2016a) adopted the definition by Goodier and Gibb of OSM and focused on volumetric and non-volumetric/panelised systems and verified the data used in the study through the OECD member countries and housing industries referenced evidence.

OSM of housing in the USA comprises around 3-4% of housing production. The percentage for the USA is not exact since many consumers live in “mobile homes” which according to definition are not OSM houses; they are easily relocated but defined as manufactured. Contrast this with Sweden where the production of houses using OSM according to Steinhardt and Manley (2016a) is estimated at 90% of the total supply. However, OSM housing in Sweden mainly comprises production of components emulating conventional construction and replicating on-site systems, although their systems are extremely sophisticated. Japan according to Steinhardt and Manley (2016a) has 12-16% OSM of housing, whilst Germany has 9%. J Barlow et al. (2003) support the level of OSM in Japan at 13%. Venables, Barlow, and Gann (2004) argue Germany has an active OSM housing industry evidenced by the level of production estimated at 13% of the total market. Noguchi (2003) describes manufacturer’s warranties (up to 20 years) as an important factor for consumer acceptance of OSM in Japan. In Australia, N. Blismas (2007) supports the Steinhardt study that market share for OSM is 3% of the total housing supply. This assessment is supported by Aitchison (2014) who more recently confirms 3% of the Australian housing market is satisfied by OSM indicating the market for OSM is still restrained.

2.4.2.8. ***Overview of OSM detached housing in Australia***

There are a number of companies in Australia currently producing OSM housing. It is not possible to accurately record numbers of companies active in actual OSM housing production in Australia. This quandary is shared with UK and USA where estimates only are available. Prefab AUS is the peak body representing OSM companies in Australia and perusal of their website indicates 75 members, of whom 13 produce OSM housing, the remaining members are consultants and suppliers to the industry. Most of those are manufacturing housing, which emulates conventional housing systems simply transferring on-site systems into a factory and then delivering transportable portions to site and joining the parts. Several other companies are producing volumetric modules often the size of standard shipping containers and therefore suitable for ease of transport. A few companies are using panelized wall systems utilizing sandwich panels (sips) and other companies are manufacturing pods of bathrooms and kitchens. The only production line examples of OSM are pods and production of mining camp accommodation.

Typical characteristics of the two typologies are indicated in Table 2.1 below.

Attributes	Volumetric	Non-volumetric
Location and configuration of rooms and accommodation were not included in the comparison		
Time; from order to completion on-site of 12 to 14 weeks (excludes approvals)	x	X
Cost; a fixed cost for a standard system.	x	X
Quality; few if any defects and reduced maintenance	x	X
Passive solar design; Orientation, shading, insulation, airtight, no VOC's, double glazing available.	x	x
Energy efficient; Solar hot water, solar power generation,	x	X
Waste; zero waste	x	X
Water efficiency; rain water harvesting and grey water systems, AAA plumbing fixtures.	x	X
Services; Installed in the factory	x	

Table 2.1. Comparison of attributes of volumetric and non-volumetric obtained from various manufacturers' web sites used in the interviews.

2.4.3. Aspects of OSM for time, cost and quality

This research into housing supply in Australia examines aspects of time, cost and the quality of conventional construction systems and explores the use of OSM as an alternative. It is relevant to note that the Australian Parliamentary Senate Select Committee on Housing Affordability (ASERC) suggested the use of modular pre-fabricated housing as an appropriate innovation to address the provision of viable housing. The committee stated this innovation could allow delivery in less time and for less cost than a conventional housing supply (Payne, 2008).

Former craft industries such as shipbuilding, motor cars, furniture, appliances and textiles, have transitioned into a manufacturing system (Gibb, 2001). The change has enabled mass manufacture of consumables, which are consistent in quality and availability whilst meeting diverse tastes (Schoenwitz et al., 2014). Examples of building component supplies, which have transitioned to manufacture, include windows, kitchen packs, bathroom fixtures, wall and roof trusses. These innovations have improved cost and productivity in the industry. However, these examples essentially reinforce the continued dependence on conventional systems; they do not satisfy the definition provided by Gibb (1999) of off-site fabrication which by his definition requires manufacture and then installation. For Slaughter (1998) issues for off-site manufacture are the need to produce expensive full scale prototypes to test the system. Then there is delineation of site responsibilities most often accepted by the head contractors combined with on-site managers, now borne by the manufacturer.

*2.4.3.1. **Manufacturing and economies of scale***

Time, cost and quality are seen as major drivers for use of OSM (Boyd et al., 2012; Gibb, 1999). The history of the industrial revolution saw industries (e.g. clothing, ships, cars) which evolved into a manufacturing system demonstrating consistent high quality, less time for production and lower costs, particularly when the process is highly automated. Quality control and management has not only been mandated for many industries including construction, but has been seen to be facilitated by factory environments (N. Blismas, 2007; Gann, 1996). A

constraint for Australia is the relatively small market, a factor which compromises the ability to achieve economies of scale thereby reducing costs of production (Steinhardt et al., 2013a). Systems adopted for OSM need to be designed to maximise the repetition of components and minimise inventories (Gibb & Isack, 2001).

2.4.3.2. ***Balancing environmental performance***

Elnaas et al. (2014) qualitatively researched the use of OSM for UK housing supply to improve time cost and quality. Their research echoed findings of N. Blismas (2007) for Australia. While time, quality and cost were found to be highly important decision factors for use of OSM in housing production in both UK and Australia, environmental factors are also now regarded as extremely important. OSM is favoured for improving the environmental performance of housing and importantly the reduction of environmental impacts during construction (K. Ross, Cartwright, & Novakovic, 2006). The Elnaas et al. (2014) study also asserted the UK construction industry believes OSM can raise production levels to a level of supply which can meet demand, a goal conventional systems according to Soetens, Roozenburg, and Smulders (2005) cannot reach. It is of interest to note a Committee of the Australian Federal Senate examining the Australian Housing Affordability Challenge (Australian Federal Senate, 2015) , recommended an inquiry into introduction of OSM to improve the cost of housing suggesting this action could also result in the stimulation of the Australian manufacturing sector.

2.4.3.3. ***Occupational health and safety***

Occupational health and safety risks for off-site systems are less than on-site systems, in part due to less time spent on-site and therefore less exposure to weather and accidents (Chandler, 2014). Off-site also reduces the need for multiple site visits by various trades (Akmam, Gajendran, Rose, & Brewer, 2018). Fewer trades and people on-site reduce risks. However, a constraint for OSM is the need to handle heavier components or volumes, possibly requiring cranes which can be a source of serious injury (N. Blismas, 2007).

2.4.3.4. ***Skills availability***

One of the strongest drivers for innovation for the construction industry is the shortage of skilled trades for conventional on-site systems (Nadim & Goulding, 2011). The lack of skills however is also an issue for OSM. There are few OSM industries in Australia and few trained operators (Arashpour et al., 2015). The issue of inadequate skills may also affect on-site assembly e.g. low tolerances at interfaces (Arif, Blismas, & Wakefield, 2009). Further, the process integral to successful OSM is the speed of production and certainty of timing. Importantly, the choice of construction systems in many projects is a decision made by the design consultant team, particularly architects (Davies, 2005), few of whom have experience in this genre. Further constraining the uptake of OSM is the design process hindered by a lack of training for both designers and manufacturers (Arif, Goulding, & Rahimian, 2012; N Blismas, McCoy, & Lingard, 2009.).

2.4.3.5. ***Industry reluctance for OSM housing***

Steinhardt and Manley (2016b) argue a major barrier for the greater use of OSM by the housing construction industry is reluctance to adopt innovation and change. They concluded the industry fears increased costs and uncertain business risks. Further, they suggest modern high quality OSM housing products fail to overcome consumer resistance due to historical stigmas of quick and easy accommodation solutions described in Section 2.5.

The industry is regarded as conservative and driven by dogmatic and preconceived attitudes, also described as path dependencies. Djeclic (2007) describes path dependencies as events of earlier experiences affecting events occurring at later times. He argues path transformation will only occur when there are dramatic events, even shocks (such as war or possibly the prospect of climate change). OSM housing is also regarded as inflexible in regard to design options, often characterized as a cookie cutter product, which cannot be easily personalized. This phenomenon is examined further in section 2.4.6.

2.4.3.6. ***Finance for the purchase of housing***

The use of OSM requires different treatment of material flows as well as methods of payment for those materials and components (Vrijhoef & Koskela, 2000). However, if the speed of the assembly of housing is condensed, the terms for payment could be absorbed in a short time frame. Most importantly, Steinhardt and Manley (2016b) observe there is reluctance from finance providers to support an OSM product mainly due to the security of a loan relying on a site only. As Jordan (2015) describes the problem, financiers will only release all the funds once the OSM house is on site, rather than the current situation for conventional construction of releasing funds based on progress of construction. The problem of financing a prefabricated house therefore arguably becomes the responsibility of the housing supplier until the house is fixed on site. This impost has been found in the past to financially cripple OSM providers (Fetters, 2001). This serious barrier to acceptance of OSM housing has been addressed in New Zealand by the PrefabNZ group. Together with the housing industry they have negotiated with New Zealand banks agreements to fund loans on a trial basis for housing produced by OSM. Westpac New Zealand chief executive David McLean said easier mortgage finance should help put New Zealanders into warm, well-designed, affordable houses that would otherwise have been out of reach (McLean, 2018).

2.4.3.7. ***Regulations for housing***

Regulations may impact on OSM particularly where site inspections by authorities are required at set points during site works progression (C; Pasquire & Connolly, 2003). Some relief may be gained by workshop certification by specialist licensed trades such as electricians and plumbers. However it is clear Australian codes are based on conventional systems of construction and if the OSM system falls outside those systems performance assessments may be required to gain approval. Blayse et al. (2004) argue costs for the use of OSM could increase to an unacceptable level due to cost of consultants to design

options and the seeking of authority approvals, a process which is also time consuming.

2.4.4. Producing viable housing: comparison between off-site and on-site systems for time, cost and quality

It is relevant to this research to compare on-site with off-site systems seeking advantages and disadvantages of both and distilling the features which will affect consumers housing choice.

Aspect	**Off-site**	**On-site**
Time		
Duration	Finish dates more certain (N Blismas & Wakefield, 2009)	Finish dates often overrun (T Dalton et al., 2015)
Schedules	Reduced erection times if components are not in stock long lead times may occur resulting in delays.	Time overruns are common (T Dalton et al., 2015; Gharaie et al., 2010)
Co-ordination	Co-ordination essential (Arif et al., 2012; Elnaas et al., 2014)	Co-ordination flexible Changes can be adjusted on site
Authorities	Approvals can be faster due to preliminary negotiations for standard systems. (C Pasquire, Gibb, & Blismas, 2003)	Often new approvals are required for one off customised designs
Weather	Most of the work is carried out in a factory	Delays due to poor weather are common (Arashpour, Wakefield, & Blismas, 2013)
Work flow	Scheduling of tasks can be concurrent and not sequential	On-site is a linear process with trades waiting on other trades to complete stages (Dubois & Gadde, 2002)
Sub-contractors	Sequential processes do not apply	Trade conflict is normal due to sequential trade programing. (De Valence, 2010a)
Supply chain management	Factory management relies on quality controls for materials and labour to obtain maximum efficiency.	On-site management is usually a day to day operation due to factors such as weather and contractor availability leading often to waste (T Dalton et al., 2013)

Aspect	Off-site	On-site
Cost		
Finance	Finance is difficult to organise due to lack of industry standard security resulting in finance difficulty for the manufacturer (Gyrn, 2011)	Mortgages for housing are based on conventional systems of construction making progress payments based upon agreed stages of completion.
Overheads	Potentially large investment in a factory and employment and general overheads (Fetters, 2001)	Overheads form part of the building budget
Transportation	Two deliveries, one to factory the second to site however where long distances are involved costs will increase	Multiple site deliveries of raw materials and labour however these costs are incorporated into the contracted price
Site infrastructure	Minimal scaffolding, formwork and shuttering	Use of scaffolding and formwork/shuttering essential. (R. Smith, 2011)
Construction schedules	Less time on site enables faster return on investment	Schedule overruns are common most often increasing costs (Arashpour et al., 2013)
Variations for time and cost	Extra cost and delay (Davis Langdon, 2004)	Changes usually accommodated without conflict but with delay and cost
Component handling	Use of cranes can be expensive and dangerous	Normally for single housing projects cranes are not required
Initial set up costs	Depending on the adopted system the setup costs can be very high resulting in the cost of OSM higher than on-site (Kenley, 2012)	Low costs for standard projects but for bespoke unforeseen costs
Waste	Waste minimised (Barrett & Wiedmann, 2007)	Waste of both labour and materials is common
Productivity	Productivity is high due to lack of interruption and use of skilled labour in the factory	Productivity improvements difficult to achieve (T Dalton et al., 2013)
Markets	Market fluctuations can be severely damaging to an OSM business (Steinhardt et al., 2013a)	Small scale contractors can adjust more readily to markets (Arashpour et al., 2013)

Aspect	Off-site	On-site
Quality		
Consistent timing	Reliable within a short timeframe	Depends upon site conditions and skill levels available at the time (De Valence, 2010)
Production levels	Output is predictable, prototype is normally required (Gann, 1996)	Unpredictable depends on the availability and skills of the construction team (Koebel, 2008)
Environment controls	Low waste less site disturbance lower energy required (Barrett & Wiedmann, 2007)	Waste and energy difficult to manage during construction processes which can be chaotic
Materials handling	Quality controls exerted in a factory environment	Depends on source and handling and storing on site
Warranties	One supplier potentially simplifies offer of guarantees simple or extended	Multiple providers complicates warrantees
Skills required	Use of machinery and automation requires different skills which could be sourced from a now defunct auto industry	Typical construction industry skills are in short supply and is increasing due to lack of apprentices (Noonan, 2016)

Table 2.3. Adapted from R. Smith (2011) Prefab Architecture pp 95-97.Table comparing attributes for time cost and quality for off-site and conventional on-site housing systems.

Table 2.3 compares off-site with on-site conventional housing for time, cost and quality. Off-site demonstrates superior results for faster and more consistent time for completion. On-site suffers from sequential trades, the effect of weather and poor project management. Off-site can enjoy fixed costs, although, historically the cost has been greater than an equivalent on-site house. Final costs for on-site however are often subject to variations due to uncertain site conditions or poor documentation. Off-site claims superior quality due to controlled factory conditions. However on-site enjoys easier financial arrangements and greater flexibility for change during construction, often resulting in the variations noted.

There are also advantages of familiarity of the process for both consumers and the housing industry.

2.4.5. Time comparison of various systems for production of housing

Clearly there is a significant difference between conventional construction systems and OSM systems for time on-site. The literature argues that extended time on-site has many downsides such as materials damaged and wasted through unhelpful site conditions and therefore implications for time, cost and quality. Davis Langdon (2004) and Gorgolewski (2004) argue hybrid OSM systems have the potential to be not only the most efficient OSM system as demonstrated by figure 2.10 and 2.14, but also offer consumer customisation.

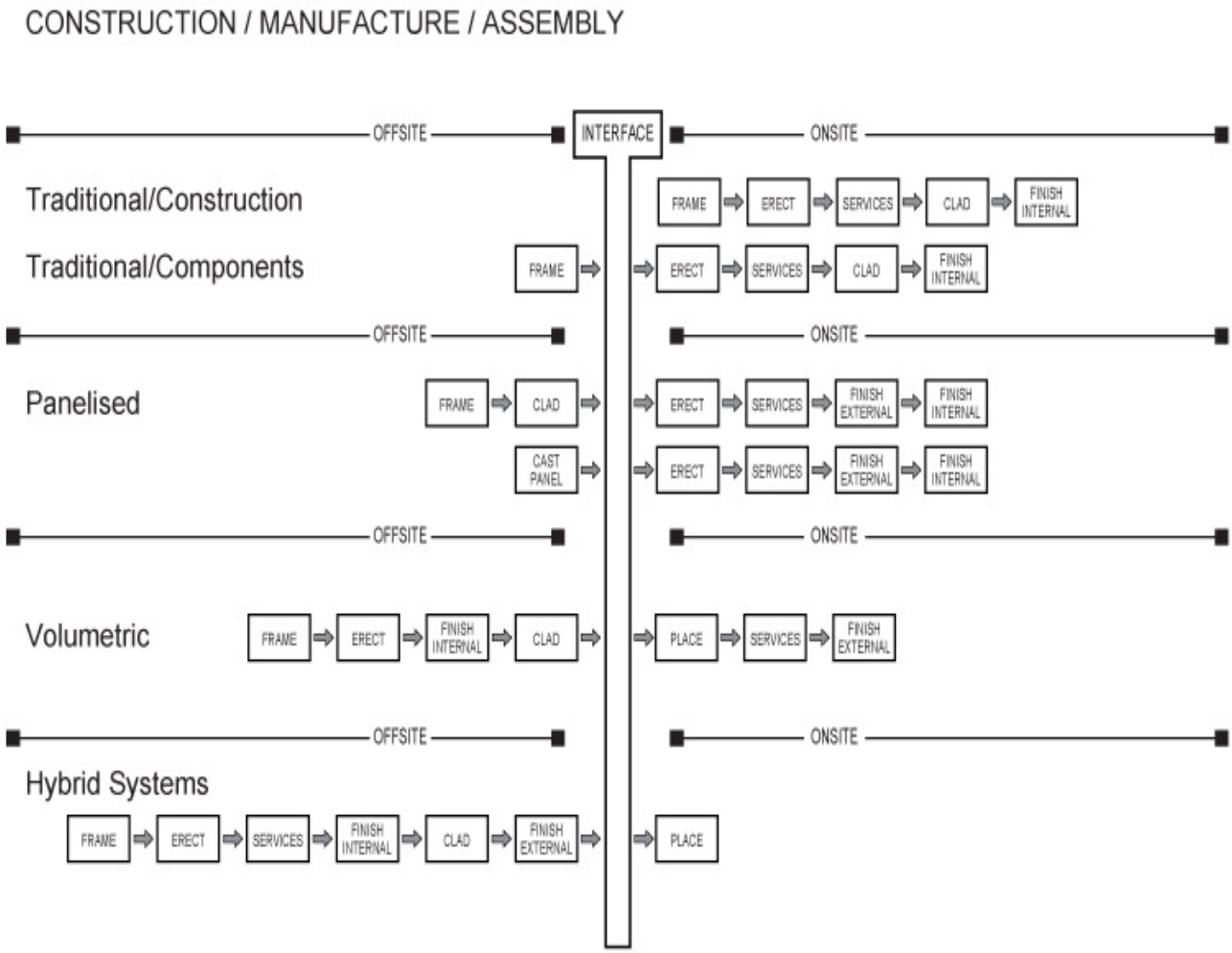

Figure 2.14. Chart comparing off-site to on-site activities developed from N Blismas and Wakefield (2008)CRC for Construction Innovation

2.4.6. Consumers' perception of OSM housing

OSM housing is often described to consumers as prefabricated housing, a term which according to Edge et al. (2002) engenders resistance to choose the OSM product. Madigan (2012) describes prefabrication as burdened with stereotypical images of repetitive buildings. It is therefore useful to examine the factors contributing to the market resistance for OSM housing.

There are numerous references to the negative perceptions held by consumers for prefabricated housing generated during the post war period (Arif & Egbu, 2010; J. Barlow, 1999; Gibb & Isack, 2003; Nadim & Goulding, 2011). These perceptions continue today to obstruct and influence the acceptance of OSM housing. These negative perceptions have been perpetuated by examples of prefabrication such as housing for miners and demountable classrooms, both of poor design and insubstantial construction (M Luther et al., 2007.; Steinhardt et al., 2014).

According to Genz (2001) OSM housing in Australasia is associated with mobile homes, a system regarded as cheap and non-permanent. P. Bell (2009) suggests consumers regard OSM as similar to institutional demountable structures whilst N Blismas et al. (2009.) refer to mining camp accommodation as negatively affecting perceptions of prefabricated housing. Early examples of prefabrication described in this review following WW2 (Gay, 1987) reflect poorly on perceived durability and quality of current day examples of OSM (Goulding & Arif, 2013).

2.4.7. Housing issues of supply and demand

Housing is a basic essential for all communities. S. Smith (1994) describes the qualities of a home (house) as providing privacy, continuity and self-expression which is essential for social relationships. It was Robinson and Adams (2008) who examined the relationships between housing cost, housing stress, mental health and well-being. They concluded that Australia is experiencing serious issues in regard to the shortage of suitable and affordable housing as well as aspects of quality. These impacts include financial stress as well as psychosocial outcomes which result in poor outcomes for family and relationships. Maclennan

et al. (2018) agree adding concern for the needs of communities (excluding concerns for social density) to enjoy suitable and sufficient housing to enable social engagement and to be economically productive. Therefore the effects of unaffordable and short supply of housing have wide ranging and undesirable outcomes (Slaughter, 1998).

2.4.7.1. ***Housing and path dependence***

Robertson, McIntosh, and Smyth (2010) in their analysis of social identity define path dependency as social processes which exhibit positive and negative attitudes and behaviour. The phenomenon includes historical, economic, social and cultural aspects of decision making. B Bengtsson and Ruonavaara (2010) describe path dependency as historical events taking a direction that then precludes alternate paths, which although feasible, are closed or difficult to reach. This describes the reactions to early systems of prefabrication demonstrated by consumers. Path dependence is described by Malpass (2011) as significantly applicable to authorities demonstrated by the actions of governments post WW2, as described earlier. However, it is argued that the longer a policy is in operation the more time there is for the deficiencies around that policy to become obvious and for change to occur (Malpass, 2011). Given the current state of housing supply and the recognition by the community of housing supply issues, there is evidence that the authorities are considering change (BEIIC, 2012), although Mahoney and Thelen (2010) suggest institutional change is a slow process. Mahoney and Thelen (2010) argue that environmental change can also change institutional attitudes, a situation currently confronting society and representing a catalyst for change (Leviston et al., 2014). Van Looy, Debackere, and Bouwen (1997) suggest that a way to neutralise path dependencies is to provide information and to encourage information exchange. Ozorhon (2012) considered the aspects of path dependency for the housing industry and contends reluctance to change can be described as a problem related to investments, that to adopt new systems does not necessarily guarantee a return on investment. Path dependence in relation to housing is exhibited by consumers, institutions and the industry.

2.4.7.2. ***OSM housing and consumer acceptance***

Housing produced by non-conventional systems, although having positive characteristics of time cost and quality are not readily accepted by the market (Edge, Craig, Laing, Abbott, & Hargreaves, 2003). It is interesting to note that while Edge et al. (2002) argue the consumer is reluctant to accept housing innovation, it is Steinhardt and Manley (2016b) who suggest, in the Australian context, that builders make decisions based on the builder's perception of what the market desires. The question this raises is who to target when seeking acceptance of OSM housing in the Australian marketplace.

Steinhardt and Manley (2016b) found that low volumes of non-conventional OSM production of housing (3% to 5% of the Australian market) preclude widespread experience of products. Therefore there is a lack of knowledge by the consumer in regard to those alternative products. Marsh and Gibb (2011) argue that lack of knowledge creates uncertainty and a perception of unnecessary risk particularly when linked with the purchase of a house, regarded by most as a significant long term and large-scale commitment of finances. Marsh and Gibb (2011) identified other factors of health and wealth, lifestyle and social networks for consumers in relation to house purchase. M. Koklic (2011) goes further to point out that there can be a perception of financial risk associated with non-conventional housing, failure of components and also a loss of capital due to economic fluctuations or buyer resistance on resale. The literature clearly indicates that for non-conventional housing systems to be accepted, the houses should not have a "prefabricated" appearance (Davies, 2005; Gay, 1987; Kieran & Timberlake, 2004).

Aesthetic standards held by the consumer favouring conventional systems for housing choice are a powerful constraint in the choice of OSM. It is however argued for OSM solutions to successfully appeal to consumers they must demonstrate a style suitable to and expressive of the factory typology (Goodier & Pan, 2010; K. Ross et al., 2006).

It is argued by Ozorhon (2012) that change and innovation in the housing industry can only be achieved by community involvement, and further by enabling familiarity and exposure to the new product.

2.4.8. Consumer perceptions and attitudes for housing

This literature review identified consumer perceptions and attitudes and important attributes used to assess housing choice. While location of a house and the accommodation contained in the house are important considerations, they are not regarded as perceptions and their influence therefore excluded from this paper. The attributes identified were refined to six perceptions and given a reference key from P1 to P6. These perceptions were regarded as useful when assessing consumer choice for housing. Further discussion of perceptions can be found in section 3.2.9.1 in methodology. The first is a need for quality workmanship and materials for both the physical presence of a house and the house's performance (Boris, Aleksandra, & Damijan, 2004; Laing, Craig, & Edge, 2001). Secondly comprehension, understanding and knowledge of the product such that the consumer has confidence and believes there is a low risk of unwanted surprises (M. Koklic, 2011; Lindley, 2007). Third is a need for sustainable values of the product, particularly that the house will experience longevity and minimal maintenance (Manley & Miller, 2014; Moore, Maller, Home, & Strengers, 2016; Oliver & Smith, 2018). The fourth attribute is the choice and ability to customize and enjoy options (J. Barlow, 1999; Kendall, 2013; Schoenwitz, Naim, & Potter, 2012). The fifth attribute is for the house to have enjoyable aesthetics or be in a style which positively contributes to the consumers' lifestyle for health and well-being (S. Fox, Marsh, & Cockerham, 2002; Warren-Myers & Heywood, 2016). Finally the consumer desires a house which is affordable offering financial security as an investment (ABS, 2009; Dave, Watson, & Prasad, 2017; Marsh & Gibb, 2011). How these perceptions apply to conventional and OSM housing is outlined below.

2.4.8.1. ***P1 Perceptions of quality***

A common requirement for housing selection relates to the quality of the build. Structural integrity for longevity, quality of the finishes and fitments are important (Lovering, 2014; Woudhuysen & Abley, 2004). However, the literature suggests conventional housing currently available to consumers has aspects of poor quality requiring maintenance and occasioning inconvenience for the occupants (P Love & Edwards, 2004; Soetens et al., 2005). OSM housing suffers from poor perceptions in regard to quality. The OSM product is associated with various typologies of temporary accommodation such as emergency housing, site workers housing colloquially known as dongers, and demountable school classrooms. These examples are often described as “prefabricated” and as such present a building of poor quality and limited life expectancy (Boris et al., 2004; Edge et al., 2002; Koones, 2019).

2.4.8.2. ***P2 Knowledge/understanding***

Consumers are familiar with the on-site constructed system of housing. Generally the only knowledge they have is the on-site genre. Historically housing has been an on-site process which reinforces this sense of having knowledge. Consumers are confident that they understand and therefore trust on-site systems (B. Bengtsson, 2010). This is not the case for consumers of OSM housing which may be explained by unfamiliarity with the product. The housing industry comprises many actors who have knowledge relating to housing systems. These actors include designers, head contractors, sub-contractors, material and services suppliers, real estate agents, financial institutions, lawyers and authorities. These industry groups have little, if any, knowledge of alternate systems of producing housing and therefore cannot advise consumers of alternatives such as OSM (M. Luther, 2012.).

2.4.8.3. ***P3 Sustainable housing and sustainability***

Sustainable actions related to the environment are becoming more important to the Australian community. Today the majority of the Australian population believe human actions are contributing to climate change (Leviston et al., 2014).
High levels of waste of materials and of labour in reworking faults compromise conventional housings' efforts from being a viable system.
The industry is reluctant to innovate to improve housing performance for time, cost and quality (Woudhuysen & Abley, 2004). A house also needs to respond to the climatic conditions for comfort and energy efficiency. Literature has demonstrated housing construction is not viable without change, and that change is resisted by the industry. OSM housing does exhibit viable characteristics particularly for time, cost and quality (Laing et al., 2001; Pan, Gibb, & Dainty, 2012).

2.4.8.4. ***P4 Customisation***

Products produced in factories are regarded as standard and repetitive. However using the example of a motor car, that industry has developed limited but attractive options for consumers to individualise their purchase. Consumers also desire options to customise their houses seeking individuality that expresses their personality. This is realised through planning options, design of kitchens and various finishes. OSM housing is a factory product which to many consumers offers only "cookie cutter" solutions and precludes choice. However, some choice and personalisation is possible for OSM housing (Gorgolewski, 2004; Kendall, 2013; Noguchi, 2003).

2.4.8.5. ***P5 Style/lifestyle***

As stated in P2, consumers are familiar with on-site constructed housing. The conventional typologies are well known to the housing market and accepted as a norm (e.g. brick facades). As demonstrated by the literature, familiarity engenders a sense of security and certainty. This in turn enables the consumers to feel comfortable to move around a community with confidence choosing life options. Selecting unfamiliar forms such as OSM housing exposes consumers to

unforeseen risks and potentially attracts negative attention from society and their peers (Edge et al., 2002). Selection of an OSM housing system could compromise a consumer's sense of well-being if society perceives the house to be unusual, cheap or the result of an expedient decision (Marsh & Gibb, 2011).

2.4.8.6. ***P6 Financial***

In Australia, a house represents financial security and is regarded as an investment, as well as a home. Some consumers expect their house to maintain value and to serve as a stepping-stone to future wealth by acting as security for investments. Housing is often the largest investment consumers will make therefore choosing a house and then financing it can be stressful. Further issues arise in the current times due to fluctuating house prices, both up and down and fluctuating interest rates. Perceptions of finance for housing are therefore complicated beyond day-to-day purchases. For OSM housing the aspect of obtaining finance can add further complications. Choosing housing which is not conventional could jeopardise the ambition of purchasing a house (Gyrn, 2011; M Koklic & Vida, 2011).

2.4.9. Conceptual framework

Figure 2.15 is a graphical representation of the framework for this research. Perceptions of consumers defining aspects of consumers' behaviour towards housing choice and their expectations of housing were distilled from the literature review and described in detail in this chapter. These were nominated as P1-P6. The TPR was evaluated for its usefulness in providing a discipline for designing questions for interviews and then obtaining codes and themes from those interviews for both conventional and OSM housing.

The codes and themes, using the TPR, were analysed using the interviews to find common agreement of the participants and the most important codes for both conventional and OSM housing.

The perceptions P1-P6 were reviewed against the TPR to compare and find the strongest links of perceptions to each risk, in order to find participants' attitudes to conventional and OSM housing.

With this data, the propositions developed in chapter 1 are revisited and assessed for their validity.

Interpreting the findings and analyzing the perceptions through the six perceived risks enabled this study to make conclusions. These conclusions are presented in chapter 5.

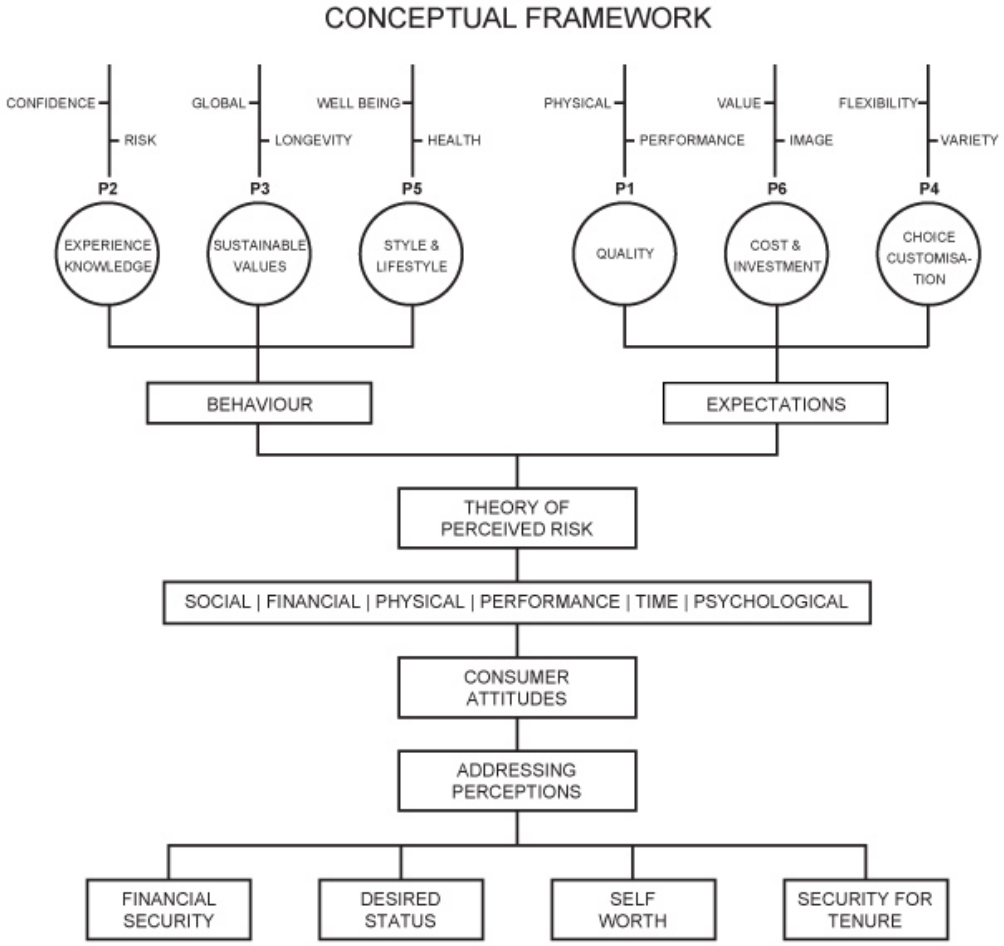

Figure 2.15. Graphical representation of the use of perceptions P1 - P6 to assess the data and find attitudes.to housing using the theory of perceived risk, and then addressing perceptions to revisit propositions.

2.5. Summary

This chapter has established that the conventional housing construction industry (CHCI) in Australia fails to produce housing in a cost effective or timely manner, and cannot ensure the product is defect free and of acceptable quality. Unless there is change and innovation, the conventional systems cannot address the issues of time, cost and quality. There is evidence the industry resists change and continues to be a fragmented model and adversarial in performance. The literature also indicates the industry has poor credentials for sustainability. This is demonstrated by excessive waste of both labour and materials, which is in part responsible for the increasing costs of housing. Further, housing uses a needless amount of energy during construction, which in turn is linked to undesirable greenhouse gas emissions.

Suggested systems for the CHCI to adopt and incorporate to improve viability include building information management (BIM), lean management and agile flexibility. These tools and systems which require access to IT skills according to the literature, fail to interest the CHCI due to a number of factors such as, the majority of CHCI builders being small business organisations without professional IT management skills (Soetens et al., 2005). They in turn rely on sub-contractors who are also small businesses often resulting in a disorderly supply chain.

One option to improve the provision of housing includes bypassing the CHCI and adopting alternative technologies. The literature clearly supports and endorses the use of OSM of housing to satisfy aspects of time, cost and quality. Numerous advantages are listed including certain and condensed time frames, certain and reliable cost outcomes and certainty of quality with fewer defects. Additionally OSM promises sustainable attributes such as less waste and manufacture in factory conditions offering greater productivity and quality management to ensure the product meets appropriate environmental standards.

Various government enquiries have found the CHCI has fundamental problems which need to be addressed if housing is to demonstrate acceptable characteristics of time, cost and quality (BEIIC, 2012). Some of the reports

suggest OSM is a part of the solution (Economic Reference Committee, 2015). In June 2019 the Australian Federal Government allocated $2M for a lab to be set up in a manufacturing growth centre researching systems of producing buildings using principles of pre-fabrication (Department of Industry, 2019).

Numerous obstacles are noted in regard to the use of OSM. Major issues include a lack of suitable skills and a suitable manufacturing infrastructure. Other factors include the lack of support from authorities and financial providers. There is a history of the product being more costly than CHCI systems and importantly reluctance by the consumer to accept the OSM system.

It is crucial to understand some of the reasons consumers express in their reluctance to accept OSM housing.

This research posits perceptions and attitudes of consumers are most influential in constraining the use of OSM in Australia. As found in the literature, there are many obstacles for the consumer in choosing the OSM house. The obstacles include poor perceptions of “prefabricated” housing causing cultural resistance and concern in regard to market acceptability and subsequently poor financial implications for the consumer. The review also identified important attributes consumers consider when they choose housing. They are quality, knowledge of the product, sustainable properties of the product, the ability to customize and enjoy options, pleasant aesthetics or style to benefit lifestyle and finally financial security. These consumer considerations were utilized in this study and are nominated as P1 to P6.

It is clear that aspects of sustainability are important to the majority of Australians, and those concerns flow through to housing. This research proposes an investigation of the consumers’ reactions to current systems of OSM housing.

The next chapter proposes a methodology to answer the research questions framed in Chapter 1.

3. Chapter 3 – Methodology

3.1. Introduction

This study sought to explore the phenomenon of reluctance by consumers to choose OSM housing and then find what needs to change for consumers to accept OSM housing. The typology selected for this study is the detached residential model which in Australia comprises 70% of all residential housing stock. Understanding their perceptions and attitudes to housing may assist in facilitating change in the Australian housing industry to produce housing which is viable, particularly for the aspects of time, cost and quality.

In order to assess the status of housing provision, Chapter 2 reviewed the available literature relevant to the research questions and addressed the context surrounding the research problem. Examining issues related to the methods of the supply of housing and problems of viability experienced by the industry in the past and the present informs this research. Methods of satisfying aspects of supply to match demand for housing and delivering an affordable product were also explored, including OSM systems.

The literature found consumers and attitudes of the housing industries demonstrate reluctance to accept OSM systems of production.

This research seeks to examine consumer perceptions and attitudes to conventional housing and OSM housing, and whether perceived risks of owning houses can be affected by important issues such as time, cost and quality. This chapter describes the development of a research method by which individual perceptions, perspectives and understandings can be obtained in relation to a particular situation (or phenomenon).

A better understanding of this phenomenon could allow consumers to make housing choices more objectively and could educate the housing industry to offer viable housing through the use of OSM systems.

By seeking participants of the same phenomenon from consumers, experiences can be assessed in order to answer the questions posed by this research. Those questions were stated in Chapter 1 and are repeated later in this chapter.

The research methodology and method used for the study discusses the following subjects: (a) the rationale for the research approach, (b) a description of the research sample, (c) a summary of the information needed, (d) an overview of the design of the research, (e) the method of data collection, (f) methods for analysis and synthesis of the data, (g) ethical issues, (h) consideration of trustworthiness and rigour, (i) the limitations of the study and (j) models of reasoning (induction, deduction and abduction). This chapter also discusses the "Theory of Perceived Risk" mentioned earlier as valuable tool to discipline and structure the study and so address trustworthiness, rigour and replication.

3.2. The rationale for the research approach

This research explored the attitudes of consumers to housing choice. This contrasts with quantitative methods where usually the objective is to establish facts and find relationships between variables. Creswell (2014) describes quantitative methods as creating hypotheses that are specific, narrow, measurable and observable. This research sought rich personal data from consumers to answer the questions; therefore a qualitative method was adopted. Thick descriptive data would not be forthcoming from quantitative methods (Bloomberg & Volpe, 2012). This enquiry used both deductive and inductive logic, both characteristic of qualitative study (Kumar, 2014). The study used both deductive by using propositions 1 to 4, and inductive reasoning developing perceptions from the literature review. Features of qualitative methods include enabling interactivity between the researcher and interview participants, maintaining flexibility of the research design, choosing an interpretive stance and understanding responses from the participants interviewed during the research (Creswell, 2014).

Qualitative research addresses and examines a social situation or interaction through enabling the researcher to enter into other people's worlds and attempt to understand a holistic rather than a reductionist view (Maxwell, 2012; Patton, 2015). A qualitative method facilitates research, which interprets and understands experiences at a point in time and in a particular context thereby yielding rich data to address the research questions. The method importantly enables comparisons between sections of text noting similarities and differences (Bloomberg & Volpe, 2012). A qualitative methodology according to Denzin (2008) seeks to interpret the meaning of an experience. Kumar (2014) describes the focus of qualitative research as seeking to understand, explain, seek perceptions and attitudes, and find the values, beliefs and experiences of groups of people.

3.2.1. Qualitative methodologies

Claims for what knowledge is, are based upon ontology (what knowledge is) and epistemology (what we know and often assume we know) and methodology which is the process of studying knowledge. According to Bloomberg and Volpe (2012) there are four core paradigms which inform qualitative research. They are post positivism, social constructivist/interpretivist, critical theory and pragmatism. Post positivism relies upon reductionist principles testing and verifying laws and theories to support the research theory and is comparable with quantitative research methods (Bloomberg & Volpe, 2012).

Social constructivism relies upon reality that is socially, culturally and historically constructed (Guba & Lincoln, 1994).

Critical theory is described by Creswell (2014) as having a clear focus on social justice, and the goals of this theory are described as seeking to create political debate and empower people to challenge the status quo.

Pragmatism is a model that is not committed to any one research philosophy including mixed methods using both quantitative and qualitative models, adopting multiple data collection models and data analysis.

For the purposes of this research the social constructivist/interpretivist models is regarded as most suitable since it develops a phenomenon which is socially constructed, that people develop subjective meanings as a result of their life experiences, and from that obtain multiple meanings. This is particularly relevant for this study since the focus is to understand the multiple realities and perspectives of consumers. Constructivist researchers according to Lincoln, Lynham, and Guba (2011) position themselves within the research and in doing so recognize their own historical, cultural and social experiences. Further, constructivist researchers pose research questions to inductively develop meaning from data to understand social phenomena from the perspective of specific contexts, for this research seeking perceptions and attitudes to OSM housing.

3.2.2. Qualitative research genres

Qualitative methodologies are holistic and complex relying on reasoning which flows between deduction and the induction of complex reasoning. The literature identifies six main genres for qualitative research, case study, ethnography, phenomenology, grounded theory, narrative research and action research (Bloomberg & Volpe, 2012).

Case study designs are used in both quantitative and qualitative research. The focus is on a holistic understanding of individuals or groups, situations or episodes, to explore and understand rather than confirm or quantify (Kumar, 2014). Further, Bloomberg and Volpe (2012) consider the most important feature of the case study model is that of transferability rather than generalizability, enabling the understanding and knowledge from a case study to be applied to similar (but not identical) contexts and settings.

Ethnography or participant observation (Kumar, 2014) is a design which studies in depth cultural and social groups in their natural setting. The focus is to describe and interpret cultural patterns of practices, values and behaviors and this is achieved by the researcher's prolonged immersion in the day to day actions of a society as a participant observer.

According to Bloomberg and Volpe (2012) the purpose of **phenomenological** research is to investigate participants lived experiences. This methodology involves studying a small number of participants to establish patterns and relationships of meanings (Moustakas, 1994) to derive not only descriptive results but also to enable interpretation.

Grounded theory inductively generates theory which is grounded in or emerges from the data. Grounded theory exhibits two main characteristics, theoretical sampling and a comparative method of data analysis. Creswell (2014) argues that grounded theory is used when a researcher seeks to study a process, an action or an interaction.

Narrative inquiry studies the lives of individuals through storytelling or avenues of performance. This method, rather than finding conclusions and certainty is guided by tensions and uncertainty seeking understanding and meaning (Miles & Huberman, 1994).

Action research is a collaborative process requiring a routine of research, reflection and action. An outcome of action research according to Schwandt (2015) is a blurring of the distinctions between theory and practice. The goal of action research is to produce theoretical understanding to inform future actions (Bloomberg & Volpe, 2012).

For this research, the use of a phenomenological methodology is regarded as most suitable. This method enables a deep understanding of a phenomenon experienced by individuals in this case through a structured method of interviews and the interpretation of the data. This approach is considered to be the most reliable method to obtain accurate and comparable data. It is important to note that Creswell (2014) suggests that rather than seek bracketing (isolating personal experiences of the researcher) which is extremely difficult, the researcher should introduce his own personal understandings into the study and incorporate those into the analysis, a method adopted for this study by developing propositions. Once the data was analysed, those propositions were able to be tested.

3.2.3. Strengths and weaknesses of the phenomenological method

Strengths: The phenomenological approach can provide a rich and complete description of human experiences and meanings. Findings are allowed to emerge through responses to semi-structured questions to avoid participants being led by the researcher. Use of thoughtful and considerate techniques enables descriptions as faithful as possible to the experiential raw data; this can be and was accomplished by taking care in moving step by step and in being ever mindful not to delete from, add to, change, or distort anything originally present in the initial “meaning units”. Recognition of presuppositions and biases was important through all phases of the research in order to minimise their influence on the findings. Research derived from the literature it is argued, assists in identifying this important factor of bias (Bloomberg & Volpe, 2012).

Weaknesses: The method according to Bloomberg and Volpe (2012) relies upon certain aspects of the participants. For example, on how articulate the participants are to provide the information and conclusions depend on the particular participants chosen for the study. In its orientation toward a particular issue, the method may miss information about broader issues. Kumar (2014) suggests validity of the methods and outcomes can be questioned due to the lack of scientific specificity. Validity and reliability of the methods employed in this research are addressed in section 3.7.

3.2.4. Phenomenological research for this study

Phenomenology seeks to understand the construction of meaning. This is achieved by direct investigation of the conscious experience without seeking causal or objective reality. The research sought responses from participants in individual interviews to identify issues and implications to inform the research. Van Manen (2016) describes four aspects of “lived experiences” relevant to phenomenological study, namely lived space (spatiality), lived body (physical world), lived time (temporality) and lived human relations (relationality). It is important to note these aspects of a “lived experience” have direct links to the

Theory of Perceived Risk (TPR) since experience informs risk. TPR is a theory used in this research to design the interview questions and assess the data. This focus in preparing questions (and probing questions), Van Manen (2016) argues, results in direction and purpose for the interview, ensuring the goal of exposing and explaining the phenomenon is achieved. Van Manen (2016) also states interviews structured in such a manner will have a clear and purposeful passage thereby avoiding irrelevant and misguided results. Applying the discipline and focus provided by use of the TPR gave the research the desired structure described by Van Manen (2016). Care was taken however to avoid theory laden questions, questions created by the theoretical propositions of the researcher (Bevan, 2014).

This study seeks consumers' beliefs and perceptions and their interpretation to issues of housing in order to obtain insights into their actions and motivations. For Giorgi (1997) the operative word in research using phenomenological methods is 'describe', denoting the rigour of accurately describing a phenomenon. However, Groenewald (2004) prefers to use the term "explication" meaning that the process of analysis is one of unfolding and of making clear the meaning of things, rather than simply, description. Explication according to Groenewald has five stages, bracketing and reduction, delineating units of meaning, establishing themes, summarizing interviews and validating or modifying and finally generating general and unique themes from all the interviews for a composite summary. This regimen was followed for this research.

Therefore the method designed for this research is qualitative, using a phenomenological approach, a method with the ability to work flexibly with various face-to-face enquiries. The method produces authentic rich responses suitable to obtain the data necessary for the study.

3.2.5. Rationale for the use of semi-structured interviews

Qualitative researchers employ various methods to obtain primary data. Creswell (2014) describes three of the most used methods; observation, interviews and

questionnaires. Observation yields considerable data of participant interaction within selected settings but does not include their personal views and opinions, particularly in regard to their choices as consumers. Questionnaires are valuable data sources, however, it was considered inappropriate for this research as the participants would need explanations of some of the concepts around which some of questions asked in the questionnaire were developed (Kumar, 2014). Various forms of interview methods are frequently used; one-on-one, focus groups and telephone interviews. Telephone interviews were considered; however, an important part of the interview was use of visuals to present images of housing and present some sustainable principles described later in this chapter (De Leon & Cohen, 2005). Focus groups enable participant interaction which yields valuable discussion often resulting in valuable spontaneous outcomes (Kumar, 2014). However, it was considered that the process of assembling multiple participants for focus groups would be too difficult given the purposive sample selected for participation.

Therefore the decision was made to use face-to-face one-on-one interviews. Importantly, the collection of suitable primary data from the interviews satisfied the study.

In making this decision it was noted that there are limitations to be considered using this method. Rubin and Rubin (2011) discuss the aspect of people being unequal in co-operation, their ability to articulate and being perceptive. Interviewers must ensure they exhibit or develop suitable skills (Seidman, 2006). Finally Bauman et al. (2011) argues interviews are not neutral tools of gathering data, they are the result of interaction between the interviewer and the participant in the study.

3.2.6. The research sample and selection of participants

Phenomenological research usually produces large quantities of data that requires substantial effort to decode and find rich themes to inform the findings of the research. The literature for the adopted model recommends small rather than large samples of participants and the group of between 10 and 20 participants

was adopted based upon that literature (Creswell, 2014; Mason, 2010; Srivastava & Thomson, 2009; Sutrisna, 2009). The final number of participants was 15, thereby falling within the recommended range. Sutrisna (2009) argues saturation will occur within the range of fifteen.

The selection of interview participants was guided by the following criterion: consumers who were commissioning the construction of a new house in the near future but had not made the final decision. No other criterion was applied as the only other relevant factor was the intention to purchase a new house in the near future. Location and size of the allotment was not considered because the focus of this study is the perceptions and attitudes to houses.

Initially it was decided that it would be possible to identify participants with the co-operation of established real estate agents. This was considered to be a direct method to find a purposive sample because of the agents' everyday associations with clients with a construction site and an interest in building a house. Real estate agents were contacted to request their assistance and they were invited in accordance with the requirements of the ethics approval. Three agents agreed to contact their clients and seek their agreement to participate. Follow up calls to the agents were made over the next weeks. However, only one participant was identified by just one agent.

In order to identify additional participants an interview on a local radio station was arranged as well as an opinion piece in the city's newspaper. Ethics approval was obtained as a variation to the original approval for both. The radio interview and the opinion piece covered the topics of housing and sustainability and asked for participants to be interviewed. Interested parties were invited to contact the researcher directly if they were willing to participate in an interview. Twenty people responded to the request from the radio interview. The aforementioned selection criterion was applied and 11 were found to be suitable.

The opinion piece by the researcher in the Herald attracted further participants. Six readers responded and three were selected in accordance with the selection criteria. The ethics approval was applied for all participants.

Kumar (2014) and Creswell (2014) argue that small samples of up to 20 are suitable for qualitative investigations. Fifteen participants were recruited for this study, falling within this range. However, comparing the opinions of such a small number of participants can produce unreliable data. This is because each participant's viewpoint is regarded as valid (Nicholls, 2009). The demographic characteristics of participants were thus not incorporated in the analyses reported in the thesis. Future quantitative studies administered to large populations would need to consider demographic data and it is acknowledged that, in such circumstances, the question the examiner asks is valid. A recommendation for further studies to compare consumers' perceptions and attitudes to OSM housing has been included in Chapter 5.

Most participants lived within 10 kilometres of the Newcastle CBD while two lived outside the immediate environs in a rural setting. It is interesting to note that Newcastle and the Hunter Valley have often been used for product launches seeking to test market acceptance of a product. The area was described by Cyril Renwick (Professor of Economics UoN and Director of the Hunter Valley Research Organization) as a demographic microcosm of Australia and many marketing projects have been carried out on that premise (Scott, 2007; Stephens, 2010). Stephens (2010) wrote polymer banknotes, Australia Post products, hamburgers, pasta sources [sic] and Tiny Teddy biscuits were all tested on the people of the Hunter before being launched around Australia. While the use of the Hunter as a demographic microcosm is not a claim of this research, applying the study findings in the Hunter Valley could have relevance for the Australian context.

3.2.7. The research design; an overview

The following steps were taken to carry out this research.

3.2.7.1. ***Literature review***

A selective and ongoing literature review was carried out to theoretically ground the study. The topics identified for examining the literature were:

- The viable status of the housing construction industry including the world stage but with a focus on Australia;
- Systems available to the industry to improve its viable attributes including OSM systems;
- Attitudes of consumers to housing choice were examined.

The literature exposed the unsatisfactory state of the housing construction industry in Australia with respect to time, cost and quality, as well as waste and energy use. The review also provided context for alternative systems to improve the unsatisfactory aspects of the housing construction industry and concluded OSM could provide a suitable alternative to on-site systems. The review also addressed attitudes of consumers to housing generally and in particular OSM.

3.2.7.2. ***Confirmation of the research proposal and ethics consent***

A research design and proposal together with a literature review was presented to a University of Newcastle (UoN) review panel comprising senior academics from the School of Architecture and the Built Environment. The proposal included the background and context; the problem statement and the research questions. The panel approved the research proposal including conducting participant interviews.

Following approval, an application using a standard on-line template was prepared seeking ethics clearance from the UoN Human Research Ethics Committee (HREC). The application required information sheets for the prospective participants and consent forms to be signed prior to their interview. The application was peer reviewed prior to submission to the HREC. Since the interviews were to be conducted off campus, a detailed risk assessment was

prepared and submitted for approval. Approvals were granted for the interviews to proceed. A copy of the approval to conduct interviews can be found in the appendices.

3.2.8. The Theory of Perceived Risk

The Theory of Perceived Risk (TPR) is regarded as an important tool to design interview questions and set a framework to analyse the data needed to complete the study. Therefore the theory and its relevance are discussed in this chapter.

3.2.8.1. The nature of the Theory of Perceived Risk (TPR)

The theory of risk taking and risk reduction (perceived risk theory) was first introduced into the marketing industry by Bauer (1960) and has been a useful tool in research into consumer behaviours, particularly where there is uncertainty (Snoj, K, & Mumel, 2004). It is clear consumers demonstrate a level of certainty when conventional housing choice is being made, however it appears not for OSM systems of production of houses (Ball, 2003).

Campbell and Goodstein (2001) argue that the use of TPR enables an evaluation of variables of consumer behaviour thereby linking the theory to qualitative methods. It is important to note that the TPR as a research tool is described by V. Mitchell (1999) as most suited to purchases which are expensive, infrequently made and personally expressive, attributes which describe housing choice. Previous examples in the subject area of this research have been found. In particular it was Perez-Cabanero (2008) who used the TPR to provide clear criteria for designing research questions for the choice of housing. A structure using the TPR offers a method to enable accurate and meaningful evaluation of consumer responses in regard to housing (Perez-Cabanero, 2008).

M. Koklic (2011) concurs with these findings in her research into consumers' deliberation of a house purchase, describing the transaction as strategically important entailing the making of complex decisions such as a long term financial commitment and a purchase that can be individually customised. M Koklic and Vida (2011) also found that cognitive and rational factors do not fully explain behaviour in regard to the selection of a house. They argue that examining the

role of feelings, experiences, needs and goals enables a deeper understanding of decision making.

3.2.8.2. ***Characteristics of perceived risk theory***

Whilst Bauer (1960) described the initial TPR, it was Cunningham (1967) who expanded the theory from simple uncertainty to a two component model to include the concept of consequences. This dual component model measured on various scales has become an industry standard where risk is defined as the probability of negative consequences occurring and the importance of those negative consequences (see Figure 3.1). V. Mitchell (1999) supports the rationale for use of the two component model for use when it is evaluated against the research criteria of usability, practical implications and prediction, suitability for reliability and validity testing, and developing understanding.

The theory also describes the consumer's decision process as problem recognition, information search, evaluation of alternatives; purchase decision and post purchase behaviour, and describes this model as most relevant to understanding complex decision making combined with significant risk and uncertainty, perceived or otherwise (V. Mitchell, 1992).

To further understand the concept of perceived risk, it is useful to define the sources of uncertainty. V. Mitchell (1992) listed six sources of uncertainty and indecision. First, the consumers' knowledge of their own needs, purchase goals and their importance is often inadequate (B Bengtsson & Ruonavaara, 2010), evidenced by house buyers using experts to evaluate housing (e.g. structure and pests) and then often experiencing uncertainty in regard to the quality of those services. Second, consumers do not identify the attributes of alternatives for housing such as sustainability (Manley & Miller, 2014). Third, consumers are uncertain as to how they may predict future performance; for example conventional housing is shown in the literature to perform poorly for time cost and quality (Arashpour et al., 2013). Fourth, is the consumer's confidence, high or low, as to their ability to assess attributes of a product or service, for example the ongoing financial return on sale of housing (M Koklic & Vida, 2011). The next source is simply choice uncertainty of brands, such as preferring established

conventional housing rather than a product demonstrating innovation (Craig et al., 2000). Finally, there is uncertainty in relation to the anticipated and actual experience of the outcomes; selection of housing represents a large investment of money and time (T Dalton et al., 2015; De Valence, 2010a).

Slovic, Finucane, Peters, and MacGregor (2004) argue that providing information about benefits changes the perception of risk. They also suggest lack of information results in negative feelings for risk (see Figure 3.1).

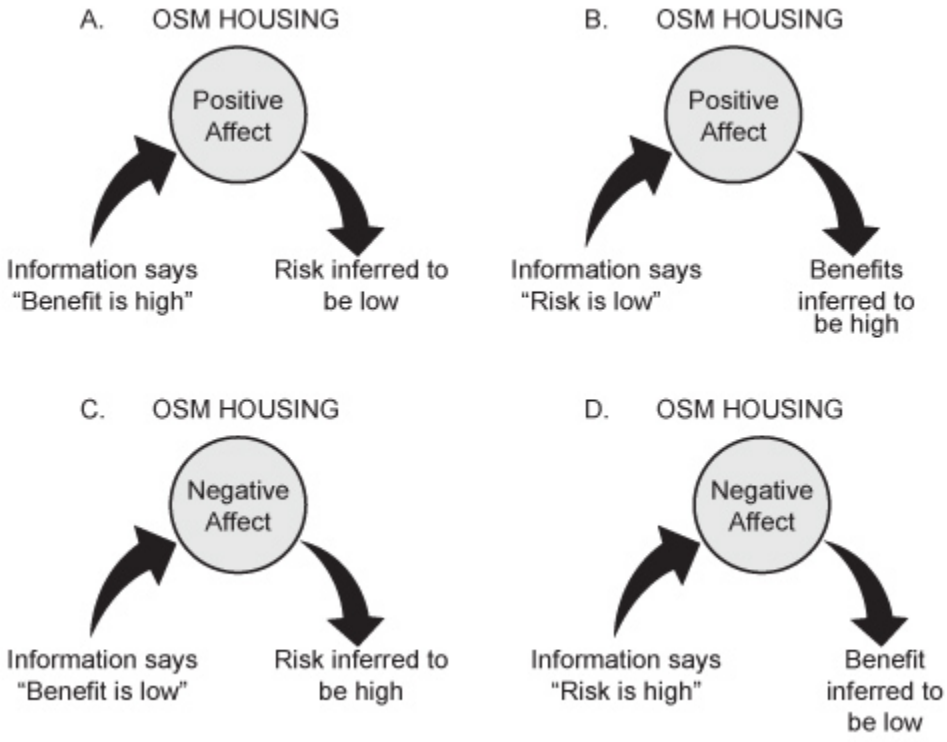

Figure 3.1. Information and the Theory of Perceived Risk

Figure 3.1 has been modified from its source Slovic and Peters (2006).

Figure 3.1 explains how if information demonstrates benefits for using OSM is high then the risk is inferred to be low (A). If the graphic B describes information indicating low risk, then the consumer will believe the benefits to be high. Both A and B indicate positive effects. However, for C where information shows a low

benefit for OSM then the perceived risk will be high and for D if the information indicates the risk is high, then the perceived benefits will be low. Both C and D indicate negative effects. The concept of supplying information to elicit levels of risk for OSM housing was used in the interviews of participants.

In order to assess the attitudes of consumers in regard to risk, it is important to provide appropriate information, a technique used in the interviews seeking data for this study.

When applying the TPR, six factors are important to establish potential consequences for the consumer.

Initially the literature listed four risk dimensions, namely financial, psychological, social and physical. It was Roselius (1971) who identified of loss of time as another distinct perceived risk. Jacoby and Kaplan (1972) in their research added performance. M Koklic and Vida (2011) employed those six factors for enquiry in their qualitative research into the consumers' perception of risk when buying a home. They concluded that consumers do not sufficiently define their needs or goals or research the products or producers to inform their decision making process. On a conceptual level, the six dimensions can be considered as independent so that as one source of risk increases, the other risks can increase, decrease, or remain unaffected (Slovic, Fischhoff, & Lichtenstein, 1982). While psychological and social risk are often treated as one (i.e., psycho-social risk), the psychological risk situations take into account how the individual perceives self, while social risk refers to how others will perceive consumer's actions (Campbell & Goodstein, 2001).

Descriptions of types of perceived risk in relation to housing are listed below (Cunningham, 1967; Roselius, 1971). Adjacent to the categories listed are typical themes related to housing.

- Social — Other people's perceptions of the OSM housing purchase compared to conventional housing could be negative (Gurney, 1999)
- Financial — Uncertain final cost of a house causing financial stress or future sale jeopardised by purchase of OSM housing resulting in a financial loss (Apaydin, 2011; Davies, 2005)
- Physical — That the innovation will have some unknowns resulting in injury or illness caused by, for example, unfamiliar materials or contaminants causing illness (ABCB, 2018)
- Performance — The house will not perform as expected by not fully meeting functional needs, or there is insufficient scope for customisation or flexibility to allow changes (Schoenwitz et al., 2014; Till & Schneider, 2005)
- Time — An unknown product could require reworking with the subsequent loss of work/leisure time to organise the reworking or a need to relocate temporarily (P. Love, 2002)
- Psychological — The house could have a negative effect on peace of mind/self-perception due to it not meeting expectations of form or quality (Madigan, 2012)

3.2.9. Use of the Theory of Perceived Risk

The TPR and in particular the two component model, described by Cunningham (1967) of probability and consequences, have been in use by researchers since 1967. It is important to note V. Mitchell (1999) argues the use of the theory for research over a period of more than 30 years has produced reliable and valid results.

As described, the use of TPR is important in assessing consumer decisions made in regard to purchases which are expensive and infrequently made (I. Ross, 1975). The two major components of perceived risk are uncertainty and consequences (Lim, 2003). M. Koklic (2011) describes the purchase of housing as falling into this category because the decision to purchase requires addressing many factors beyond most consumers' knowledge and a poor decision can have serious repercussions, as demonstrated by the TPR. Characteristics of TPR are described by Laroche, McDougall, Bergeron, and Yang (2004) as follows:

Social risk is the potential loss of esteem or respect for the consumer by other individuals regarding a house style or genre deemed to be undesirable.

Time risk is the potential loss of time and effort associated with the purchase of the item, typically by delayed housing completion.

Psychological risk is the potential loss of self-image or self-concept as a result of the house purchased not meeting expectations.

Financial risk is the potential loss of money and assets associated with the depreciation of the purchased house due to unforeseen circumstances such as a market downturn.

Performance risk is the potential loss due to, for example, structural failure after purchase.

Physical risk, the sixth risk is not described in the Laroche et al. (2004) paper; however the risk pertains to the uncertainty that there could be danger causing injury or harm (Jacoby & Kaplan, 1972), for example finding toxic mould or asbestos in a house.

The use of TPR provided a structured discipline for establishing logical and consistent questions for the research, enabling reliable and consistent outcomes from the interviews.

3.2.9.1. ***Perceptions as a source of data***

While the method of designing the questions relied on TPR for the reasons previously indicated, it is also prudent to demonstrate caution when relying on perceptions P1 to P6 as a source of data. Johnson (1994) discussed factors to consider when interviewing and obtaining participants' views and experiences. Briefly those factors are:

- Perception has stages, personal acceptance of stimuli, choosing the stimuli and then analysing and understanding.
- Perceptions can shape attitudes and behaviour of a person and those around that person.
- Perceptions create firm viewpoints which become a person's reality, often equated with heuristics.
- These viewpoints are often unrecognised as such by a person and can lead to irrational responses.
- Perceptions although inconsistent can be defensible and justified by the holder of the view of an opinion.
- Path dependencies such as social and cultural influences affect responses to new options.
- Preceding events impose on perceptions, for example previous success or failure of an innovation.

These factors of perception could potentially compromise the research data and were therefore carefully considered and integrated into the process of carrying out the interviews and analysis of the data. The distilling of perceptions P1 – P6 from the literature review was carefully assessed against the factors listed above. In this way the perceptions were a valuable aid in finding attitudes of the participants to the housing.

3.3. Design of the interview questions

Saldaña (2012) refers to a method of devising a provisional list of codes thereby enabling an analysis, which explicitly answers the research questions. This contrasts with the goal to develop new theory about a process or phenomenon. The use of the TPR provided an initial set of codes (social, financial, physical, performance, time and psychological) to frame the interview questions and assess the data. Further, the use of open-ended questions rather than closed questions was made on the basis that the interviews should elicit opinions, attitudes and perceptions rather than merely factual information (Kumar, 2014). According to Kumar (2014) open-ended questions importantly reduce the possibility of introducing the researcher's bias. Neuman (2011) agrees with this assertion arguing that open-ended questions allow participants to create responses from within their social experiences instead of the responses the researcher may have. For the researcher these responses resulted in the need to find codes and themes in order to explore the data from the interviews. Creswell (2014) suggests the use of open-ended questions is appropriate for situations where the researcher aims to explore options rather than assume responses from participants.

In order to ensure that the development of the questions followed good practice an initial discussion was held with Mark Sargent who has a PhD (in public policy) and who also graduated with an MBA and a masters in marketing. Mark Sargent has recognition for expertise in developing market research questions. His company carries out business research and has knowledge of affordable housing (Holmes & Sargent, 2014). The initial questions were developed and reviewed by Sargent who then approved their suitability after adjustments.

3.3.1. Rationale for the development of the interview questions

Table 3.2 lists the questions framed within the TPR. There are two sets of questions. The first focuses on conventional housing, the second addresses OSM housing. The first column contains the questions developed using the discipline of TPR and the second column describes the rationale. Probing

questions were also used and they can be found in Appendix C. Section 3.5 discusses in detail the two-stage interview process.

First set of questions seeking perceptions of risk in regard to housing	Rationale
Social Risk	
Q1 Some people suggest that houses can express the personality of its owner? What is your view? Q2 It has also been said that people label others by the type of a house they live in. What do you think about this statement?	The questions may reveal levels of personal esteem and their relationship to housing and how important a house is to an occupants' status in the community
Financial Risk	
Q3 Do you regard your house primarily as a place to live or as an investment? Q4 In your opinion what are the financial implications when housing has elongated construction times?	The research sought to find whether finance was the most important factor in housing choice and to find the stress associated with the risk. Also it is important to find the level of emotional attachment to a house.
Physical Risk	
Q5. What have you heard about physical risks in houses? Q6. When choosing a house, what aspects in regard to being safe from injury do you think might concern you in regard to your family?	For the physical risk it is important to find whether consumers are aware of potential dangers in houses and then establish the level of concern.
Performance Risk	
Q7 Please describe your views in regard to the need for repairs to and improvements of a house. Q8. What in your view improves the performance of houses for sustainability, for example, energy and water usage?	These questions relate to perceptions of quality of housing particularly in regard to defects and maintenance. Finding the level of concern for housing performance was important to this research.

Time Risk	
Q9. What things are most important to you in the function of houses, how they work? Q10 What is your opinion in regard to the importance on flexibility in housing, for example accommodating change in family size or the way you live?	Time can be wasted if housing is inefficiently planned or has unnecessary obstacles such as poorly planned functional relationships. Obtaining views from the participants in regard to alterations and additions is valuable to the research.
Psychological Risk	
Q11 Can you describe your preferences for housing in regard to: a. Appearance the style and presentation, b. Size for example the number of rooms, c. Materials such as external finishes, internal features in bathrooms or kitchens. Q12 What is it in a house which gives you the sense of security and privacy?	Finding personal preferences of the participants for housing provides a benchmark for finding the perceptions of the OSM systems they will be presented in the second round of interviews. As stated above participants' views of security and privacy assists in evaluation of their response to the OSM systems.
Second set of questions seeking perceptions in regard to OSM housing	**Rationale**
Social Risk	
Q13 Often sustainability in our society is defined by three aspects; social (our social obligations to each other), environmental (global warming and climate change) and financial (a successful economy). Can you describe your attitude to these goals? Q14 What is your understanding of the term 'sustainable housing'?	OSM housing demonstrates desirable attributes therefore obtaining participants perceptions of those qualities provides a base to assess attitudes for social risk to OSM housing.
Financial Risk	
Q15 Of the examples of OSM houses that demonstrate good sustainability	These questions seek personal perceptions of the OSM housing presented in the PowerPoint

practices, what are your views about attractiveness, form, materials and overall appearance? Q16 The houses shown here are offered with a fixed price and a fixed delivery date. As we have discussed, these attributes are not common found in conventional housing offers. How would you describe your reaction to the differences?	presentation and how financial issues have an influence.
Physical Risk	
Q17 Would you have any physical concerns in regard to buying one of the three houses for example stress or anxiety? Q18 The three houses shown claim to have design characteristics which reduce the occurrence of mould, and all three avoid volatile organic compounds (VOC's). What is your reaction to knowing that?	Perceptions of physical risk are important when examining the participant's attitudes to OSM housing.
Performance Risk	
Q19 One of the factors listed in talking about issues of productivity in building houses is the problem of poor working conditions. Accidents for conventional construction sites result in the highest rates of permanent injury and workers disability claims of any industry. How important do you think these factors would be in the overall decision about the type of housing you might opt to build? Q20 We talked about flexibility before. If we focus on the capacity to adjust to climatic conditions and meet individual energy goals, what is your view of the three models shown when they claim to have the flexibility to adjust to meet any climatic condition and meet individual energy goals?	It is important to find whether issues of performance for OSM houses affect participants' perceptions, positive or negative.
Time Risk	
Q21 The OSM houses claim low maintenance regimes offering time	Time is important so would saving time for aspects such as maintenance positively affect

savings for the occupants. Would this be a positive /negative influence on your housing choice? Q22 The OSM systems claim short manufacture and assembly times. How would this affect your housing choice?	attitudes to OSM housing? The issue of shorter time for manufacture and assembly is a benefit OSM housing enjoys. When compared to conventional systems will this affect housing choice?
Psychological Risk	
Q23 With your own preferences for housing established in question 11, in the previous section for materials, size and appearance; please describe the positive attributes in the OSM systems shown. Q24 How would you regard people who purchased one of the three housing systems discussed today?	It is important to know how participants' perceptions of OSM housing affect self-esteem.

Table 3.1. Development of the questions for the interviews using the Theory of Perceived Risk

3.4. Interviews

The interview as an instrument seeks answers to the following research questions;

Question 1. What are consumer attitudes to conventional housing and housing which is manufactured off-site?

Question 2. What are the relationships between risk, perception and attitudes to conventional housing and OSM housing?

The literature review indicated historical and contemporary evidence of consumers' reluctance of to accept housing production systems such as OSM. Attitudes of consumers to both site-built housing and housing using OSM

systems were sought using semi-structured questions. The study also assessed consumer attitudes to sustainable housing.

The questions employed in the interviews were, as previously described, informed by the “Theory of Perceived Risk”. The theory provides insights into consumer attitudes in regard to financial risk, exposure to physical harm, whether the goods will perform as needed, will personal convenience be eroded, are there adverse issues of self-worth and could other people’s perceptions be negative.

For the interviews a four stage method was adopted. First a PowerPoint presentation, then a first set of questions followed by a second PowerPoint presentation and finally a second set of questions. According to De Leon and Cohen (2005) the use of images as probes in interviews can be an extremely effective elicitation of meaningful responses. This method was adopted by using PowerPoint (see Appendix B). So that the participants were adequately informed and could therefore positively contribute to the interviews. Facts indicating aspects of sustainability for conventional housing construction were presented. The facts were established from the literature. The first set of questions followed and then the participants were shown a second part of the PowerPoint presentation. They were shown images of nine examples of houses produced by OSM systems by three Australian manufacturers. The second set of questions addressed OSM housing.

Three manufacturers were used to obtain examples of readily available contemporary OSM housing. They were selected for their established track record over years of producing detached housing in a factory, and then delivery to or assembly on site. The websites of these companies illustrated a variety of actual solutions and houses sold and now occupied. The manufacturers’ websites also make claims about the sustainable attributes of their housing, particularly in relation to productivity, cost certainty and supply within a firm time frame.

Further, the companies selected had a number of models available to enable the selection of three models from each of them thereby offering a range of product and choice for the participants to consider. Importantly all three companies have a number of houses produced and installed compared with other groups who rely on three dimensional computer generated images to attract clients. The attributes for the housing models were extracted from the websites of the three companies and presented to the participants in the PowerPoint.

It is important to note that although the models presented to the participants did not fully satisfy the definition for OSM houses adopted by this study, the models provide an appropriate representation for the interviews to generate suitable and relevant data. Two of the manufacturers use volumetric systems and the third non-volumetric. The characteristics for volumetric and non-volumetric typologies are described in Chapter 2.

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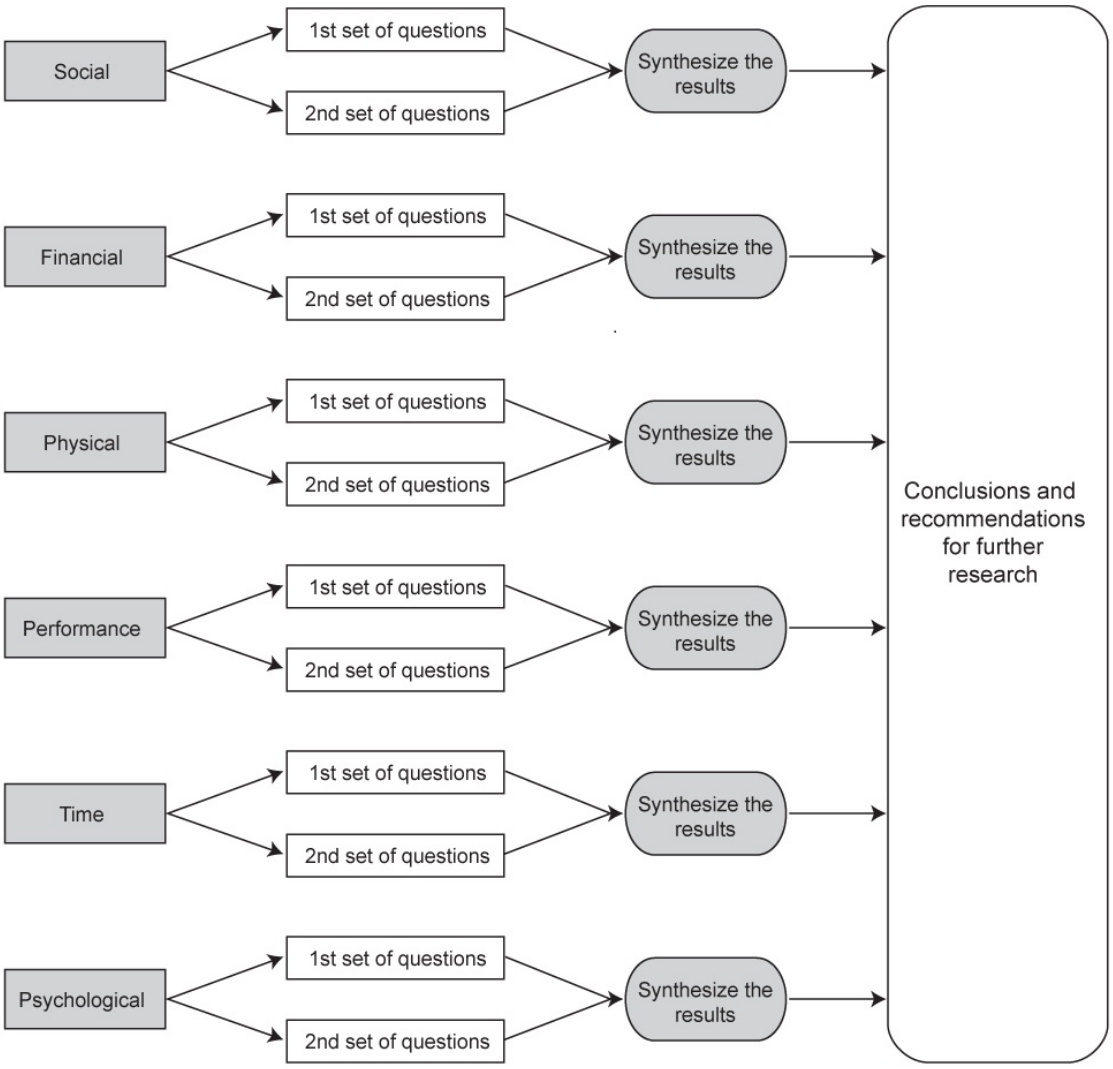

Figure 3.2. Graphical representation of the use of the Theory of Perceived Risk for this research.

Figure 3.2 cites the six risks applied to the research questions, the questions applied in the first round and the second round and then the synthesis of those to produce the data for analysis.

In both sets of questions, two questions were designed to address each of the six risks described by the theory of perceived risk. Those questions are included with each risk summary in Chapter 4. Additional probing questions were also asked. For the purposes of this research each participant was identified by a discrete letter of the alphabet (i.e. A, B, C, etc.) to ensure anonymity. Appendix C

describes the structure of the interviews together with the questions and the probing questions.

The interviews were audio recorded (with permission of participants) and filed with a code and a date. The digital recordings were replayed as soon as possible after the interview and notes made, key words and phrases and statements were transcribed. Field notes as well as observational notes and memos were recorded to further clarify the interview setting.

As demonstrated prior, there are strong perceptions held of risk and patterns of preconceived opinions in regard to housing choice. Understanding these perceptions and patterns presents an opportunity to find deeper meanings and therefore realise outcomes, which contribute to the research. Additionally, the use of a uniform and consistent interviewer and participants' format arguably ensures greater reliability of the data (Cicourel, 1964). Guba and Lincoln (1994) argue that validity and reliability of the findings in qualitative research rely upon an identical replication of the process and methods of data collection. Therefore this study adopted a set of questions and delivery of probes, both verbal and visual and identical in all interviews.

As previously described, to obtain sufficient data from the interviews the number of participants was set at between 10 and 20. The decision as to whether the interviews yielded sufficient and reliable data relied upon the principle of saturation. This is defined by Kumar (2014) as a point at which there is no or very little new information from the respondents, and by Creswell (2014) as the point at which the researcher makes a subjective decision that new data will not provide new information or insights to the research. Saturation, according to the research data was reached after 7 interviews, however to ensure the data was consistent and reliable, 15 interviews were completed.

3.4.1. Interview format

Participants were asked where they would be most comfortable to be interviewed, and importantly with the least inconvenience. Three participants nominated the researcher's office, one their workplace, and the remainder their own residences. All the interviews were carried out in a quiet place without other people in the space. This enabled uninterrupted interviews varying in elapsed time from 30 to 50 minutes. While the participants had already consented, the researcher outlined the purpose of the interview and reiterated the terms of the UoN ethics clearance under which the interview would be conducted.
Following this introduction, the participants were advised of the format and timing for the interview, also referring to the documentation produced for ethics approval supplied prior to their agreement. This included the request that the meeting be recorded and transcribed. They were also invited to review the recording and/or the transcription and comment on those to ensure they were satisfied the records of the interview were accurate.

3.4.2. Interview execution

It was recognised that the participants should feel at ease during the interview, however also ensuring the researcher avoided any rapport with the participant. This method reduces the possibility that the elicited answers produce adjuvant or confirmatory answers. Each interview was managed in a consistent manner with the same sequence of introduction: initial PowerPoint: the first set of 12 questions: presentation via the PowerPoint software and then the second set of 12 questions. After both stages the participant was asked if they had any comments to add to the discussion. The questions were asked one at a time and followed up with one or two probing questions. The participants were given a sheet with the list of questions prior to the interview, which they could retain; the probing questions were not revealed in order to maintain a flow to the interview. While the questions were designed to align with the theory of perceived risk, care was also taken to allow participants to frame their answers in their own terms. The questions were also designed to avoid yes/no responses or cause the

participant to feel as if they needed to justify their responses. Further, the questions were neutral to avoid unnecessarily influencing the responses.

3.4.3. Post interview procedures

Following the completion of each interview, the recorded interviews were transferred from the digital recorder onto a computer (secured by password) and also stored on a USB device (locked in a secure drawer) to ensure the data was retrievable in the event of a computer malfunction. The interviews were transcribed as soon as practicable. This enabled accurate recollection of the circumstances during the interview and facilitated notes being added to the files in regard to any special circumstance, which may have had a bearing on the interpretation which followed. Transcription into a word document was carried out by both the researcher and professional transcribers and the transcriptions read and reread in conjunction with listening to the recordings to ensure consistency (Miles & Huberman, 1994). The word documents were loaded into a computer software program NVivo 12.

Software such as NVivo 12 has tools and features available to assist the creation of memos and codes which adds objectivity to the qualitative method (Miles & Huberman, 1994).The use of the IT however did not preclude rigorous research design and implementation by the researcher, placing technology as a useful but contributory tool. The researcher had no experience in the use of NVivo 12 and enrolled in a UoN sponsored two day training course at the university to develop proficiency and also joined a student collaborative to gain further experience. NVivo 12 was used to list answers to the questions in a file which gathered together the participants' answers for each question. In other words the answers to question 1 were in one file, the answers to question 2 in another and so on to question 24. This enabled consideration of the collected answers to be compared and analysed more directly against the question. Further, the participants' answers were coded under the six perceived risk categories and further coding within the categories was carried out to refine the themes.

3.4.4. Analysing and interpreting the data

The steps to analyse and interpret the data are as follows;

The transcripts were distilled into the 24 questions and reread several times.

Any a priori ideas and knowledge concerning the phenomena was bracketed in order to mitigate the potentially harmful effects of preconceptions held by the researcher.

An examination of various coding methods was carried out resulting in the selection of a structured method (Saldaña, 2012).

Coding according to Saldaña (2012) on page 3 is;

"A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language based or visual data"

A first run coding of the data to obtain broad themes was completed. Themes are an outcome of coding and analytic reflection.

The themes were distilled in order to provide detailed material rather than generalised information (Saldaña, 2012).

Key factors from the literature review were synthesised with the analysis.

The outlined steps were performed against the background of a phenomenological qualitative model as described earlier.

Saldaña (2012) describes six categories of first cycle coding methods. These have twenty two subsets. Of the six categories the most applicable method to this research was "elemental methods" for the following reasons: within that category the "structural coding" was determined to match with the conceptual framework of this study and permit an analysis, which expressly answered the research questions. According to Saldaña (2012) the structural coding method is suitable for use in virtually all qualitative research and particularly for multiple participants answering semi-structured questions using major categories or themes, such as the use of perceived risk to guide the creation of data. The first round coding produced detailed themes and findings such that a second coding cycle, whilst considered unnecessary, was carried out to ensure the findings were accurate.

Analytical methodology was also formally considered. The three most used models of reasoning are induction, deduction and abduction. Bloomberg and Volpe (2012) describe induction as being data driven, deduction is theory-driven analysis (theory determines the data) and abduction seeks an understanding of why something happens. As previously stated, this study employed an inductive method to interpret the data produced by the interviews.

3.5. Summary of validity and reliability of this research

In the course of describing the methodology, numerous references have been made of maintaining validity and reliability. Those methods are summarized below.

Firstly the use of the Theory of Perceived Risk (TPR) applied a discipline to the framing of the questions used in the interviews. Section 3.3.1 table 3.2 lists the questions and the rationale for them. According to Van Manen (2016) constructing questions using instruments such as the TPR provides direction and purpose to the interviews. The TPR has been utilized in research by M. Koklic (2011) and Perez-Cabanero (2008) into housing and infrequent purchases of expensive items. V.-W. Mitchell (2015) describes 30 years of the use of TPR, which confirms its reliability in seeking consumer perceptions and attitudes.

Using a consistent set of questions throughout according to Kumar (2014) and Guba and Lincoln (1994) results in data which is reliable and has predictive validity. This method was used in all the interviews asking two sets of questions around the same PowerPoint presentation.

Bloomberg and Volpe (2012) consider stating propositions based on certain premises provide important issues around the topic of the research, which can be revisited at the end of the research. The propositions can be found in Section 1.2.1 and as a result of the research were found to be flawed.

The participants were purposively chosen using strict criteria. Miles and Huberman (1994) argue this discipline enables the successful replication of the research and this aspect is expanded in Chapter 5.

Finally, Neuman (2011) and Kumar (2014) both recommend open-ended questions to reduce bias on the part of the researcher. Open-ended questions allow participants to create responses within their social experiences instead of the responses the researcher may have.
By using the TPR, and a focused purposive sample of participants who were asked exactly the same questions searching for perceptions and attitudes to OSM housing, the study was satisfied.

3.6. Conclusions

This chapter has described the method, and the methodological design used to obtain the data needed to explore the questions raised by this research.

Uses of phenomenological principles were explored describing their suitability when seeking consumer beliefs, particularly in regard to their perceptions and attitudes. Important aspects related to this method were explored such as bracketing and reduction, finding meanings and establishing themes from the interviews. The rationale for recording the interviews and actions to transcribe and validate the data were examined.

Strengths and weaknesses of the phenomenological methods were stated to ensure awareness of factors that could compromise or enhance the study.
It is important to note Creswell (2014) suggested that rather than to seek bracketing (isolating the personal experiences of the researcher) which is extremely difficult, the researcher should introduce his own personal understandings into the study and incorporate those in the analysis. This was accomplished by establishing research propositions P1 – P6 from the literature review.
An important aspect of the methodology for this study was described, the use of the Theory of Perceived Risk, a tool developed by marketing disciplines to assess consumer's choices based upon perceptions of uncertainty and the

consequences. Further, recognition of the variability in the perceptions of consumers was discussed, and therefore the need to use caution when developing conclusions from the data.

This chapter addressed the benefits of a qualitative research methodology when examining diverse and intangible attitudes. The focus and rationale for participant selection and methods of attracting suitable participants was described.

Finally, the interview process and extraction of the data were documented. Importantly the methods for transcribing the interviews and the use of IT together with accepted and recognised systems of analysis were specified.

The next chapter examines the interview material and the data generated by the research methodology.

4. Chapter 4 Analyzing Data and Reporting Findings

4.1. Introduction

Chapter 3 described the phenomenological research method adopted in this study to elicit individual experiences through interviews with participants. This research addressed the subject of housing and the subjective and objective attitudes of consumers to housing choice in general, and then in regard to OSM housing. The following research questions initiated this study.

What are consumers' attitudes to conventional housing and OSM housing?
What are the relationships between risk, perception and attitudes to conventional housing and OSM housing?

This chapter describes the interview results and analysis of the data.

Firstly, in section 4.2, the codes and themes developed using NVivo 12 are examined against the TPR and summaries developed for each of the six risks. An x against letters identifying each participant indicates responses from the participants. This action sought the extent of agreement and frequency of consensus to the codes. *It should be noted that the codes in the analysis are derived from the responses to the questions specifically developed for conventional and then OSM housing.* The questions were developed to address the different attributes of the housing models.
Secondly, data from the interviews was examined seeking the participants' perceptions of conventional housing in Australia and then for OSM housing. The data (framed by the TPR) from the interviews was analysed. The results were compared and contrasted with the P1–P6 consumer keys described in section 2.4.8 and the conceptual framework guiding the research described in 2.4.9. These two sets of results were then synthesized to develop tables indicating frequency of links to P1-P6 and frequency of the relationship of P1-P6 and the TPR. These tables informed the research questions.

4.2. Tables of coding results from the interviews

These tables list each of the codes obtained from the analysis of the interview responses. Individual responses are then aligned with the codes. The method found any concurrence or otherwise between the participants' answers to the questions based upon each of six risks comprising the "Theory of Perceived Risk".

4.2.1. Social risk for conventional housing

Codes	Agree houses can express an consumers personality	Disagree houses can express an consumers personality	Families houses are important places for family life	Wealth has a positive effect on perceived personalization of a house	Labels Are attached to a houses' occupants and even suburbs	Cost is an important factor for housing
Participants						
A		x			x	x
B	x		x			
C	x					
D	x				x	x
E		x		x		
F	x		x		x	
G				x		x
H	x		x		x	
J			x	x		
K	x					
L	x					
M	x					
N	x			x	x	
O			x	x		
P	x		x	x		

Table 4.1. Comparison of responses to social risk for conventional housing

*4.2.1.1. **Summary of table 4.1***

Table 4.1 shows that there was strong support for the principle of housing expressing the personality of the occupants. However, participant **G** expressed a

cynical view; “Not necessarily, generally no. The only time I see it is when people have a lot of money. They can express it then”.

There was moderate support for the importance of houses for successful family lifestyles. Participant **H** was more explicit; “I would also say yes that’s true but I want to make the distinction between a house and a home, a home is much more likely to express the personality than a house”.

4.2.2. Social risk for OSM housing

Codes	Environmental credentials this is an important principle for the worlds sustainability	Cost Important to control and reduce if possible	Positive response To the OSM systems	Sustainable Attributes of the OSM houses is appealing	Authorities Perceived as negative to OSM
Participants					
A		x	x	x	
B		x	x		
C			x		
D	x		x	x	
E			x	x	
F			x		
G	x	x	x		
H	x	x	x		x
J	x		x	x	
K			x	x	
L	x		x	x	
M			x		
N	x		x	x	x
O			x	x	
P	x		x	x	

Table 4.2. Comparison of responses to social risk for OSM housing

4.2.2.1. ***Summary of table 4.2***

Table 4.2 indicated there was general agreement that housing which has best practice characteristics of design is a preferred system confirmed by **H**: “Because the earth’s sustainability solutions can be expensive and you need to balance that with what you can do.”

All participants were positive for the OSM systems. The participants were impressed by the OSM systems citing surety of time for supply as desirable, controlled cost essential and lack of faults indicating a quality product. This contention was endorsed by participant **D** who said, “Something that can be repeated indefinitely, that does not use non-renewable resources, consume stuff that cannot be replaced and I guess you would broaden it to include the triple bottom line stuff.”

Some concern by participants was exhibited in regard to authorities accepting the use of OSM systems and also as to whether the systems satisfied regulatory controls. Participant **N** replied, “But although the systems claim complete control they still face the issues of difficult councils.”

4.2.3. Financial risk for conventional housing

Codes	A house is a home	A house is an investment	A house is both a home and investment	Delays In construction expensive	Skills Deficits are causing extra costs	Stress Can be a by-product of housing selection
Participants						
A	x			x		
B		x		x		
C	x			x		
D	x				x	
E		x		x		
F	x					x
G			x			x
H	x					
J			x	x		x
K			x		x	x
L		x				
M	x					x
N	x			x		
O	x					
P			x	x	x	

Table 4.3. Comparison of responses to financial risk for conventional housing

4.2.3.1. ***Summary of table 4.3***

Table 4.3 indicates the participants demonstrated a preference to regard a house as a home, rather than an investment. However, there was a strong awareness that houses are in any event a sizable investment of both time and money. Participant **J** replied; “Primarily it’s a place to live. Yeah I guess the investment side of it wouldn’t come up till years later down the track and that’s something we are not interested in at this stage.”

It was also mentioned that elongated construction times can be expensive adding to overall cost and sometimes by going so far over budget the house is then

unaffordable. These issues also result in stress for the owners supported by participant **K** who said, “I think the owners get frustrated, and in some cases the builders get frustrated.”

Interestingly, most of the participants were aware of the difficulty in obtaining skilled trades for both new building as well as repairs to existing houses. Participant **D** replied, “I think residential building has been professionalised enormously in the last 20 years but skill and craftsmanship has gone backwards.”

4.2.4. Financial risk for OSM housing

Codes	Investment positive response for OSM	Investment negative for OSM	Fixed price for a completed house is positive	Quality of OSM Is acceptable	Appearance acceptable	Sustainable Aspects well received
Participants						
A	x		x		x	
B	x		x		x	
C	x				x	x
D	x			x	x	x
E		x				x
F	x			x	x	
G	x		x		x	
H		x				
J	x				x	x
K	x		x			x
L	x				x	
M	x				x	x
N	x					
O		x			x	
P	x		x		x	x

Table 4.4. Comparison of responses to financial risk for OSM housing

4.2.4.1. ***Summary of table 4.4***

It was remarkable to find in Table 4.4 that most of the participants regarded the OSM housing as a sound investment. Participant **E** stated an often expressed sentiment in regard to OSM housing, “I think they are less solid than site-built houses.” and therefore would not regard the OSM houses as a desirable investment. Later in the interview participant **E** suggested that despite her concerns she would seriously reconsider. Support for a fixed price for a house,

whilst unsurprising, was extremely positive. Participant **L** replied, “Of course it would, absolutely it would, and being fixed gives you peace of mind.”

The suitable and attractive appearance of housing has been shown to be an important factor for social acceptance (Craig et al., 2000) and the OSM houses were found to satisfy these criteria. Sustainable housing is considered important for the reduction of waste and energy conservation (Barrett & Wiedmann, 2007) and OSM was considered by the majority of participants to be sustainable. However participant **B** astutely recognised an issue for financing non-conventional housing, “If it were a kit home the banks would not want to know you. Owner-builders have a similar issue for finance.”

4.2.5. Physical risks for conventional housing

Codes	Poor workmanship resulting in defects and danger	Health risks such as mould/spores and chemicals such as VOC's	Pollutants such as asbestos and formaldehyde	Safety devices can fail such as hot water valves	Maintenance of defective work exposes danger of accidents	Authorities and regulations ignored may be a hindrance to consumers
Participants						
A		x		x	x	
B	x	x		x	x	
C			x			x
D	x	x	x	x	x	
E	x	x	x		x	
F				x		
G				x		
H		x				x
J			x			
K	x	x			x	
L		x			x	x
M		x			x	
N		x				x
O	x					
P	x		x			x

Table 4.5. Comparison of responses to physical risk for conventional housing

4.2.5.1. ***Summary of table 4.5***

In Table 4.5 most participants indicated they were aware of the consequences of poor workmanship describing issues such as leaking water pipes and faulty wet area sealing and the subsequent damage to internal linings. Often as a result mould develops and on occasions participants described the need to evacuate the houses until repairs were completed. Historical actions such as faulty installation of roof insulation were mentioned which resulted in serious injury to

workers attested to by participant **O:** “various things such as when you are in the roof space do not touch the metal conduits the pink batts scandal, batts over wires it overheats and all those sorts of problems.”

The issue of trust in the correct implementation of building codes was also a concern following recent and recurring failures in compliance. Participant **C** commented, “Houses have to comply with the law. Today you take for granted these will be included.”

Currently the approval of installations and fabric relies on self-certification by the trades and then a sign off of the certificates by a private certifier. In the words of participant **D,** “So there was a period there from the 60s to the 90s where we were using a lot more of these products and had not yet appreciated the downside of them and I know quite a few tradespeople who have carked [sic] it from it.”

4.2.6. Physical risks for OSM housing

Codes	No physical concerns security or anxiety	No peer group pressure Expected for choosing OSM	Site safety no expectation of mould/voc's and a safe site for workers	Fixed cost Mitigation of stress
Participants				
A	x			
B		x	x	
C	x			
D	x			
E	x			
F	x			
G	x			
H		x		x
J	x		x	x
K	x	x		
L				x
M	x			
N			x	
O		x		
P	x	x		

Table 4.6. Comparison of responses to physical risk for OSM housing

4.2.6.1. ***Summary of table 4.6***

In Table 4.6 the majority of participants were supportive of most of the OSM systems for the potential of a quality product, which precluded unwanted contaminants and resulted in safe sites for workers. Participant G stated: "I love the fact that it turns up and it's just erected and you don't have the site in disarray for four months, probably 4 to 6 months".

There were no concerns for security or anxiety being a product of an OSM system as supported by participant **E** who said: “I would not feel stress or anxiety buying one of those houses.”

Support for the model was also noted due to the proposition of a fixed cost as stated by participant **L**: “No sense of concern due to the fixed price and time that would ease the stress side of things.”

4.2.7. Performance risks for conventional housing

Codes	Maintenance quality labour and materials will reduce need for repairs	Innovation with new technologies will improve housing performance	Sustainable houses becoming more passive to conserve resources
Participants			
A	x		x
B	x		x
C			x
D		x	x
E	x		x
F	x		x
G			x
H			
J	x	x	x
K			x
L		x	
M		x	x
N			
O			
P		x	x

Table 4.7. Comparison of responses for Performance risk for conventional housing.

4.2.7.1. ***Summary of table 4.7***

Table 4.7 indicated the participants were cognisant of the importance of quality of the materials and trades work in order to experience less maintenance on their houses with participant **F** suggested: “upfront costs may be a little more but in the life of a house it is insignificant.”

They were also aware of the new technologies available now and in the future such as passive design, efficient solar installations and the smart IT. Participant **J** stated, “So, we were waiting for technology to kind of get up to speed here and for the prices to come down before we were to commit.”

A final word regarding the performance of conventional housing was offered by participant **E:** A sustainable house has to be built such that the house will not deteriorate as you hand them the keys.”

4.2.8. Performance risks of OSM housing

Codes	Concern for site safety mitigated by OSM	No concern for safety due to factory conditions	Customisation choice of layouts and ongoing flexibility is a positive	Sustainable Attributes such as energy conservation is a positive
Participants				
A		x		
B			x	
C	x			
D	x		x	
E		x	x	
F	x		x	
G		x	x	
H				
J	x			x
K				x
L	x			x
M	x			
N				x
O	x		x	
P	x			x

Table 4.8. Comparison of responses for Performance risk for OSM housing

*4.2.8.1. **Summary of table 4.8***

Table 4.8 found the issue of site safety for workers was initially understood by three participants. Following the information session in the Power Point presentation the issue became important for five other participants expressed by participant **J:** “it hadn’t really crossed my mind hearing about that it certainly is on my radar and it makes that decision making more important for me.”

Site safety for some participants was an issue only for the builders or construction companies. Customisation was perceived as a benefit to many whilst the concept of ongoing flexibility of layout eluded others. Again, sustainable houses proved to be an extremely desirable attribute for the participants. participant **L** stated: “An energy efficient home would be a great attractor.”

4.2.9. Time risks for conventional housing

Codes	Liveability the preferred criteria for a new house to avoid unnecessary change	Flexibility able to change with minimal disturbance is a preference	Nil flexibility Encourage different systems for variety of choice
Participants			
A		x	
B		x	
C	x	x	
D			x
E			x
F		x	
G	x	x	x
H			
J		x	x
K	x	x	
L		x	
M			
N			x
O		x	
P	x	x	

Table 4.9. Comparison of responses for Time risk for conventional housing

*4.2.9.1. **Summary of table 4.9***

In relation to the question of functionality, Table 4.9 found the common reply was for the house to be liveable. There was an understanding that if a house causes

inconvenience frustration may result. There was clear understanding of the pitfalls, which befall alterations and additions to existing houses, particularly time delays and cost variations.

Therefore if designs for housing could accommodate the ability to easily change this would be in participant **J**'s view, "something that is affordable as well as I guess affordable as well as sustainable for a period of time as well, that it will suit our changing needs."

Participant **D** dissented from the group in regard to flexible housing systems: "ensuring that we've got different models of housing that people can access."

4.2.10. Time risks for OSM housing

Codes	Positive for low maintenance	Negative for low maintenance	Positive for speed of delivery	Negative for speed of delivery	Knowledge More information would enable better decisions
Participants					
A	x		x		
B			x		
C					x
D		x		x	
E	x		x		x
F	x		x		
G				x	x
H					
J	x		x		x
K	x		x		
L	x		x		
M					
N	x		x		x
O					
P	x		x		

Table 4.10. Comparison of responses for Time risk for OSM housing

4.2.10.1. ***Summary of table 4.10***

Table 4.10 found the low maintenance regime offered by OSM was well received by the participants and confirms previous sentiments that quality materials and competent tradespeople more often produce a product with few defects. Factory produced items that are mass-produced enjoy acceptable time, cost and quality. The participant **D** who rejected short time frames and low maintenance explained his experience of housing provision has resulted in a certain level of skepticism: "No and if that becomes a selling point I think that is a destructive thing because if something takes 16 weeks to do it well, doing it in 12 weeks is not progressive." The other dissenter repeated previous reactions concerning the longevity and stability of OSM houses. Participant **G** stated: "Is it firmly fixed to the land or is it going to shift over time, you know it is not going to lift and shift."

Some participants stated they were ignorant of the availability and forms of OSM housing, suggesting lack of promotion has compromised the market.

4.2.11. Psychological risks for conventional housing

Codes	Modern lightweight contemporary finishes	Open plans free flow of space	Conventional expression of housing	Comfort An abode with efficient thermal properties	Sanctuary a house offering privacy mixed with community
Participants					
A	x			x	
B	x				x
C		x			
D	x				x
E					
F			x		x
G	x	x			x
H					x
J				x	
K		x	x		x
L		x		x	
M		x			
N			x		x
O					
P			x		

Table 4.11.Comparison of responses for Psychological risk for conventional housing

*4.2.11.1. **Summary of table 4.11***

Table 4.11 indicated the importance of privacy to housing occupants and the choice of the level of community involvement are clearly demonstrated by the code sanctuary. This aspect for housing choice is made evident by the preference for detached models, representing 70% of Australian housing supply. Participant **N** suggested: “It’s about not feeling part of someone else’s environment”.

Conventional features favoured by some are verandahs and often, conventional exteriors with modern interiors. The majority of participants preferred modern light spaces and designs as stated by participant **A**:

"I've got to say I like all the new modern finishes, lightweight finishes" referring to some of the OSM examples.

4.2.12. Psychological risks for OSM housing

Codes	Positive cognitive for OSM	Negative cognitive for OSM	Open planning Of houses is considered to be preferable	Peer group Agreed positive reaction to OSM occupants	Promotional support for OSM	Future evolution Regarded as a positive
Participants						
A	x			x		
B	x			x	x	
C			x	x		
D	x			x	x	x
E	x			x		x
F				x		
G			x	x	x	
H				x	x	
J				x		
K			x	x	x	x
L	x		x	x	x	
M			x	x		
N	x			x		
O		x		x	x	
P		x		x	x	x

Table 4.12. Comparison of responses for Psychological risk for OSM housing

*4.2.12.1. **Summary of table 4.12***

In Table 4.12 the reaction of the participants to the question of how they would regard people who purchased an OSM house can be distilled into the comments by participant **J**

“I think just taking all things into consideration in their choice I think that I would say personally if someone was to take something on like that they obviously have a fairly well rounded value system and they are fairly forward thinking”.
Clearly the majority of participants were supportive of the OSM systems. The dissenting views could be interpreted as reflecting a strong personal opinion. For example participant **O** said: **“**Maybe it’s a reflection of the current styles of extremely boxy houses. You can see it in our neighbourhood a conventional house and they put this box off it and very close to the boundary.”
Many participants suggested that the OSM systems are not promoted sufficiently and therefore according to participant **B**: “In its infancy, how does it become sustainable in terms of the market, it needs large companies to promote it”.
Participant **P** who participates in the housing industry summed up: “It’s no different to modern but if that’s the way architecture is going to go then that’s what is going to happen. It’s evolution you know.”

4.2.13. Conclusion

Housing is regarded as having attributes that express the personality of the occupants. This indicates a level of social significance. There was definite approval for the OSM housing systems thus signifying social acceptance.
Housing is regarded as an investment as well as a home. There was also understanding of the importance of maintaining the value of that investment through appropriate maintenance. For the OSM system participants accepted the system for investment and considered the house to have positive attributes of low maintenance.
The participants expressed concern for the quality of conventional housing and the shortage of skills in the industry causing harm to the occupants through contamination. No physical concerns were felt for OSM houses.
Participants have concern for the environmental performance of housing and are aware conventional systems have issues for this respect. For the OSM system there were positive responses for sustainable aspects of the system and a positive reaction to better site safety.

For family enjoyment liveability was highly regarded. However, the mention of changes to houses elicited concern about discomfort during change and poor prospects for timely conclusion. The participants, as found earlier, regard OSM housing to be of quality, involving less maintenance and highly regarded in terms of timely delivery.

Houses are regarded as homes rendering security and a place of sanctuary. The participants once aware of the OSM systems agreed they would satisfy their needs in regard to a home.

4.3. Findings, interpretation and perceptions from the interviews

This part of the analysis was conducted in two parts. Firstly, perceptions about conventional housing were obtained, and then perceptions concerning OSM housing.

The results are expressed in tabular form.

The tables used in this section re-examine the data from the interviews and interpret the findings to find the correlation for the risk with the perceptions P1-P6. The number of occurrences was then noted and a matrix developed to find the relative strength of the participants' perception of conventional and OSM housing.

4.3.1. Consumer perceptions for conventional housing

4.3.1.1. ***Social Risk***

The questions about social risk for conventional housing were:

Q1. Some people suggest that houses can express the personality of its owner. What is your view?

Q2. It has also been said that people label others by the type of a house they live in. What do you think about this statement?

4.3.1.2. ***Responses of the participants***

There was a general consensus that the choice of housing to some extent expresses the personality of the owner. One participant, **F,** suggested a house expresses lifestyle and how the family lives, whilst participant **B** claimed houses today are too large compared with years past, reflecting a common, current, lifestyle desire. A response from participant **H** held the opinion that if a house is regarded as a home, this then reinforces the identity of the owner, implying an emotional level of involvement. For an expression of individuality, participant **O**, made a comparison between a new purpose built house and the purchase of an existing house indicating that having a personal choice for a new build has a stronger bearing on the final character of the house than a preowned example. According to the participants the choice of a new house or a pre-owned house can express the owner's personality.

In relation to the question about labelling people through their housing choice, universally the aspect of wealth and expense was mentioned. Both participants **E** and **N** suggested that houses at the affordable end of the spectrum, it can be more difficult to express personal attributes while people with greater resources are able to do so more readily.

Participant **G** said: "I don't necessarily think an expensive home is a nice home, it says something about their wealth and where it is located".

Often the accrual of style was strongly tied to wealth. Interestingly that was also stated by participant **K,** in respect to pragmatic regional dwellers, mentioning wealthy farmers for whom style or luxury is not notable on their list of desirable features.

Participant **O** said "it is true it [house] does reflect your status in society as well as your situation in life".

Participant **E** brought up the subject of people interpreting housing quality by making a comparison between a house and images in the ubiquitous housing magazines. This issue mentioned earlier of media affecting consumer attitudes to choice recurs later in the interviews.

4.3.1.3. Findings, interpretations and perceptions for social risk for conventional housing

Findings	Interpretations	Perceptions P1-P6
Twelve participants agreed that housing choice expresses the personality of the owner, while three believed some do and some do not. The choice of house, new or preowned, can express the personality of the occupier for observers.	Consumers of housing are concerned as to opinions of people in regard to their choice of housing. Choosing a house involves a number of factors, budget, personal preferences and previous experience.	P5, Housing is important to lifestyle and well-being. A preowned house also involves choice of style and lifestyle. P6 Housing cost which is affordable is important to engender financial security. Choice of a preowned house also reflects consumers' financial capacity.
If a house is regarded as a home, this then reinforces the identity of the owner,	This confirms there is an emotional level of involvement in housing choice	P5 There is evidence housing needs to satisfy needs of well-being.
There was a comparison made between a purpose built and purchase of an existing dwelling for expressing individuality.	Having personal choice for a new build has a stronger bearing on the final character of the house due to greater choice and customisation.	P4 Consumers have high regard for choice in housing particularly for customisation to create perceived individual styles.
In relation to the question of labelling people through their housing choice, universally the aspect of wealth and expense was mentioned as an influence. For houses at the affordable end of the spectrum, it can be more difficult to express personal attributes whilst people with greater resources are able to do so more readily. Often the accrual of style was strongly tied to wealth. Interestingly it was also	Consumers believe conventional housing solutions are superior with greater financial resources. The corollary is also true. Consumers also understand some members of the community do not need to express their personality through their house.	P5 Housing clearly has a profound effect on consumers' lifestyle. P6 Houses can be a financial indicator of status in a community.

stated that in respect of pragmatic regional dwellers (*wealthy farmers*) style or luxury is not notable on the list of desirable features.		
People interpret housing quality by comparison with the ubiquitous housing magazines.	Publications impart knowledge the consumer would not otherwise have.	P2 Knowledge is important to overcome expectations which can be difficult to realise.

Table 4.13. Social risk for conventional housing

4.3.1.4. ***Summary of table 4.13***

It could be concluded from the responses that housing and status is considered to be an expression of a house owner's personality. There appeared to be an underlying reluctance to admit wealth as a strong criterion for assessing a house-owner's status. However personal traits are important for Australians when making a housing choice (Mares, 2018; Paris, 1993). According to Gurney (1999) housing can imbue a sense of pride for the home owner through customisation. In the literature it is very clear housing is regarded to be a reflection of status in the community, on various demographic levels from typical community lower and middle class through to the upper classes (Clapham, 2011; Marsh & Gibb, 2011). One simple expression of status is the preferred use of brick for external surfaces, evident in the use applied brick cladding in a biscuit form to prefabricated housing to emulate a full brick conventional house (Lovell & Smith, 2010).

Housing plays an important role in the self-image of consumers, particularly in regard to the status afforded by their choice of housing. Currently conventional housing according to the data fulfils that need.

4.3.2. Financial risk

Questions seeking responses to financial risk for housing in general were:

Q3. Do you regard your house primarily as a place to live or as an investment?

Q4. In your opinion what are the financial implications when housing has elongated construction times?

4.3.2.1. ***Responses of the participants***

The balance between liveability and investment is an important nexus in housing choice. This question produced clear opinions from all the participants. 7 regarded livability as most important, 5 looked for a balance and 3 stated a house is an investment.

"…a bit of both" "I probably wouldn't over capitalize" "a place to live….a house has become the biggest tradable commodity and is undermining so many things in our society," "in the next house we would seek a balance".

Interestingly, comment was made by participant **P** in relation to the interaction of neighbours to create a sense of community, reinforcing the importance of liveability. It was participant **J** who suggested that early in family life, choice was aligned to addressing immediate modest needs rather than in the making of an investment. Part of the choice paradigm also included the type of accommodation expressed by participant **B,** who found a three bedroom house was less sound financially than a four bedroom house, reflective of the current Australian attitudes which prefer larger houses (for those who can afford this option).

As for opinions to what is most important in housing choice, both liveability and investment were given equal weight. There was a full understanding of the risks involved. All participants had a story to tell about acquaintances or themselves, of suffering adverse financial outcomes due to problems with choice of housing, particularly where they had a direct relationship with the builders through a contractual arrangement.

There was a clear understanding of the issues involved in long construction times and as a result, compromised financial outcomes. Not only because of the burden of one or two mortgages during the build and on-site costs such as scaffolding and accommodation infrastructure, but importantly the emotional strain of delays and financial pressure. Participant **A** described one build as so unsatisfactory in terms of time that he undertook his next build as an owner-builder to retain control of the construction program and therefore finances. Participant **F** also pointed out the building process is slowed down not just by builders but by authorities through lengthy bureaucratic processes. Participant **J** also referred to the unsatisfactory process caused by the uncertainty of progress when seeking a final proposal from her consultants that would satisfy her criteria. Participant **K** suggested not only that house owners become frustrated, but also builders specifically mentioned the issue of a shortage of suitably trained tradespeople.

4.3.3. Findings, interpretations and perceptions for financial risk for conventional housing

Findings	**Interpretations**	**Perceptions P1-P6**
The balance between liveability and investment is an important nexus in housing choice. This question produced clear opinions for investment or liveability for all of the participants.	Owning a house in Australia is important evidenced by the high rate of house ownership. Apart from the need for shelter houses represent security, physical and financial.	P6 Housing which can be afforded enables Australians to fulfil an important life goal of owning your own home.
Housing choice also involves the type of accommodation and the relationship to sound financial considerations.	The marketplace drives choice for housing through availability and cost.	P4 Housing choice is not simply housing which suits a brief but can be affected by financial outcomes

There was a clear understanding of the issues of long construction times and as a result compromised financial outcomes and emotional stress.	New build housing can be detrimental to financial viability and emotional security due to cost and time overruns.	P6 If housing production has fixed budgets and time constraints housing choice may be simplified.
The procurement of housing is elongated not just by builders but by authorities and consultants.	Procurement of housing is complicated and confused by multiple agencies as well as contractors and sub-contractors.	P2 The process needs to be more direct and simplified. Communication from the housing industry should be improved.
Not only prospective house owners become frustrated, but also the builder due to a shortage of suitably trained tradespeople.	The housing industry is deemed inefficient and frustrating for consumers and the industry.	P6 In Australia there is a shortage of skilled trade people, and that situation is worsening due to less apprenticeships being offered and less applicants for trades. This results in poor productivity and additional costs and financial pressure.
As for attitudes to what is most important in housing choice, liveability or investment, equal weight was given to both. There was full understanding of the risks involved; all participants were aware of suffering adverse financial outcomes due to problems with housing choice.	Consumers are aware that the housing construction industry is problematic for efficiency and productivity resulting in poor outcomes.	P1 The consumers are frustrated by the housing industry which demonstrates unviable attributes for time, cost and quality. Communication should be improved to improve consumer knowledge.

Table 4.14. Financial risk for conventional housing

4.3.3.1. ***Summary of table 4.14***

It is evident that consumers recognize the industry has issues which compromise its ability to produce housing which does not exceed financial budgets and time constraints (T Dalton et al., 2013). There is frustration on the part of consumers

and industry constituents with the current processes but seemingly no obvious solutions for improvement ***(Woudhuysen & Abley, 2004)***.
The industry finds difficulty in addressing the issues of supply and cost particularly in regard to skilled trades and increased training to remedy the situation. Noonan (2016) describes the current apprentice training programs as inadequate due to a politically compromised training regime.
Housing is an essential component in Australian lives.
Robinson and Adams (2008) argue that increasing housing costs results in poor health outcomes and this is evident in the responses from the participants.
Due to issues of cost for some house owners (and prospective owners) significant financial stress may lead to insecurity and compromised well-being.
Conventional housing solutions while having poor characteristics for cost and productivity remain the only choice for most consumers.

4.3.4. Physical risk

Questions seeking responses for issues of injury in regard to conventional housing:

Q5. What have you heard about injury risks in houses?

Q6. When choosing a house, what aspects in regard to being safe from injury do you think might concern you in regard to your family?

4.3.4.1. ***Responses of the participants***

There was general recognition of issues adversely affecting health in houses such as mould and spores. Other contaminants present and understood by the participants are volatile organic compounds (VOC's) including the historical presence of asbestos and lead. Surprisingly, the participants often mentioned problems created by services as health risks. For example participant **P**

mentioned electrical services as a risk when carrying out alterations or working with old installations and obscure gas pipes, when demolishing sections of a house. Other risks include the use of urea- formaldehyde glues, silicones and mineral fibres, causing ill health both during construction and in use by users. Participant **D** has worked in the construction industry and stated “I think it’s going to get worse”, and “it’s a really significant issue” referring to the potentially injurious effects of contamination on workers.
Some physical issues were mentioned such as falls involving stairs and balconies, falls from windows and injury from very hot water.

Significantly, houses are not regarded as intrinsically having serious threats to health or the prospect of injury, otherwise consumers would avoid them, and that is clearly not the case.
Previously aspects of poor workmanship and lack of skilled trades have been described resulting in reworking and compromising liveability. Participant **K** described a common failure in housing: “We have just had two bathrooms rebuilt and the work was just appalling so again the workmanship of on-site stuff there is variables there you just cannot control.”

It is certain consumers place trust in the current systems. Participant **C** suggested, “Houses have to comply with the law”. Participants **L**, **M** and **N** also referred to the law and codes offering protection from injury within and around houses.

*4.3.4.2. **Findings, interpretations and perceptions for physical risk for conventional housing***

Findings	**Interpretation**	**Perceptions P1-P6**
Issues identified adversely affecting health were mould and	Participants are aware of common health threats which exist in	P2 Knowledge does not necessarily transpose into active

spores, volatile organic compounds (VOC's), asbestos and lead contamination.	houses. Consumers demonstrate little concern for these threats.	consideration of physical risks.
Services of electricity and gas were also described as potential physical risks.	When altering existing housing there are risks. Misuse of equipment can also result in injury.	P2 Knowledge of danger does not override the need for housing particularly when suitable housing is in short supply especially housing which can be afforded.
During construction, physical risks include use of urea- formaldehyde glues and mineral fibres (and asbestos in older houses) causing silicosis. Physical risks from contamination were thought to be increasing due to recent materials introduced and inadequately scrutinised.	Construction workers are exposed to many health risks during construction. Inhabitants are also exposed during occupation of the houses.	P2 This research has described an unacceptable level of accidents on building sites. Mitigation of this scenario for conventional systems is difficult to achieve albeit both the industry and consumers have knowledge of this shortfall.
Some physical injuries were mentioned such as falls involving stairs and balconies, falls from windows and injury from very hot water	Participants had knowledge of potential injury caused by some housing design elements. Most of the injuries mentioned are essentially poor occupant behaviour.	P5 Use of housing requires prudent lifestyle choices to preclude injury.
Participants were certain building regulations would offer protection from injury. However they also recognise poor outcomes arise from inferior installations.	Consumers expect housing to comply with building regulations.	P1 Acceptable quality in housing is a proposition not supported by current housing examples.

Table 4.15. Physical risk for conventional housing

4.3.4.3. ***Summary of table 4.15***

Consumers have long associations with conventional housing and this familiarity has resulted in confidence that they understand both the product and the process

(Koebel, 2008). As a result regardless of flawed housing causing poor health outcomes, consumers accept the product.

In addition, the housing construction industry uses conventional systems and practices which result in injury and debilitating illnesses for its workers (Lingard, Blismas, Cooke, & Cooper, 2009; WorkcoverNSW, 2014).

Consumers are confident that regulations and the authorities protect them from risks associated with health. However, there is significant evidence to suggest that compliance with the building codes is problematic. Perinotto (2019) argues as a result of high profile building failures in Sydney and Melbourne, that governments must take action to ensure adherence to the codes.

Regardless of physical risks for consumers and workers, conventional housing production continues to be the option adopted by most consumers.

4.3.5. Performance risk

The questions seeking responses to housing performance were:

Q7. Please describe your views in regard to the need for repairs to and improvements of a house.

Q8. What in your view improves the performance of houses for sustainability, for example, energy and water usage?

4.3.5.1. ***Responses of the participants***

The interviews indicated there were concerns for the need to maintain an expensive asset, albeit begrudgingly. Further, there was clear understanding that the choice of the highest standard of affordable materials, systems and equipment would reduce the need for maintenance. Participant **A** stated: “It would be nice to have one that is less maintenance in the future”.

The participants expressed concern for roofs and their potential to leak with the subsequent damage to the house's interior finishes and structure. Other areas for water damage included leaks from windows and faulty bathroom seals.
The second question for this risk demonstrated clear concerns for a house to include the new technologies such as solar hot water systems and solar power generation. Participant **D** in particular mentioned LED lighting, passive house performance, and efficient heat pumps for heating and cooling. He also expressed the sentiment that the use of these technological advances, particularly on-site power generation, demonstrated empowerment and engagement for a community. Most of the participants understood the concept of passive housing design. Participant **A** stated "I'm very interested in having a house that is as passive as possible."
Participant **K** described the value of using grey water systems for the conservation of water particularly in remote areas where connected water is often not available. The responses for this risk demonstrated the community has a clear understanding and concern for current dilemmas facing the world, water shortages and increasing costs of energy.

4.3.5.2. Findings, interpretations and perceptions for performance risk for conventional housing

Findings	**Interpretation**	**Perceptions P1-P6**
Participants stated maintenance whilst necessary could be reduced if quality systems and materials were employed in construction.	Maintenance is recognised as grudgingly essential for housing longevity. The consumer also understands that the housing industry could build houses with fewer defects and of better quality.	P6 A house represents an important investment and must be protected. P1 Quality produced housing has less maintenance however the conventional industry seems to be unable to improve aspects of time, quality and cost.
Participants were very aware of	Defects in housing production	P1 Quality produced housing has

issues for water damage, whether from roof, window or building fabric and the result is damage to structure and personal effects.	result in damage and loss.	less maintenance. However as stated previously this characteristic eludes the conventional housing industry.
New technologies such as LED lighting, solar systems and heat pumps were readily accepted providing their cost was within budget	New technologies can improve consumers' lifestyle through better environments and cost savings. Many of these technologies arise from principles of sustainability.	P3 Sustainable technologies have the potential to improve lifestyle which enhances health and well-being.
Sustainable aspects such as suitable water supply and energy supply were of concern. Passive house design interested most of the participants.	There is more awareness by consumers of technological developments which result in sustainable outcomes.	P3 Concerns for sustainable outcomes can be satisfied by new technology. P5 Lifestyle can be improved by new technology.

Table 4.17. Performance risk for conventional housing

4.3.5.3. ***Summary of table 4.17***

The participants recognized technological advances in society including housing have the potential to improve their lifestyles (Ding, 2013). Housing represents a significant investment which must be maintained in order to retain the value. The participants also suggested a house that has been produced with quality as preeminent criterion will require less maintenance and will have greater longevity. According to Robinson and Adams (2008) quality housing has a positive effect on the well-being of its inhabitants. P Love and Edwards (2004) however argue that the numbers of defects in Australian construction are increasing and the associated costs and delays are unacceptable. Further, conventional housing exhibits poor aspects for performance and there is evidence the industry resists change (Roy, Brown, & Gaze, 2003). Yang and Yang (2015) argue that new technologies, which improve systems, are increasing in their availability and cost effectiveness. These technologies reduce emissions allow more efficient use of energy and improve the environment and consumers lifestyles.

Housing that performs well and satisfies the needs of the community are essential to communities. Currently housing in Australia was recognized by the participants as not performing to a satisfactory standard.

4.3.6. Time risk

The questions seeking responses for the risks associated with time were:

Q9. What things are most important to you in the function of houses, how they work?

Q10. What is your opinion in regard to the importance on flexibility in housing, for example accommodating change in family size or the way you live?

4.3.6.1. ***Responses of the participants***

There was little adverse reaction to the risk of time in relation to housing in general. Throughout the interviews participants regarded time spent in maintenance and repairs as regrettable but necessary. While the interviews attempted to tease out attitudes to time spent due to the need to alter a house to suit new needs, this only met with moderate concern.

There was however evidence of an understanding of the principles of what comprises good house design. Participant **C** for example said: “Function is more important than the way it looks”. Aspects of design such as screened outdoor areas, natural light, breezeways, northerly aspect, thermal mass and the need for a house that functions well were mentioned many times.

Introducing the option of a house that could be flexible intrigued some of the participants and nine of them considered the concept favourably. While they had not considered the possibility before, it could be a consideration in the future, participant **C** replying: “Flexibility is a good idea, we hadn’t thought about it. You tend to look at the long term for housing design”. Participants **J, K** and **P**

suggested flexibility for conventional housing often meant carrying out alterations and additions an experience which “can be difficult and stressful” as well as “hugely costly”. Participant **P** stated “Alterations and additions are bad stories, mostly bad”.

*4.3.6.2. **Findings, interpretations and perceptions for time risk for conventional housing***

Findings	**Interpretations**	**Perceptions P1-P6**
There was little concern from the participants in regard to time expended for housing, other than time expended in maintenance.	Lack of concern for time lost or gained is possibly due to the expectation that time would be amortised over a long period of time.	P2 Experience and knowledge of conventional housing has resulted in latent acceptance of what is the norm that is loss of convenience and time making corrections to a house.
For this research time was equated with the future quality of the house and its ability to adapt to future needs. The responses from the participants indicated an appreciation of the concept but little in the way of how to do this.	Flexibility in housing to enable ease for change is a favourable concept but difficult to envisage.	P4 Consumers anticipate the need for future customisation to meet future needs however they also accept the challenges for the process.
To accommodate change in houses to new functions, the participants envisaged alterations and additions to accomplish this goal. To make change it was recognised this process is potentially stressful and expensive.	Altering and adding to existing houses is an undesirable process.	P4 Consumers regard future customisation of housing as stressful however they accept the process as unavoidable.

Table 4.18. Time risk for conventional housing

4.3.6.3. ***Summary of table 4.18***

The risk of time was not identified as a serious concern. This is possibly due to the fact that houses are regarded as a long term involvement for the consumers (S. Smith, 1994). The participants had experienced (either personally or by acquaintances) the often unpleasant and time-consuming process of alterations and additions. There was the acknowledgement that time would necessarily be invested in maintenance. This was also mentioned in the assessment of the risks for performance. Conventional housing, regardless of well understood deficiencies, is nonetheless accepted as the only option (Warren-Myers & Heywood, 2016).

4.3.7. Psychological risk

The questions seeking responses to psychological risks were;

Q11. Can you describe your preferences for housing in regard to:

- *Appearance the style and presentation,*
- *Size for example the number of rooms,*
- *Materials such as external finishes, internal features in bathrooms or kitchens.*

Q12. What is it in a house which gives you the sense of security and privacy?

4.3.7.1. ***Responses from the participants***

Responses to the questions regarding attitudes to the style of housing were unsurprising, for example in houses using timber frames and linings and conventional designs of houses with verandas. Participant **F** stated: “We tend to like conventional Australian design with verandahs around and cross-flow air,

with gable roofs which conventionally look good," and N commented: "We want it to look like it came from a period we respect but inside it is modern."

However, there was criticism by participant **D** of the current examples of project houses being like a "painted cardboard box", and by participant **P** who was disappointed by the demolition of existing houses of a period, and their replacement by a house with a different character. Participant **B** stepped outside the square stating he would not use brick and tiles, opting for newer materials such as aerated concrete.

There was little concern for security and some for privacy, particularly in regard to noise. There was general consensus that houses should be bright and airy with contemporary finishes, good ventilation and optimal site orientation to address a northern aspect and appropriate interaction with neighbours. Open planning was favoured with careful arrangements in regard to separation of functions, e.g. communal areas to quiet rooms.

There was mention of the problems facing future home buyers in the aspect of housing cost, noting the increasing prices of houses and land particularly in major cities which can result in a consumer's attitude demonstrating poor self-perception.

*4.3.7.2. **Findings, interpretations and perceptions for psychological risk for conventional housing***

Findings	**Interpretations**	**Perceptions P1-P6**
Responses to aspects of style could be categorised as conventional citing timber, verandahs and pitched roofs.	Attitudes to housing style and function follow expected conventional norms. The participants are not aware of relevant and feasible options to conventional housing solutions.	P2 The response to questions of housing style and form are unsurprising and follow acceptance of housing products which have serious outcomes for time, cost and quality despite knowledge of these issues by the industry.

There was significant criticism of the new wave of housing where existing houses are demolished and a new house erected which was styled with statements unrelated to context or function.	Participants were cynical of the new wave of housing designs comparing them with pastiche.	P5 Acceptable styles for housing are related to a sense of well-being.
The participants had great interest in principles of good planning to include the correct orientation, efficient planning of spaces and integral integration of privacy from neighbours.	Consumers have a sense of what constitutes good housing design.	P4 Consumers can differentiate between good and poor housing solutions; therefore if they are shown options which are viable for time, cost and quality and customisation it could be concluded there would be strong interest.
Cost of housing was mentioned as being of concern.	Consumers are dealing with escalation of house prices to a point where some have no expectation of owning a house.	P5 Serious issues for mental health arise when suitable accommodation is not available.

Table 4.19. Psychological risk for conventional housing

4.3.7.3. ***Summary of table 4.19***

Consumers in the interviews had opinions as to what constitutes suitable housing designs, citing orientation and efficient planning. However, preference for a conventional style may compromise their access to better performing housing. There was criticism of the designs currently offered by the Australian market in which the houses focus mainly on unique appearance to the detriment of the existing streetscape. There was concern in regard to the current phenomena of cost and poor expectations of home ownership for first home buyers (M Thomas & Hall, 2016).

The prognosis for housing cost is for increasing stress and an inability to afford to buy houses, leading to the genre of permanent rental of housing (M. Thomas,

2008). This dynamic has the potential to change the way Australians have experienced housing and life to date (Martin, 2018).

4.4. Questions seeking consumer attitudes to OSM housing

4.4.1. Social risk for OSM

The questions seeking responses to social sustainability and housing were:

Q13. Often sustainability in our society is defined by three aspects; social (our social obligations to each other), environmental (global warming and climate change) and financial (a successful economy). Can you describe your attitude to these goals?

Q14. What is your understanding of the term 'sustainable housing'?

*4.4.1.1. **Responses of the participants***

In order to set a baseline to compare reactions to the OSM examples presented, a question was posed to find the participants' stance in regard to sustainability. Surprisingly there was in general a lack of comprehension of the concept of the triple bottom line comprising the factors of environment, social and financial goals for the global sustainable community. The individual answers placed an emphasis on aspects of finance and cost over those aspects of society and environment involved in housing choice. Only participant **H** stated there had to be a balance struck between the three factors. Participant **A** linked a socially responsible position with environmental issues: **"**I mean if you are socially responsible then you are going to build a house that is ecologically sound."

Participant **N** expressed himself and the general sentiment well when he said: “as a motherhood statement I find no difficulty with it” [sustainability]. “As with all things it comes down to the financial situation you find yourself in”. Participant **N** had had the misfortune of attempting to obtain a new house but was then frustrated by the poor performance of his consultants and builders, and that together with council errors resulted in an outlay of unexpected substantial resources. He completed his answer to this question: “So the point is living by high minded goals gets a bit shattered”.

Participant **O,** in answering the question in regard to understanding the concepts of sustainability, revealed a sceptical position suggesting sustainability is probably used in many cases as a marketing tool.

A probing question sought opinions in regard to perceptions of consumers who would choose the OSM systems. Participant **A** suggested only a certain demographic would choose the OSM systems stating further that typical suburban dwellers would *“not have any interest in these houses”.* This opinion could be construed as a position from which criticism was made of those consumers who would have poor preconceptions of the OSM system. Participant **D** suggested there would be a caveat for acceptance of OSM: “These are the future however there is a need to consider appearance vs substance,” a clear reference to unacceptable historical examples of OSM. In regard to financially viable outcomes for OSM housing, participant **A** stated: “Financial, well if it’s efficiently done then it’s going to be financially good all the *way round.”*

Participant **G** reflected other participants’ comments stating she had preconceived images of OSM houses as “they cannot always be as modern or as nice a looking home”, and “my second perception is that they are quite expensive”.

Participant **J** criticized house builders as being unwilling to look at alternatives to improve the sustainability of housing, and further suggested that those same builders are “always in your face”. This suggests that the top tier housing providers hold a position of market power and therefore exert control of the product. She suggested the OSM industry should promote their product enabling

comparison of conventional with the OSM housing. Participant **K** who was impressed by the OSM systems but unaware of the offering until shown the examples in the presentation supported this position.

*4.4.1.2. **Findings, interpretations and perceptions of social risk for OSM housing***

Findings	**Interpretations**	**Perceptions P1-P6**
There was a lack of knowledge of the concept of harmonizing environmental, social and financial goals for the global sustainable community.	Although the literature argues a majority of Australians are concerned about climate change and human contributions to change, it appears they have a lack of knowledge as to what action can be taken to mitigate the problem.	P2 and P3 More education of the public is necessary if meaningful actions to address climate change are to be undertaken.
In regard to housing choice, participants' emphasis was on aspects of finance and cost over those of social balance and environment.	Personal concern for housing cost is an understandable trait. Housing in Australia is often described as the "Australian dream".	P6 These responses support a proposition of this research that housing cost is of great concern to consumers and that unaffordable housing will have poor social outcomes.
The responses revealed a sceptical position suggesting sustainability is probably used in many cases as a marketing tool without providing sustainable solutions	Consumers are knowledgeable in regard to market offerings and the need for "buyers beware".	P2 Based upon the responses it is doubtful as to whether consumers have the knowledge to avoid the market strategies created by concepts of sustainability.
The responses to the question of consumer acceptability were contradictory. It was stated that those who would not choose the OSM systems are those who inhabit typical suburbia, but then praised the OSM systems by	The interpretation would be that there is a preconceived notion that consumers generally find OSM housing cheap and undesirable however the models shown in the presentation looked expensive.	P2 This supports a premise of this research that OSM (prefabrication) is undesirable to many consumers compared to conventional systems for appearance and quality due to a lack of knowledge.

suggesting they must be expensive.		However this is questioned by consumer observations that the OSM housing as demonstrated is expensive, and therefore could assume good quality.
Builders would not be interested in offering the OSM product because they already have sufficient market share.	Consumers believe house builders are not interested in the OSM system.	P2 These comments create another premise for this research, that the housing industry is not the vehicle for OSM housing, more likely manufacturers. The industry lacks knowledge in regard to the OSM product.

Table 4.20. Social risk for OSM housing

*4.4.1.3. **Summary of table 4.20***

Leviston et al. (2014) in their report for the CSIRO stated over 80% of Australians believe climate change is happening. However, the results of this research indicate consumers have an imperfect understanding of the issues.

In Australia there is concern in regard to housing cost (ABS, 2017; MacKillop, 2013), therefore it is not surprising that this issue strongly affects consumer attitudes, particularly for those contemplating house purchase (Bruce & Kelly, 2013).

The responses from the participants gave mixed messages. The OSM systems were described both as appealing to a low socio demographic and expensive. Additionally there was a suggestion by the participants that typical suburbia would reject the OSM systems due to the systems being expensive, however no mention of any other disincentive such as appearance or longevity.

There was considerable support for better promotion and exposure of the alternative OSM housing product and the qualities described in the presentation. This would indicate that the participants had little or no apprehension in regard to the OSM being an option for their housing choice if the OSM product is readily available.

4.4.2. Financial risk for OSM

For the second set of questions related to financial risk for housing choice, contrasting finance with issues of sustainability (particularly time cost and quality) was considered important to the research questions.

> *Q15. Of the nine examples of houses that demonstrate good sustainability practices, what are your views about attractiveness, form, materials and overall appearance?*
>
> *Q16. The nine houses shown here are offered with a fixed price and a fixed delivery date. As we have discussed, these attributes are not commonly found in conventional housing offers. How would you describe your reaction to the differences?*

4.4.2.1. ***Responses of the participants***

As discussed in the literature review, an important issue is the substantial investment in housing and whether the choice of housing will realise a satisfactory return (or loss) on that investment. There is sufficient data to indicate that the choice of housing produced by other than conventional means will struggle to find consumer acceptance with the potential result of a financial loss on resale.

However, in the interviews no such reluctance was present, 11 participants were extremely positive and the remainder favourable.

There was some evidence of path dependencies in the interviews. For example participant **E** was of the view that the OSM were less “solid than site-built houses”, however given the current unsatisfactory circumstances in the construction industry, participant **E** said she would not have a choice but to consider the OSM technology. In contrast participants **D**, **J** and **N** stated the OSM would be a good investment, and participant **J** further reinforced a common theme from the interviews suggesting greater exposure of the typology would result in knowledge and acceptance (supported by **A**). Participant **K** stated he

had not seen these housing examples before but was of the view that OSM systems being produced under factory conditions would benefit from quality control processes.

The second question and prompts for financial risks required care in the selection of the models of OSM chosen for the visual prompts. The selections were based upon the positive claims made on the manufacturers' promotional websites. The claims for environmental sustainability, fixed price and delivery dates must, by Australian consumer law, be accurate and able to be substantiated. All the manufacturer's had been in the industry for more than 5 years, so it could be assumed if there were credibility issues they would no longer be trading.

From the responses to these questions it is clear both a fixed price and delivery program are desirable and incentives to choose OSM. Positive responses were qualified by participants **N** and **H** suggesting local councils could constitute a negative influence due to concern for unknowns. This then again argues that the exposure of the OSM systems must be employed to educate authorities and consumers. This was reiterated by participant **B** who stated: "it needs to be promoted on TV etc." But that also raises another barrier to consumer acceptance in the availability of finance, an issue also covered in Chapter 2. The visual acceptability of the OSM system was evident when participant **G** suggested she would refer the houses to an architect to inform them as to "reference points" for her future housing needs.

It was interesting to note that participant **P** suggested one potential positive for acceptance of OSM systems would be for the supplier to offer supportable guarantees similar to motor car warranties.

4.4.2.2. ***Findings, interpretations and perceptions of finance risk for OSM housing***

Findings	**Interpretations**	**Perceptions P1-P6**
OSM houses are often regarded as being less solid. They may also be less secure when there are storms.	This issue arises from early examples of prefabricated housing and association with temporary housing, for example mining villages.	P1 There is a perception that OSM housing is of inferior quality compared with conventional housing. P2 Consumers lack experience and knowledge of OSM housing.
Participants have opinions that conventional housing has poor quality issues.	As a result some participants suggested alternative housing solutions may be acceptable.	P2 Consumers are knowledgeable that conventionally produced housing has unacceptable attributes.
There was acknowledgement that factory produced houses could have superior qualities than conventional houses due to better quality controls.	This aspect of housing production could ameliorate poor perceptions of OSM housing.	P1 and P6 As described in the literature review, OSM producers in Japan are offering extensive warranties and guaranties which engenders confidence in quality and investment for financial security.
Fixed prices and fixed times for delivery was attractive to all the participants.	There is dissatisfaction in regard to the cost and reliability of the current housing offer in Australia.	P2and P6 Consumers are aware of frustration with the conventional systems of producing housing; however they cannot easily find other options. Having knowledge of fixed costs is a financial incentive to accept OSM housing.
The participants were able to identify negative issues for OSM housing such as obtaining finance, navigating authorities and building codes. They also were concerned about the lack of knowledge of the products.	Clearly there are tasks for the OSM industry if it is to improve market penetration and consumer acceptance.	P2 The housing industry in contrast to the construction industry needs to reconsider its position and responsibilities to consumers in order for there to be ready availability of viable housing. The housing industry

		needs to be informed as to housing options.
Positive responses were praise of the appearance of the systems and the suggestion warranties would assist in promotion of the systems.	OSM systems are acceptable housing solutions however more support from the industry is needed.	P2 The OSM industry needs to be more proactive in promotion, not just to consumers but to the housing industry, for example finance authorities and agents enabling better knowledge.

Table 4.21. Finance risk for OSM housing

4.4.2.3. ***Summary of table 4.21***

Clearly the participants had concerns for OSM housing in regard to permanence and quality, a preconception informed by the associations with pre-fabrication of early systems of housing and temporary accommodation (M Koklic & Vida, 2011). Therefore investment in an OSM house could have risks. Obtaining finance for OSM housing is more difficult than for conventional systems due to established methods of funding based upon progressive payments and security on the building site (Steinhardt et al., 2013a) . Concerns of time, cost and quality were noted for conventional housing construction. Indeed it was these concerns that interested the participants sufficiently to consider alternative systems. There was recognition that manufacturing per se has characteristics which offer cost, time and quality certainty due to controlled systems and shorter time frames, particularly where weather and site conditions prejudice delivery programs (Arashpour et al., 2013). The housing industry must address the issues of time cost and quality confronting consumers. The producers of OSM housing must address the issue of better promotion and servicing the market.

4.4.3. Physical risk for OSM

Questions asked seeking responses for physical risk are as follows:

> *Q17. Would you have any physical concerns in regard to buying one of the three houses for example, stress or anxiety?*
>
> *Q18. The three houses shown claim to have design characteristics which reduce the occurrence of mould, and all three avoid volatile organic compounds (VOC's). What is your reaction to knowing that?*

4.4.3.1. ***Responses of the participants***

There was a universal response in the acceptance the OSM evidenced by ten participants who expected no physical concerns or emotional stress. Participant **K** elaborated and added that because the OSM is produced in a factory he would have great confidence due to their quality procedures and systems. Participant **K** stated "in the factory there are procedures and systems that control all that. So I'd much rather that."

That there would be less disarray on the house site was commended by participants **G**. **N** had concerns in regard to longevity of the OSM systems recalling versions he saw produced in the 1970s which he described as "pretty crummy". Those concerns according to participant **N** would only be satisfied by inspecting an OSM house which had been in use for at least 5 years. Participant **G** also had concerns for durability fearing a house "would be stronger if fixed on the land" rather than "placed on the block*"* a factor more related to the next risk, performance*.* However participant **G** also said *"*I love the fact that it turns up and it's just erected and you don't have the site in disarray for four months, probably 4 to 6 months."

For the OSM housing systems presented to the participants there were positive reactions to the warranty of a fixed time for completion and a fixed price. Participant **L** responded to the first question "no sense of concern due to the fixed price and time that would ease the stress side of things."

Finally all participants were pleased that factories had quality controls for manufacture of OSM systems, which controlled issues of contamination, avoiding adverse effect to their health. Participant **E** expressed the participants' responses and further suggested the houses would be pleasant abodes. "Definitely no mould or VOC's would definitely be attractive. It's got to be a pleasant place to live."

*4.4.3.2. **Findings, interpretations and perceptions of physical risk for OSM housing***

Findings	**Interpretations**	**Perceptions P1-P6**
Response to the OSM houses indicated no concern or issues which may lead to stress or anxiety in choosing an OSM system.	The models of OSM houses were readily accepted as liveable houses.	P1 There is no physical risk presented by the OSM models to the participants due to the promise of quality.
There was confidence in the quality of a factory produced product.	There is an understanding of the advantages of quality controls implicit in factory manufacturing.	P2 Due to understanding factories offer quality management there is confidence in the OSM systems for quality.
There was recognition that sites for assembly of OSM housing would have less waste and clutter than conventional systems.	The participants were satisfied site safety would be superior to conventional systems.	P5 The OSM houses would satisfy the occupants' lifestyle for health and well-being.
There was still an element of uncertainty in regard to both longevity and stability of the OSM system.	Lack of personal familiarity of the OSM system causes the uncertainty.	P2 There is a need to introduce methods to enable knowledge and experience of the OSM system for consumers.
Time cost and quality were factors understood to affect the liveability of housing	Consumers are aware of the affects housing can have on their well-being.	P5 The housing industry must consider time cost and quality when providing housing to satisfy the need for suitable enjoyment.

Table 4.22. Physical risk for OSM housing

4.4.3.3. ***Summary of table 4.22***

The OSM houses presented no issues in regard to health risks. There was a level of confidence engendered by the production of the houses in a factory environment particularly due to quality management (M Luther et al., 2007.). Recognition was noted of less safety issues on a site using OSM to produce housing (N Blismas et al., 2007). The housing industry needs to fully consider the benefits of OSM realizing better characteristics of time cost and quality when compared to conventional systems (Engstrom, 2006; Nadim & Goulding, 2011; C Pasquire, Gibb, & Blismas, 2004)

4.4.4. Performance risk for OSM

The questions seeking responses to the risks for performance were:

> *Q19. One of the factors listed in talking about issues of productivity in building houses is the problem of poor working conditions. Accidents for conventional construction sites result in the highest rates of permanent injury and workers disability claims of any industry. How important do you think these factors would be in the overall decision about the type of housing you might opt to build?*
>
> *Q20. We talked about flexibility before. If we focus on the capacity to adjust to climatic conditions and meet individual energy goals, what is your view of the nine models shown when they claim to have the flexibility to adjust to meet any climatic condition and meet individual energy goals?*

4.4.4.1. ***Responses of the participants***

The responses to the first question were mixed. Most participants were unaware of the high levels of accidents on work sites, and this factor would therefore have little bearing on their housing choice. There was discussion and an understanding that manufacturing environments are safer than site based activities. Participant **D** stated: “You are probably at an advantage if you are in a

controlled environment", and participant **K** reinforced that view saying: "the more the process is controlled the less variables".

Replies to the second question were positive in regard to product flexibility, although some struggled to understand how this would work in practice. Some interpreted the flexibility to be climate related. Participant **J** believed the concept as adjusting a house to optimize climate performance and was supportive stating: "ensuring that a particular home and design was constructed in a way that met the climatic needs of our local environment." There was support for the concept of fine-tuning a house to perform satisfactorily in different climatic conditions**.** Participant **J** supported this desirable attribute responding: "that would be certainly something that would be important to me um, ensuring that that particular home and design was constructed in a way that met the climatic needs of our local environment."

However participant **P** was skeptical of the housing industries motives claiming sustainable principles to promote their product: "we have seen people bending the rules to achieve the energy goals".

Flexibility of houses was also interpreted as planning options, for example the number of bedrooms.

For performance of houses, the responses to the probing questions elicited more useful data than the initial questions. There was concern for typical problems involving water and leaks, but interestingly new technologies, particularly digital, were either misunderstood for their potential impact or disregarded as an aid to better housing performance.

Clearly the performance of the OSM system was unfavourably compared to conventional on-site systems. Participant **G** confirmed this concern responding: "I guess I would wonder how it would stand in terms of durability as opposed to a site, a house that is built on site, it's built there so my perception would be stronger on a fixed on the land rather than something that was made off site and come and placed on the block so durability would probably be a question in my

mind.” In contrast there was discussion in regard to the potential quality of OSM houses supported by participant **L** who stated: “it has that feel good factor that there are controlled environments that they are constructed under**.**

Participant **B** criticised conventional systems as being inflexible and potentially expensive: “Flexibility of choice is important, in contrast to a builder who will not consider tasks which are innovative unless they want to charge large extras.” Flexibility was fully imagined by participant **G** who stated: “Yes I think that would be a massive bonus [flexibility] particularly for budget constraints build one of these and put them on a block with the foresight you might place it a little bit forward or back so that later on you might have plans to add another module or another sort of area if need be or things like that, yes it would definitely be a bonus going into this with the knowledge that there is flexibility in the future, that would be a good selling point.”

Finally the issue of knowledge was repeated as a hindrance to choosing the OSM house. Participant **J** expressed concern for the OSM system to suit her purposes due to owning a steep block of land…” I think my only, my only thought process for myself would be that I’d need a lot of questions answered only because of my lack of knowledge we have a fairly I guess a difficult block to build on.”

*4.4.4.2. **Findings, interpretations and perceptions of performance risk for OSM housing***

Findings	**Interpretations**	**Perceptions P1-P6**
Consumers are not aware of the serious issues of on-site safety for the house construction industry workers.	Consumers would not make a housing choice based on better safety for housing production workers.	P2 Consumers have no knowledge of site safety issues and unless the benefits of OSM housing are promoted consumers would not make this an issue for housing choice.
The participants were aware that	Consumers could make the	P3 Consumers with interests in

factory working environments are regulated and the controls protect workers.	paradigm shift to choose housing systems which have greater safety for workers.	outcomes would have regard for this important aspect of community concerns for safety for workers.
The concept of a house which has attributes of customisation was well received.	Consumers understand the benefits of flexible housing solutions.	P4 Offering flexible solutions and variety for houses could be a powerful incentive for consumers choosing an OSM house.
The concept of housing which could be fine-tuned to suit individual sites for both planning and climate was well received	Consumers are unaware of systems which can be flexible and responsive to their brief.	P4 Consumers would be pleased to have opportunities to customise their house and fine tune the measures to address climate.
Use of advances in technology for improving housing was not recognised as added value.	Although consumers are aware of numerous technologies available today, they are unaware of those technologies for use in housing.	P3 New technologies available with OSM housing could be attractors to future consumers to improve aspects of sustainability.
The participants reacted positively to the concept of housing having the ability to satisfy future needs of families.	If consumers were aware of OSM systems which could satisfy future change they would consider that system.	P4 While recognising not all OSM housing systems offer future options for accommodation this incentive could be offered by some of the industry.

Table 4.23. Performance risk for OSM housing

4.4.4.3. ***Summary of table 4.23***

While the participants were unaware of the dangers to workers on building sites, they expressed concerns once appraised of the problem. Gibb (1999) suggests OSM demonstrates the safety benefits for workers in factory environments producing housing, and that could be an important aspect for housing choice. Flexibility in housing design such as fine tuning orientation and insulation as climate mitigation measures to suit individual sites, a feature rarely available for off-the-shelf conventional project houses, may also affect choices. Customization of planning, finishes and fixtures ranked highly as desirable characteristics for personalization (J Barlow & Ozaki, 2004). There are new technologies and

materials available to the construction industry, however it is clear the industry accepts only those which align with conventional systems (Ivory, 2005). Therefore production of OSM could be construed as better aligned with manufacturers rather than the conventional construction industry.

4.4.5. Time risk for OSM

The questions seeking responses to time risks were:

> *Q21. The OSM houses claim low maintenance regimes offering time savings for the occupants. Would this be a positive /negative influence on your housing choice?*
>
> *Q22. The three models claim short manufacture and assembly times. How would this affect your housing choice?*

While there was general agreement a low maintenance house would be attractive, the reasons given were noteworthy. Participant **J** admitted to her lack of knowledge in regard to carrying out building repairs and therefore had the need to ask friends to help or to hire in services. Importantly there were references to the "hassle of getting trades" (**N**) and "always disappointed in the workmanship" (**A**), a characteristic of the construction industry (P. Love, 2002). There is poor availability of trades in construction and that scarcity is growing. Additionally many trades in the industry demonstrate poor levels of skills. Only one participant did not agree the OSM houses were low maintenance, participant **D** expressed his view "Low maintenance for those houses you have shown me, I am not convinced the models are that."

The responses in regard to fixed production times and fixed cost reflected a broad understanding of the process of house building and the apparent difficulties in obtaining set timeframes and budgets. Participant **B** suggested the OSM offered to young people the ability to choose an accommodation plan to suit their immediate needs and add later for "less

expense, less rent, less borrowing allowing money to finish the landscaping etc." Participant **K** stated that, "price increases can get out of hand as there is an increase in build time". The issue of poor weather conditions on build sites was mentioned by participant **N** stating: "Therefore short construction times would be a major consideration".

In contrast, participant **D** took a different philosophical position: "if it takes 16 weeks to do it well doing it in 12 weeks is not progressive" and "in fact this [short time frame] devalues the house as sustainable socially more". Clearly participant **D** was referring to the need for skilled trades to be given time to achieve quality. Participant **D** went further, decrying the goal of short time frames for housing production "No and if that becomes a selling point I think that is a destructive thing". Later however, he acknowledged the unacceptable issues for the construction industry of shortage of skilled trades and compounding that, low apprentice placement. Participant **G** reaffirmed her earlier concerns that she would need to be assured the OSM would not: "lift and shift particularly in coastal regions". Finally, participant **J** who has experienced poor outcomes previously, wasting years due to an inability to obtain a new house within her budget, stated: "so I am better educated after all this". The OSM offer is fixed in time and budget.

Participant **B** was particularly attracted to the OSM systems shown to him citing customisation and flexibility of the houses: "I am amazed by the offers these manufacturers make and really like the prospect. If you want e.g. double glazed then if they offer it I will be happy".

4.4.5.1. Findings, interpretations and perceptions for time risk for OSM housing

Findings	**Interpretations**	**Perceptions P1-P6**
A low maintenance house is attractive indicating consumers begrudge time spent on repairs.	If a housing system is promoted as low maintenance consumers will be attracted to that system	P1 The OSM housing systems shown in the presentation claimed quality control afforded by a controlled factory environment.
A low maintenance house is also attractive to consumers due to a shortage of skilled trades to efficiently and affordably carry out repairs and maintenance.	The consumer is aware of difficulties in carrying out maintenance on housing and the subsequent erosion of their time seeking repairs.	P6 Unless necessary maintenance is carried out on a house the house's value and image will diminish. This results in poor financial outcomes. The OSM systems offer better control of investment and finance.
Fixed budgets and timeframes for procuring a house is an important factor in housing choice	Currently housing provision is perceived by consumers as difficult in terms of fixed budgets and time frames.	P6 Both uncontrolled budgets and timeframes add cost to housing. Solutions such as OSM offer assurance for these factors and therefore improve financial performance.
Consumers are aware of the poor performance of builders and scarcity of skilled trades in the industry and as a result understand there are uncertain timeframes.	Understanding the poor outcomes which are normal for housing provision has become an unacceptable expectation for consumers.	P2 Consumers in part due to their experience of conventional housing production and their defects are attracted to the OSM system. From the examples of the participants obtaining knowledge they would have confidence in the system.
There remains some concern as to the permanence of the OSM system particularly in the event of storms.	The historical images of poor prefabrication systems are still fresh in consumers' memory.	P2 This aspect of preconceived attitudes to OSM houses as poor quality will only be neutralised by experience and knowledge.

Customisation is an extremely desirable aspect for housing choice as well as enabling control of acquisition costs,	Offering choice for housing outcomes is a powerful sales tool.	P4 OSM housing is capable of offering controlled choice for various elements of housing.

Table 4.24. Time risk for OSM housing

4.4.5.2. ***Summary of table 2.24***

Time as a risk for housing selection was closely aligned with consumers' concerns such as financial control and emotional stress (Robinson & Adams, 2008). It was agreed by the participants that carrying out repairs or improving a house involved their time. Their time was related to delays in finding trades and then delays in carrying out the work (P Love & Edwards, 2004). Certainty of production time for the OSM system was understood and favourably commented upon by most participants. Customisation is desirable and is possible for OSM producers to offer with their systems (J Barlow & Ozaki, 2004; Noguchi, 2003) Therefore it is reasonable to assume that promotion of OSM housing as being of superior quality to conventional housing systems thereby requiring less maintenance and time to organize or "DUI" the repairs would be attractive to consumers.

4.4.6. Psychological risk for OSM

The questions seeking responses to psychological risk were:

Q23. With your own preferences for housing established in question 11 in the previous section for materials, size and appearance, please describe the positive or negative attributes in the OSM systems shown.

Q24. How would you regard people who purchased one of the three OSM systems housing discussed today?

4.4.6.1. ***Responses of the participants***

The reactions from the participants to the OSM produced by non-conventional systems were extremely positive. Replies such as: *"*they are attractive without being pretentious" and "they look architecturally designed", were responses indicating a high degree of thoughtful interaction with the process*.* Participants **A, E** and **J** found no negative features at all. Repeated phrases such as *contemporary, current styles, dynamic, ultra-modern* were found in the data, reinforcing the impression of a positive reception to the OSM by the participants. Personal preferences were expressed in stage one by participant **P** for pitched roof solutions which none of the houses in the presentation demonstrated, however later stated in stage two: "they [an owner of an OSM] have done their research". Participant **B** also preferred a pitched roof; however the rationale was that of the ease of installing air-conditioning, a factor not addressed by this study, and if this could be solved for an OSM house then he would choose one. At this stage of the interviews, the aspect of life-style television programs arose when participant **F** referred to the similarity of the houses to those seen in Grand Designs, a BBC television show describing in detail housing solutions in the UK, which are unusual in their design or in the systems of construction (including pre-fabrication). Grand Designs is a prestigious program presenting unusual and adventurous housing solutions to which audiences often aspire.

For the second question in this stage, although the focus was on people's judgements, the importance of life-style television programs to the participants' opinions became evident. Clearly, the participants' views were positive for consumers who would choose one of the OSM presented, with expressions such as: "good on them", "I admire them", "they made a well informed choice", "fairly forward thinking", "educated and done their research."etc. recorded in the interviews. This indicates that there were positive attitudes for the introduction of OSM housing presented to the Australian marketplace. All 15 participants expressed positive views of the OSM systems with participant **K** encapsulating all responses: "I think just taking all things into consideration in their choice I think

that I would say personally if someone was to take something on like that they obviously have a fairly well rounded value system and they are fairly forward thinking."

As previously stated, many of the responses during the interviews mentioned media. For example, participant **A** spoke of an American television program describing the work of Joseph Eichler a mid-1960s real estate developer in California, whose work exposed the public to modernist tract housing, an innovative and unorthodox style which contrasted greatly with the bungalows typical of that time (McCoy, 1977). Participant **B** found the OSM innovative and one that could be found on a television reality show, while **H** and **O** believed the houses were similar to those on Grand Designs. Participant **O** also described yet another television program illustrating the work of a Californian architect who designed and assembled a cross-lam house in a relatively short time frame. Participant **O** also commented that in his opinion architectural shows would promote the benefits of OSM.
Participant **H** suggested the manufacturers of OSM should be placing the houses into project house demonstration sites: "you can go and look at, that would be fantastic to go and look and get ideas".

Finally, participant **E** mentioned a factor in regard to a shortage of trade people to maintain the current industry: "Tradesmen today are few and far between, there are no apprentices to learn what it is all about". This position is supported by Noonan (2016).

4.4.6.2. ***Findings, interpretations and perceptions psychological risk for OSM housing***

Findings	**Interpretations**	**Perceptions P1-P6**
The participants were positive in their responses to the OSM systems.	The proposition that consumers, for most of the participants, will not consider OSM housing is	P1 The OSM houses were perceived as high quality and would satisfy consumer

	incorrect.	expectations.
The OSM models were contemporary in their presentation eliciting minor comments in regard to personal preferences for some conventional exterior styles.	Overall the responses to the OSM housing were acceptable for style and lifestyle.	P5 These OSM models satisfied the need for well-being and health expectations contrary to accepted views that OSM housing is unacceptable.
It is clear that the participants had watched lifestyle television programs featuring housing and their reaction to the usually non-conventional examples was positive.	Consumers are interested in housing generally, as an interest and as prospective house owners.	P2 Consumers should be more exposed to the OSM systems and hence gain greater knowledge to enable wider choice.
The participants were positive in regard to consumers who choose the OSM systems.	Consumers who choose OSM housing does not result in poor attitudes as to their status.	P6 Choice of an OSM house will not result in a poor investment and as a result compromised financial situation.
All participants were surprised by the quality and attractiveness of the OSM houses and they suggested they should be more widely promoted on media. They also suggested placing OSM systems in housing demonstration villages to make consumers aware of their housing options.	Contrary to the views expressed in the literature review, all participants were impressed by the OSM models and expressed views that they would consider the models for their future house.	P2 OSM housing systems are clearly different to consumers' preconceived views on pre-fabricated housing. Effective promotion of the OSM systems will enable consumers' wider choice and enjoyment.

Table 4.25. Psychological risk for OSM housing

4.4.6.3. ***Summary of table 4.25***

There was neither concern nor criticism of consumers for their choice of an OSM house. From the participants' comments, it could be construed that there would be a level of support for those choosing these systems. It is relevant to note the importance of exposure to television programs which demonstrated the positive aspects of housing, aspects to which many are unfamiliar (Craig et al., 2000; M.

Koklic, 2011). More exposure of the OSM through accessible systems through villages of display homes was also noted. These considerations are described in the literature review (Venables, Courtney, et al., 2004).

Contrary to current community expectations of OSM housing being inferior to conventional housing as described by Edge et al. (2002), the participants thought there are many benefits to be realized. The participants had few objections to OSM systems or consumers who chose them identified and expressed no cognitive or emotional barriers.

4.5. Summary of perceptions P1 to P6 from the research data

4.5.1. P1 Quality

All participants understood the issue of suitable quality being intrinsic to appropriate housing. All were aware of the quality challenges facing housing choice. Poor quality whether structural or applying to fit-out usually results in financial disadvantage, either payment for repairs or loss of resale value of the property or both. Consumers according to the interviews often assume a house is of merchantable quality while fully aware there may be shortcomings. However they are unaware of and unable to envisage alternatives such as OSM.

While there was reluctance by some to choose an OSM system due to perceived “flimsiness” and the less solid nature of the system, there was recognition that factory produced products often enjoy quality assurance scrutiny and therefore realise quality results. There were also suggestions that manufacturers could offer superior and supportable warranties in contrast to conventional systems where defects in practice are difficult to remedy due to lack of trades and reluctant builders.

The participants overall were of the view that OSM houses present minimal physical risks, that a quality product will save time due to fewer defects and also add to their sense of well-being when having this knowledge. Throughout the interviewing process it was found that poor quality housing products can have an adverse influence on health due to events such as mould and water ingress damaging structure and the fit out. Half the participants mentioned this aspect.

From the summary of the data coding, the participants agreed that a house is an investment and therefore at times a source of emotional stress, e.g. meeting mortgage payments. Some also suggested the uncertainties of the construction industry can result in builders and trades experiencing stress themselves thus compounding quality issues. Participants also identified that stress can also be generated when anxiety is created due to cost and time overruns an event less likely for a manufactured product such as OSM housing.

4.5.2. P2 Knowledge and understanding

In the interviews the participants demonstrated varying degrees of knowledge and understanding of housing provision. Their knowledge was derived from magazines and other media. Importantly consumers gain an imperfect knowledge of systems of construction by casual association over time such as observation of building sites. This exposed the predominant attitude of accepting a flawed product because “that is the way things are”. For example health issues caused by mould were known, although the participants appeared to take no action or enquiry in regard to the problem in their choice of housing. It was clear that the principle of asymmetric knowledge was playing a part in the attitudes of consumers through levels of trust in the housing industry cohorts. Some of that trust was eroded by some industry claims of sustainability where the claims made were exaggerated or false.

Despite the knowledge that housing products exhibit varying degrees of defects, consumers accept them and look to the contractors to fix the problems, to the detriment of the consumer in terms of inconvenience of time and often expense. The participants stated however, that builders would not be interested in the OSM system despite the advantages of the method to preclude expensive and time consuming problems.

The participants had no personal knowledge or understanding of OSM houses. Their contact with OSM was through reality television programs such as Grand Designs, which has among many conventional housing solutions some examples of OSM. Knowledge of OSM was stated to also be provided through magazines such a “Sanctuary” which presents housing with sustainable credentials.

It was clear the participants had preconceived opinions in regard to OSM houses. Those opinions closely followed the views expressed in the literature review. Prefabricated houses were seen to be cheap and of poor quality, lacking style and repetitive. However, following the Power Point presentation, attitudes to OSM houses changed. It is clear consumers need more knowledge and understanding of the OSM housing systems.

4.5.3. P3 Sustainable housing

Sustainable housing was a concept about that most participants had some knowledge, but in practice little detailed understanding. They did express positive attitudes to sustainable OSM housing: 9 believed there would be tangible social benefits, 7 improved financial outcomes and 5 identified superior performance. There was an understanding that it is possible to produce housing which could reduce emissions and reduce energy consumption. The view that new technologies could improve health and well-being was also expressed however little detail was presented. Safe working environments were recognized as being more likely in a factory environment than an on-site operation.

Mention was made of the possibility of fine-tuning a house to suit the different environments of various house sites. Overall, the reaction to the OSM house model was positive given the choice of a sustainable house, on the basis that the model is offered with attributes of quality, timely supply and acceptable cost regime.

4.5.4. P4 Customisation

There was considerable support for houses which have flexibility, a concept not usually considered in the purchase of a house. The flexibility relates to both pre-planning of the house as well as an ongoing ability to change planning configurations to suit circumstances. Participants agreed the greater the choice of inclusions finishes and planning options the more desirable the product. Having choice in the quality or quantity of inclusions potentially enables better control of the budget. Consumers also feel they have a sense of good design which can enhance satisfaction with the housing product particularly if they feel part of the process. Ongoing customization however can be fraught with challenges from cost and time overruns. Of the OSM models presented, some offer design regimes to satisfy the need for future change and this was well received by the participants.

4.5.5. P5 Style/lifestyle

Housing as indicated by the literature review plays an important role in consumers' lives regardless of their demographic. Consumers accept conventional housing styles as a norm. Stepping outside the security of the social norm can be stressful. Therefore exploring the reaction of consumers to the OSM housing system is core in this research. A majority of participants accepted the appearance of the three OSM producers' models and all expressed no concern for their self-esteem in this regard. Aspects of general good health were considered important including the design of the house to create pleasant living environments. Ten participants believed a house expresses the consumers' personality and some agreed a house can be a source of stress (financial or emotional) so the approval for the OSM housing in contrast to the conventional system was instructive to this research.

4.5.6. P6 Investment

As stated previously a house constitutes an important investment. A majority of participants stated the OSM houses would be a suitable investment. Of the three who disagreed, two still had doubts in regard to "solid characteristics" of OSM housing while the third had a positive philosophical position in regard to housing as an investment. However all participants deemed the OSM houses shown attractive. In Australia consumers have the ambition to own their own house and many of the participants believed the OSM system could be a positive product to enable that goal. In a similar vein the promise of a fixed price and therefore surety of investment to satisfy financial considerations was a positive for OSM. Affecting the surety of final cost was acknowledged as threatened if suitably trained trades were unavailable. Furthermore since the industry essentially plays a minor part in the total economy, longevity of the OSM organisations, unless they find financial security, could pose a threat to their continuity of operation.

4.6. Tables indicating frequency of links between TPR and P1 – P6

The occurrences of each perception were listed in the Tables 4.25 and 4.26. Risk and perceptions for housing were ranked, and the variation between conventional and OSM obtained by comparing the frequency for each co-relation between risk and perception. Colours in the table separate occurrences into like frequencies.

4.6.1. Conventional housing

	Social	Financial	Physical	Performance	Time	Psychological	Total
P1		1	1	2			**4**
P2	1	1			1	1	**4**
P3			3	2			**5**
P4	1	1			2	1	**5**
P5	3		1	1		2	**7**
P6	2	3		1			**6**
Total	**7**	**6**	**5**	**6**	**3**	**4**	

Table 4.25. Risk and perceptions conventional housing

4.6.2. OSM housing

	Social	Financial	Physical	Performance	Time	Psychological	Total
P1		2	1		1	1	**5**
P2	3	4	2	1	2	2	**14**
P3	1			2			**3**
P4			3	3	1		**7**
P5						1	**1**
P6	1	2			2	1	**6**
Total	**5**	**8**	**6**	**6**	**6**	**5**	

Table 4.26. Risk and perceptions for OSM housing.

4.7. Matrix demonstrating the relationship between risk and perception

These tables and matrix demonstrates relationships between TPR risks and P1 - P6 perceptions for housing of the participants in the interviews.

4.7.1. Interpreting the matrices for risk and perceptions

The matrices were developed to explore risk and the perceptions of consumers for housing. Creation of the matrices examined the relationship between the six risks of the TPR and the six perceptions held by consumers for housing. Lines were drawn between each risk and perception, the line weight replicating the frequency with which perceptions were linked to a risk by the participants. The number of links indicated strong or weak relationships.

The matrix Figure 4.1 graphically represented the frequency of links by using three different line weights. The weight of line is only related to frequency and does not address emphasis.

Lightest line	1 link
Medium line	2 links
Heaviest line	3-4 links.

Table 4.27. Line weights and links risk and perception

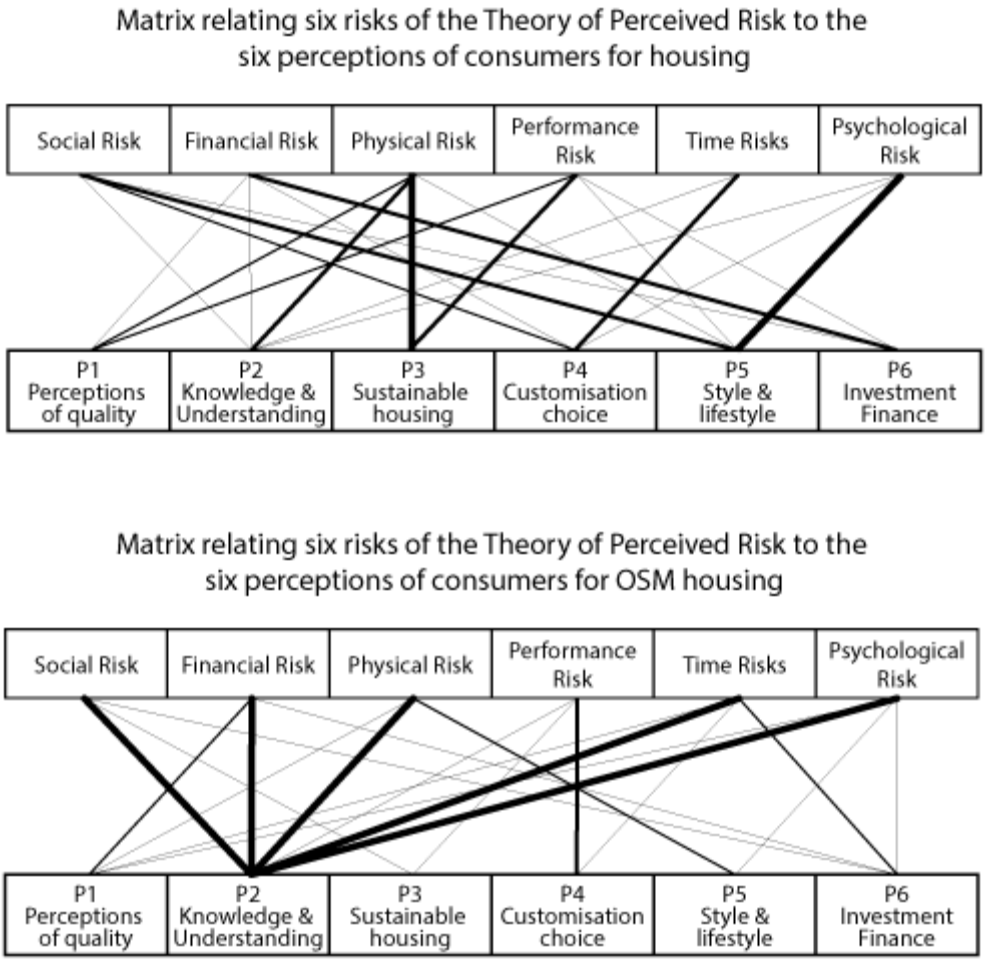

Figure 4.1. Matrix graphically representing a comparison between housing generally and OSM housing for risk and perceptions.

For conventional housing the strongest links are noted between social risk and style/lifestyle, financial and investment risk and physical risk and sustainable housing.

The next links of importance are social risk with investment, performance risk with quality and sustainable housing, time risk with customization, and psychological risk with style.

Overall, style and lifestyle presented as the major concern followed by investment and then sustainable housing and customization. Quality and knowledge were of less concern. These results indicate housing for consumers is

an important support for family and social interaction as well as an important investment. Less concern for knowledge and quality supports the theory that consumers accept the current housing product regardless of the poor aspects of time, cost and quality.

For OSM housing the strongest links are social risks with knowledge, financial risk with knowledge, physical risk with knowledge and customization, time risk with knowledge and psychological risk with knowledge. The strongest link for performance risk was customisation.
The next links of importance are financial risk with both quality and investment, performance risk with sustainable housing and time risk with investment.
These linkages of risk and perception strongly support the concern of the participants for gaining knowledge and understanding of the OSM systems. In general the participants had concerns about style/lifestyle, the implications for investment and finance, and sustainable housing.

These linkages for risk and perception have been applied to the propositions in section 1.2.1.

4.7.2. Revisiting propositions from Chapter 1 section 1.2.1

In Chapter 1 the researcher developed propositions as to what is held to be true in regard to housing choice. Revisiting the propositions and comparing with the research data has assisted in drawing conclusions. The premise on which the propositions were made when tested through the data obtained from the research can now be addressed.

First, financially houses represent a large investment and often provide a stepping-stone to a secure lifestyle. This is demonstrated by Table 4.25 where financial risk accrues three links with investment. This proposition is based on the fact that owning (with or without a mortgage) a house often provides security for loans and other financial transactions (Yanotti, 2017). Will an OSM house

provide this security in regard to finance? From Table 4.26 the strongest link is financial to knowledge, which indicates consumers with understanding and knowledge of OSM can regard OSM housing as a secure investment. This is an important factor in educating finance providers as to potential markets satisfying criteria for sound investments.

Secondly, houses are often regarded as a measure of status in the community. This proposition is guided by attitudes of home dwellers, who insist on customising individual features for their houses (Schoenwitz et al., 2014). Table 4.25 indicates the strongest links are found to be lifestyle and style and it could be argued these factors also include satisfaction with status. Will an OSM house afford the desired status of consumers? From the data the Table 4.26 links to customization were second in frequency demonstrating that consumers feel they can personalize an OSM house in order to enjoy a satisfactory status within their community. This aspect will affect the manner in which OSM housing is marketed.

The third proposition is that people's internal emotions of self-worth are affected by the house in which they live. This proposition is guided by many references to this phenomenon by psychologists describing mental health and housing stress (S. Smith, 1994).In Table 4.25 the strongest links overall were between style and lifestyle, a prerequisite for personal satisfaction. Will an OSM house afford consumers the level of self-worth they require? The data in Table 4.26 clearly indicates consumers can have satisfaction through customization with the choice of an OSM house. In fact there were indications the choice would evince superior understanding of sustainable housing systems. As with the second proposition, this aspect would be a tool for marketing the OSM system.

Fourthly, people prefer "solid" houses. This proposition is based on the preference people have for brick houses (Edge et al., 2002; Greig, 1995). Will an OSM house engender the confidence that the product has quality and solidity to

last and provide security for a long tenure? The links to investment in Table 4.25 suggest investment is an important factor to engender security. There were participants who expressed concern for the “non-solid” nature of pre-fabricated housing; however the majority of participants expressed satisfaction with the quality and sustainable nature of OSM housing. It can be concluded only through exposure of the OSM system to consumers that this attitude of impermanence can be neutralized.

4.7.3. Summary

This chapter presented the data from the interviews and found evidence to indicate that consumers understand there are many unsatisfactory aspects in regard to conventional housing products. The participants in the interviews expressed acceptance of OSM housing contrary to the literature and the housing industries market judgement. The next chapter presents final conclusions and recommendations.

5. Chapter 5 Conclusions and recommendations

5.1. Overview

This chapter describes how the four objectives for the research stated in Chapter 1 were realized. Following this is an explanation of how the research objectives attained the research aims, which then facilitated distilling answers to the research questions. Recommendations are suggested for future research and future policy and practice. Data and analysis obtained in Chapter 4 informed these conclusions. The limitations of the research are described in section 1.6, and a summary of the findings are described in section 4.7.2.

The questions which generated this research were developed from the overarching phenomenon that housing production in Australia suffers from poor outcomes for time cost and quality. Options to mitigate this situation include the use of OSM housing. However the market believes consumers' regard OSM as unacceptable. It was therefore important to directly seek consumer attitudes to housing and specifically explore attitudes to OSM housing. This research sought to answer the following questions;

Research question 1: What are consumer attitudes to conventional housing and housing which is manufactured off-site?

Research question 2: What are the relationships between risk, perceptions and attitudes to conventional housing and OSM housing?

5.2. Realizing the objectives

Objective 1: Identify key perceptions held by consumers to housing.
Establishing consumers' perceptions of conventional housing provides a background for the examination of issues concerning their housing choices. Testing these perceptions in the interviews informed the objectives. The participants in the interviews (the participants) could be regarded as being representative of the general population, in part due to the Hunter Valley/Newcastle region being regarded by researchers as a microcosm of the Australian marketplace.

From the literature six important perceptions held by consumers were distilled in regard to housing choice. This enabled the development of a conceptual framework to guide the study (see section 2.4.5).

The first perception is quality. An acceptable standard of quality in housing adds to the enjoyment of its occupants. Quality not only means a product with longevity free of defects but also one which is well designed. The participants were cognizant of poor quality in the housing construction industry.

The second perception is knowledge, the participants believed they understood the process of the housing construction industry and this in turn promoted trust and acceptance, regardless of the reality for building delays and uncertain costs and defects.

The next perception is that housing should be sustainable. Australians are concerned about the environment and many of the participants understood housing contributes to positive or negative outcomes for the world community.

Consumers believe having the option to customise a house is important if it is to be their home. The participants' perception was that personal touches create a

house different from other houses, thereby expressing the occupants' personality.

Style and lifestyle is the fifth perception and this factor involves peer group pressure. Familiarity and fitting-in is important, particularly to avoid negative attitudes from society.

Financial perceptions are important to consumers. Conventional housing is perceived to retain value and avoid unexpected and unwanted poor financial outcomes.

Objective 1 informed objective 2 by finding perceptions for housing choice.

Objective 2: Establish a hierarchy of perceptions and attitudes for consumers' housing choice.

It was essential to find the relative importance of perceptions and attitudes for housing choice if meaningful analysis of data was to be realized. Codes and themes were developed from the data, and then tables were used to compare the frequency of consumers' responses to each code within each risk category determined by the Theory of Perceived Risk (TPR).

Using the responses from the interviews it was possible to rank the importance of consumers' perceptions and attitudes. The TPR was used to guide several processes, preparing questions and comparing risk to perceptions. The risks established by the theory are social, financial, physical, performance, time and psychological. By examining each risk and identifying perceptions related to the risk it was possible to rank perceptions.

For conventional housing, style and lifestyle were most important followed by investment; next and equal in value were sustainable and customizable housing solutions followed by quality and knowledge (see section 4.6.1).

Objective 3: Explore risk factors for consumers in relation to their perceptions and attitudes for housing choice.

Perceptions of risk permeate all aspects of choice. Perceptions form attitudes and the link between risk and attitudes guide actions in making a choice. For housing this is an important factor. Houses are generally the most expensive item consumers will purchase. Finding, interpreting and concluding which perceptions are most frequently exhibited from the data informed Objective 4.

In Chapter 4 responses of the participants were coded within the TPR regime (see 4.2). The frequency of agreement for risk between them was assessed for both conventional and OSM housing. For social risk, responses for conventional housing indicated that consumers desire status from their house. Results indicated status could be satisfied by OSM housing. Financial risk was an issue for conventional housing due to the uncertain cost and quality for the current marketplace. It was found that OSM addresses these issues for consumers. The participants understood the role housing plays in a healthy life-style often frustrated by the uncertain availability and cost of housing. The promise of OSM to maintain a fixed cost offering financial surety appeared to moderate early poor perceptions of “prefab” systems by consumers.

Objective 4: Explore and compare consumer attitudes to conventional and OSM housing.

The collation of the most frequent consumer perceptions of housing for both conventional and OSM housing informs this study as to consumers’ attitudes to housing. The results provide answers about consumer preferences for housing options.

The TPR was used to compare consumer attitudes to conventional and OSM housing. Consumers have had a long association with conventional housing and that system is the one they have always been familiar with and therefore accepted as the norm. This is despite recognized failures in that system for time, cost and quality. The housing market has presented no other viable options for consumers. Attitudes to OSM housing have been negative due to perceptions created by early examples of temporary housing or current examples of OSM buildings having an industrial rather than a conventional appearance. From the results of this study availing consumers of appropriate information and knowledge of recent systems of OSM will inform them so that they may favourably consider choosing the OSM system (see section 4.6).

5.3. Aims

Aim 1: To establish a conceptual framework to find consumer attitudes towards conventional housing, particularly the detached model.

Objective 1 and 2 found important consumer perceptions from literature about housing choice. Six major perceptions held by consumers in regard to conventional housing were identified, particularly for the detached housing systems. Using those perceptions enabled development of a conceptual framework to identify consumer attitudes expressed through their behaviour and their expectations in relation to housing. Use of the TPR in conjunction with the perceptions of consumer housing choice facilitated finding and describing attitudes to conventional housing.

Aim 2: To develop methods to examine relationships of risk, perception and attitudes for both conventional and OSM housing.

Objective 3 and 4 addressed housing choice for both conventional and OSM housing through two stages of analysis. Firstly, the development of codes and themes using the data and then comparing responses from the participants to those for both conventional and OSM housing. The responses were collated to

establish frequencies and relationships to the risks presented by the TPR. Secondly, the perceptions established from Objective1 were also examined against the TPR to discover the strongest links between risk and perceptions. This then informed consumer attitudes for conventional and OSM housing systems. While consumers are satisfied with the conventional systems, there is recognition the system is not outstanding for time, cost and quality. The outcomes from the study suggest that OSM housing can succeed in a conventional housing marketplace. Initial negative attitudes for the OSM housing system can be altered when consumers have sufficient knowledge of the product to make an informed decision.

5.4. The research questions

Research question 1: What are consumer attitudes to conventional housing and housing which is manufactured off-site?

Essentially consumers accept conventional housing as the most attractive option, despite their knowledge of the product as exhibiting characteristics of long construction times, uncertain cost and negative quality issues. However, the housing construction industry continues to operate in a manner which exacerbates an already unviable position. The housing industry is reluctant to innovate and adopt an OSM system despite the systems' advantages for time, cost and quality. Further, the industry has the view that consumers will not accept OSM housing. The literature clearly demonstrates consumers will reject OSM housing due to preconceived negative attitudes.

This study found that consumers are unaware of current OSM systems. The study found with appropriate knowledge and familiarity with OSM housing consumers will consider the genre.

Research question 2: What are the relationships between risk, perception and attitudes to conventional housing and OSM housing?

The literature indicates that consumers regard OSM housing as having inherent risks. Using categories of risk such as the social perceptions of peers, financial uncertainty, physical harm, performance uncertainty, time lost and psychological issues of self-worth informed this research. Assessing risk in relation to perceptions and attitudes for both conventional and OSM houses enabled this study to interpret consumer reactions to housing. For conventional housing consumers accept the inherent risks that they are aware of because it is the status quo without obvious alternatives. Consumers' perceptions and attitudes are that conventional housing satisfies their social and psychological needs. However for the OSM system the risks for finance and performance must be managed and negotiated, a task which has eluded the industry to date. For OSM housing, knowledge has been lacking and therefore perceptions and attitudes have remained negative. This research found when consumers are informed of the contemporary OSM systems, their perceptions and attitudes are positive.

5.5. Recommendations

This research has addressed a vitally important subject: housing provision in Australia. Without suitable housing there are severely detrimental social outcomes. In the past and contemporaneously, there is insufficient housing to satisfy the market. Further, the conventional housing product suffers from unacceptably long production times, unpredictable costs and poor quality. OSM housing offers a viable alternative to conventional systems. With dissemination of accurate information and knowledge consumers will consider OSM houses.

5.5.1. Further research

Further research will be necessary to expand the findings of this study to inform the industry and authorities. Further work to fine tune understanding of the perceptions and attitudes identified in this thesis is important if consumers are to make informed housing choices. Further research into methods for housing production will also inform and expand options for consumer choice improving viability of the housing industry.

5.5.2. Authorities

The results of this research must be made known to governments who have the resources to explore and implement policies to encourage the housing industry to support and develop existing and potential manufacturers' capabilities to produce OSM housing. A recent announcement by Federal Senator Andrews of an initial $2M grant to the Australian Manufacturing Growth Centre to establish a feasibility study into prefabrication of buildings is encouraging.

5.5.3. Industry

The relationship between the housing construction industry and manufacturers needs to be reconciled, particularly in relation to future roles. The systems are currently too divergent in terms of efficiency and potential productivity. Further research needs to be undertaken into techniques of producing OSM housing and importantly, marketing of the systems.

In Germany and Japan demonstration villages are easily accessible by consumers to experience and compare OSM systems for their positive characteristics for time, cost and quality. Manufacturers of OSM houses should be incentivized to place their product into existing demonstration villages so that consumers can compare OSM houses with conventional systems. In New Zealand the OSM industry has recently negotiated with housing finance providers that OSM houses are a sound investment. Finance for consumers to purchase OSM housing is an essential aspect to address in Australia.

5.6. Contribution to existing knowledge and theory

Whilst there is significant literature describing OSM of housing its' advantages and disadvantages, there is little addressing the role of the consumer. Generally perceptions and attitudes of consumers to OSM are negative. This research has shown that with better understanding of OSM, consumers will favourably consider choosing the model in lieu of conventional models.

The use of the "Theory of Perceived Risk" to drive the research provides a lens exploring the topics of housing, the OSM debate and knowledge base.

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Appendix Part A. Ethics

Information for the real estate agent for the research project:

FACULTY OF ENGINEERING
AND BUILT ENVIRONMENT

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

Professor Peter Davis
School of Architecture and the Built Environment
The University of Newcastle
Callaghan NSW 2308 Australia
Phone +61 2 4985 4315
Fax +61 2 4921 6913
Peter.Davis@newcastle.edu.au

Information Statement for the Research Project:
"How would concern for sustainability affect consumer attitudes towards housing?"

Document Version 2; dated 02/02/2017

As an established real estate agent you are invited to assist in the research project identified above which is being conducted by Peter Davis, Willy Sher and Edward Duc from the School of Architecture and the Built Environment at the University of Newcastle.

The research is a part of studies by Edward Duc as a candidate for a PhD at the University of Newcastle, supervised by Peter Davis and Willy Sher.

Why is the research being done?

The purpose of the research is finding whether issues of sustainability affect consumers' attitudes in relation to housing choice.

Who can participate in the research?

We are seeking mature owners (30 to 50 years) of a building site suitable for a detached house to be constructed in the Newcastle area.

What would you be asked to do?

If you agree, you are being asked to nominate up to 10 recent clients between the ages of 30 to 50 years who have purchased a site for construction of a new house to be participants to discuss housing sustainability. We ask that you forward the enclosed stamped envelope (containing the client information statement, a copy of which is attached for your information) to your nominations for them to contact us directly. For your information discussions will focus particularly on issues of cost (affordability) and time (productivity) and whether improving these aspects will affect housing choice. The researchers will make a final selection from those clients who return a completed consent form. In the event that a prospective participant is not selected, the researchers will contact those clients and inform them accordingly.

What choice do you have?

Your co-operation in this research is entirely your choice and only those people you have recommended who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you.

How much time will it take?

The interviews are expected to take approximately 60 minutes.

***What are the risks and benefits of participating*?**

There are no identifiable risks, the benefits are mentioned above.

How will your privacy be protected?

All data gathered through the Interview will be treated with the strictest confidence. It is not anticipated that the interviews explore personally sensitive details; except in relation to housing choice. All identifiable features (i.e. names of individuals, projects and email addresses) will be removed and codes will be assigned. Participants will be provided the opportunity, upon request, to review, edit, or erase the recordings or transcripts of the interviews. Only the research team, except as required by law, will have access to personally identifiable data collected. All information will be stored in password protected computer files. Once the project is complete the information will be stored for a minimum of five years in the Principal Investigator's office in a locked cabinet and then destroyed according to University of Newcastle procedures. Interview data will be transcribed by the research student.

How will the information collected be used?

The information collected from the interviews is to be used to complete a PhD thesis on the topic of attitudes to sustainable housing, particularly for the issues of cost (affordability) and time (productivity).
Individual participants will not be identified in any reports arising from the project.

Audio recording is to be used, however, if the participants desire they will be able to review the recording to edit or erase their contribution.

Non-identifiable data may be also be shared with other parties to encourage scientific scrutiny, and to contribute to further research and public knowledge, or as required by law. As previously stated, summaries of the interviews will be made available for participant scrutiny.

***What do you need to do to participate*?**

Please read this Information Statement and be sure you understand its contents before you consent to co-operate in nominating recent clients. If there is anything you do not understand, or you have questions, contact the researcher. There will be no reimbursement for yourself or the participants; however, the intention of the research is to inform the housing industry of the research outcomes seeking more sustainable outcomes to benefit Australian society.

Further information

If you would like further information in regard to this request please contact Professor Peter Davis on phone # 61 2 4985 4315 or Edward Duc on phone # 61 414 660 888.

Thank you for considering this invitation.

Research Team:

Principal Investigator:
Prof Peter Davis
University of Newcastle

Co Investigator:
Assoc Prof Willy Sher
University of Newcastle

Student Investigator:
Edward Duc
PhD candidate
University of Newcastle

Research Team Contact Details

Professor Peter Davis
Chair, Construction Management
School of Architecture and Built Environment
Faculty of Engineering and Built Environment
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Edward Duc
School of Architecture and Built Environment
Faculty of Engineering and Built Environment
Telephone: +61 0414660888
Email: edward.duc@newcastle.edu.au

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee, Approval No. H-2017-0003

Should you have concerns about your rights in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49

Information statement for participants:

FACULTY OF ENGINEERING
AND BUILT ENVIRONMENT

THE UNIVERSITY OF
NEWCASTLE
AUSTRALIA

Professor Peter Davis
School of Architecture and the Built Environment
The University of Newcastle
Callaghan NSW 2308 Australia
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Fax +61 2 4921 6913
Peter.Davis@newcastle.edu.au

Information Statement for the Research Project 1:
"How would concern for sustainability affect consumer attitudes towards housing?"

Document Version 2; dated 02/02/2017

You are invited to participate in the research project identified above which is being conducted by Peter Davis, Willy Sher and Edward Duc from the School of Architecture and the Built Environment at the University of Newcastle.

The research is a part of PhD studies of Edward Duc at the University of Newcastle, supervised by Peter Davis and Willy Sher.

Why is the research being done?

The purpose of the research is finding whether issues of sustainability would affect consumers' attitudes in relation to housing choice.

Who can participate in the research?

You have been sent this invitation by you realtor, on behalf of the researchers. We are seeking mature future home owners (30 to 50 years of age) in the Newcastle area who

have purchased a site for the purpose of building a home. The researchers will make a final selection from those clients who return a completed consent form. In the event that a prospective participant is not selected, the researchers will contact those clients and inform them accordingly and thank them for their interest.

What would you be asked to do?

If you agree to participate you will be asked to discuss your housing choices and housing sustainability in an interview. Discussions will focus particularly on issues of cost (affordability) and time (productivity) and whether these aspects could affect your housing choice. Identification of potential home owners has been made by asking long established real estate agents to forward this request to clients who qualify as above.

The interviews will be facilitated by Edward Duc. The interviews will be recorded in order to obtain themes for the research. Prior to using the material a summary obtained by Edward Duc examining the records from the interview will be given to the participants seeking agreement as to the accuracy of the summaries. Comment will be welcomed to ensure the accuracy required. There will be no reimbursement for participants; however, the intention of the research is to inform the housing industry of the research outcomes seeking more sustainable outcomes to benefit Australian society. The interviews will take place in a place and at a time you may nominate, or a public place to be identified, however the criteria are that the place will be safe and comfortable e.g. a meeting room in an accommodation facility in the Newcastle CBD.

What choice do you have?

Participation in this research is entirely your choice. Only those people who give their informed consent will be included in the project. Whether or not you decide to participate, your decision will not disadvantage you.

If you do decide to participate, you may withdraw from the project at any time without giving a reason and have the option of withdrawing any data which identifies you.

How much time will it take?

The interview is expected to take approximately 60 minutes.

***What are the risks and benefits of participating*?**

There are no identifiable risks, the benefits are mentioned above.

How will your privacy be protected?

Any information collected by the researchers which might identify you will be stored securely and only accessed by the researchers unless you consent otherwise, except as required by law. Participants will be given numerical codes to protect their identity.

Data will be retained for at least 5 years at University of Newcastle. Information which might identify participants will not to be disclosed without their prior consent.

It is not anticipated that interviews will explore personally sensitive details.

How will the information collected be used?

The data will be used within a range of publications such as journals, international conferences and in the Doctoral thesis to be submitted by Edward Duc. Participants will not be identified in any reports arising from the project. The participants will be offered a summary of the results. If you would like to receive a summary of the results of the research, please register your request in the 'Consent Form' or by contacting Professor Peter Davis on the phone number or email address below. The information collected from the interviews is to be used to complete a PhD thesis on the topic of sustainability of housing, particularly for the issues of cost (affordability) and time (productivity). Individual participants will not be identified in any reports arising from the project.

Audio recording is to be used, however, if you desire you will be able to review a transcription of what was said or the actual recording to edit or erase your contribution.

***What do you need to do to participate*?**

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, contact the researcher.

If you would like to participate, please complete the attached Consent Form and return it in the reply paid envelope provided.

We will then contact you to arrange a time convenient to you for the interview.

Further information

If you would like further information in regard to this request please contact Professor Peter Davis on phone # 61 2 4985 4315 or Edward Duc on phone # 61 414 660 888.

Thank you for considering this invitation.

Research Team:

Principal Investigator:
Prof Peter Davis
University of Newcastle

Co Investigator:
Assoc Prof Willy Sher
University of Newcastle

Student Investigator:
Edward Duc
PhD candidate
University of Newcastle

Research Team Contact Details

Professor Peter Davis
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Edward Duc
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Faculty of Engineering and Built Environment
Telephone: +61 0414660888
Email: edward.duc@newcastle.edu.au

Complaints about this research

This project has been approved by the University's Human Research Ethics Committee, Approval No. H- 2017-0003

Should you have concerns about your rights in this research, or you have a complaint about the manner in which the research is conducted, it may be given to the researcher, or, if an independent person is preferred, to the Human Research Ethics Officer, Research Office, The Chancellery, The University of Newcastle, University Drive, Callaghan NSW 2308, Australia, telephone (02) 49216333, email Human-Ethics@newcastle.edu.au.

Interview consent form:

FACULTY OF ENGINEERING
AND BUILT ENVIRONMENT

Professor Peter Davis
School of Architecture and the Built Environment
The University of Newcastle
Callaghan NSW 2308 Australia
Phone +61 2 4985 4315
Fax +61 2 4921 6913
Peter.Davis@newcastle.edu.au

"How would concern for sustainability affect consumer attitudes towards housing?"

Document Version 2; dated 02/02/2017

CONSENT FORM FOR AGREEMENT TO BE INTERVIEWED
Please place signed form in stamped addressed envelope and post to Professor Peter Davis.

I agree to participate in the above research project and give my consent freely.

I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained.

I understand I can withdraw from the project at any time, and do not have to give any reason for withdrawing.

I consent to:

- participating in an interview and having it recorded;

I understand that my personal information will remain confidential to the researchers and I have had the opportunity to have questions answered to my satisfaction.

Print Name----------

Best contact phone----------

Address_____

Signature:_____ Date: _____

Herald newspaper article seeking participants for interviews

Affordable housing is now a serious issue affecting both house buyers and renters. The fundamentals of the way we produce housing must change if affordability is to be redressed.

The term sustainability is increasingly being used to describe positive and negative actions and behavior of Australians for their use of energy and attitudes in regard to waste and unwanted off-gases. An important role in sustainability is played by housing, where, while considerations of energy use are important, issues of sustainability also include cost (affordability) and time (productivity). Both these factors affect availability of suitable housing. Sustainable development is defined by the United Nations as, “development which meets present needs without compromising the ability of future generations to meet their own needs” (i.e. maintaining an equal standard). In particular this opinion seeks to address sustainability of housing in Australia, or rather its characteristics of unsustainability. I was reminded recently by an expert who assesses energy use in buildings that housing does not use energy, it is the occupants who need to accept responsibility. However, there are also important issues for how houses are produced to enable efficient use of energy.

The part played by housing production is critical for sustainability. Research has found that housing accounts for 25% of total global energy use. A Human Settlements report in 2001 found that while the population increased in Australia between 1975 and 2001 by 35%, the use of energy by the residential sector increased by 60%. Further, housing produces 18% of the world’s greenhouse gases. There is clear evidence that current construction methods are unable to mitigate these poor outcomes without innovation and change.

Building construction alone generates up to 30% of all wastes sent to land fill. Typically up to 30% of labour and materials for housing construction is wasted through reworking or changes during the works. Unfortunately, constraints for the average suburban house site prevent the waste from construction being separated into streams for recovery and recycling. Clearly preventing waste will reduce housing cost and improve efficiency.

It is clear that the cost of construction continues to rise, and worse, there is a high level of uncertainty as to the final cost, often higher than initial budgets. This is a serious situation for housing demonstrated by a measure of housing affordability, that being average cost compared with average annual wage. In Australia in 1990 the ratio for average housing purchase price compared to average gross income was 3 to 1, in 2015 it was 5 to 1 (In Sydney it is 12:1). In a recent report, the cost of housing placed Australia sixth behind UK, Switzerland, Denmark, Hong Kong and Sweden. There are reasons why this unacceptable situation cannot change, a shortage of skilled trades is one of them, and reluctance by industry and consumers to consider non-traditional production of housing is another. For example, industries supplying cars and clothing have changed from a craft to a manufacturing industry thereby producing products which are readily

available and affordable. Clearly comparison between the housing industry and other industries (such as clothing and motor vehicles) demonstrates the gap in cost and productivity.

There is an opportunity for the community to assist in addressing the challenges outlined in this opinion piece by agreeing to a one hour interview covering housing choice and sustainability. Preferred participants are those who are soon to make a new build housing choice but have not yet made a final decision.

This research is being carried out through the University of Newcastle by Edward Duc as a candidate for a PhD. Prospective participants can offer to participate by emailing edwardd@ducassociates.com.au however the final decision to accept participants will be made by the researchers.

Expedited ethics approval notification

FACULTY OF ENGINEERING
AND BUILT ENVIRONMENT

Notification of Expedited Approval

To Chief Investigator or Project Supervisor: **Professor Peter Davis**
Cc Co-investigators / Research Students: **Associate Professor Willy Sher**
Mr Edward Duc
Re Protocol: **How would concern for sustainability affect consumer attitudes towards housing?**
Date: **08-Feb-2017**
Reference No: **H-2017-0003**
Date of Initial Approval: **06-Feb-2017**

Thank you for your **Response to Conditional Approval (minor amendments)** submission to the Human Research Ethics Committee (HREC) seeking approval in relation to the above protocol.

Your submission was considered under **Expedited** review by the Ethics Administrator.

I am pleased to advise that the decision on your submission is **Approved** effective **06-Feb-2017**.

In approving this protocol, the Human Research Ethics Committee (HREC) is of the opinion that the project complies with the provisions contained in the National Statement on Ethical Conduct in Human Research, 2007, and the requirements within this University relating to human research.

Approval will remain valid subject to the submission, and satisfactory assessment, of annual progress reports. *If the approval of an External HREC has been "noted" the approval period is as determined by that HREC.*

The full Committee will be asked to ratify this decision at its next scheduled meeting. A formal *Certificate of Approval* will be available upon request. Your approval number is **H-2017-0003**.

If the research requires the use of an Information Statement, ensure this number is inserted at the relevant point in the Complaints paragraph prior to distribution to potential participants You may then proceed with the research.

Conditions of Approval

This approval has been granted subject to you complying with the requirements for *Monitoring of Progress*, *Reporting of Adverse Events*, and *Variations to the Approved Protocol* as detailed below.

PLEASE NOTE:

In the case where the HREC has "noted" the approval of an External HREC, progress reports and reports of adverse events are to be submitted to the External HREC only. In the case of Variations to the approved protocol, or a Renewal of approval, you will apply to the External HREC for approval in the first instance and then Register that approval with the University's HREC.

Monitoring of Progress

Other than above, the University is obliged to monitor the progress of research projects involving human participants to ensure that they are conducted according to the protocol as approved by the HREC. A progress report is required on an annual basis. Continuation of your HREC approval for this project is conditional upon receipt, and satisfactory assessment, of annual progress reports. You will be advised when a report is due.

Reporting of Adverse Events
It is the responsibility of the person **first named on this Approval Advice** to report 1. adverse events.
Adverse events, however minor, must be recorded by the investigator as observed by the investigator or as volunteered by a participant in the research. Full details are to be documented, whether or not the investigator, or his/her deputies, consider the event to be related to the research substance or procedure.
2.
Serious or unforeseen adverse events that occur during the research or within six (6) months of completion of the research, must be reported by the person first named on the Approval Advice to the (HREC) by way of the Adverse Event Report form (via RIMS at https://rims.newcastle.edu.au/login.asp) within 72 hours of the occurrence of the event or the investigator receiving advice of the event.
3.
Serious adverse events are defined as:
Causing death, life threatening or serious disability.
Causing or prolonging hospitalisation.
Overdoses, cancers, congenital abnormalities, tissue damage, whether or not they are judged to be caused by the investigational agent or procedure.
Causing psycho-social and/or financial harm. This covers everything from perceived invasion of privacy, breach of confidentiality, or the diminution of social reputation, to the creation of psychological fears and trauma.
Any other event which might affect the continued ethical acceptability of the project.
4.
Reports of adverse events must include:
Participant's study identification number;
date of birth;
date of entry into the study;
treatment arm (if applicable);
date of event;
details of event;
the investigator's opinion as to whether the event is related to the research procedures; and
action taken in response to the event.
5.
Adverse events which do not fall within the definition of serious or unexpected, including those reported from other sites involved in the research, are to be reported in detail at the time of the annual progress report to the HREC.
6.
Variations to approved protocol
If you wish to change, or deviate from, the approved protocol, you will need to submit an *Application for Variation to*
Approved Human Research (via RIMS at https://rims.newcastle.edu.au/login.asp). Variations may include, but are not
limited to, changes or additions to investigators, study design, study population, number of participants, methods of recruitment, or participant information/consent documentation. **Variations must be approved by the (HREC) before they**
are implemented except when Registering an approval of a variation from an external HREC which has been designated
the lead HREC, in which case you may proceed as soon as you receive an acknowledgement of your Registration.
Linkage of ethics approval to a new Grant
HREC approvals cannot be assigned to a new grant or award (ie those that were not identified on the application for ethics
approval) without confirmation of the approval from the Human Research Ethics Officer on behalf of the HREC.
Best wishes for a successful project.
Dr Kerry Dally
Acting Chair, Human Research Ethics Committee
For communications and enquiries:
Human Research Ethics Administration
Research & Innovation Services
Research Integrity Unit
NIER, Block C
The University of Newcastle
Callaghan NSW 2308
T +61 2 492 17894
Human-Ethics@newcastle.edu.au
RIMS website - https://RIMS.newcastle.edu.au/login.asp
Linked University of Newcastle administered funding:
Funding body Funding project title First

Appendix Part B. PowerPoint presentation to participants indicating aspects of housing sustainability and examples of OSM housing:

How will concerns for sustainability affect housing choice?

Thank you for participating

The information presented has been derived from the following web sites.

www.ecoliv.com.au/ www.habitechsystems.com.au/ www.archiblox.com.au/

Aspects of Sustainability

- Traditional housing construction in Australia experiences 10% to 30% waste for both materials and labour. Waste removal for an average house costs between $2000 and $3000, waste typically goes to landfill including demolition for alterations or renewal. Traditional construction creates more solid waste in landfill than any other industry.
- A factory produced house can be zero waste and due to the flexible design allows reuse of materials for alterations and/or relocation.
- Research indicates traditional housing is a major contributor to green-house gas emissions in construction, in use and then demolition. For example, in a typical construction process there are multiple site visits by various trades and workers as well as materials deliveries.

Aspects of Sustainability

- Housing typically has the highest use of energy of any building typology. Most energy is used for heating and cooling.
- Factory produced houses can be airtight (mould eliminated by use of inert materials) and insulated in the factory to satisfy the climate needs of individual sites. Cross ventilation reduces need for energy use.
- Housing costs continue to increase due to poor weather conditions, poor co-ordination and increasing skills shortages. The traditional methods are uncertain and rely on management by SME organisations.
- Factory produced houses are efficiently manufactured in an OHS environment without delays. Site assembly has no exposure to the traditional site problems.

Aspects of Sustainability

- The traditional house construction industry has been shown to be unable to substantially improve productivity, and with increasing skills shortages cannot improve.
- The traditional construction industry has the greatest number of injury claims of any industry, particularly permanent disability.
- Factory produced houses are manufactured under rigorous factory safety conditions. Site work is minimal.

Case study A

Case study A

Case study A

Case study A

- 01. Siting and Design Efficiency
- 02. Energy Efficiency
- 03. Water Efficiency
- 04. Materials Efficiency
- 05. Indoor Environment Quality
- 06. Waste Reduction

Case study B

Case study B

Case study B

Case study B

- SUSTAINABLE DESIGN PRINCIPLES
- The built environment plays a vital role in the human impact on the natural environment and our wellbeing. Our sustainable designs integrate consideration of resource and energy efficiency, healthy buildings and materials, ecologically and socially sensitive land use, and aesthetic sensitivity that aspires, upholds and enhances humanity.
- We believe our prefabricated modular homes unite the senses and bring us closer to nature.
- OUR "STAND OUT" ADVANTAGE
- Our designs, workmanship and use of sustainable materials all contribute to our unique design build advantage.
- WE “DESIGN BIG” RATHER THAN “BUILD BIG”
- We design homes for life, ensuring that areas and rooms can be used for more than one purpose to maximise usage, we design big rather than build big.”
- FUTURE PROOFING
- Our modular homes are designed and built for sustainable performance and longevity for future generations to come.

Case study C

Case study C

Case study C

- your brief and lifestyle
- your site and surrounding landscape
- the climate you are located in
- the orientation of your specific site more comfortable for you and your family to live in much cheaper to operate - protecting you from continuing rises in energy prices

Appendix Part C. Structure of the interviews

Following are the questions for the interviews of participants seeking data in regard to consumers' attitudes to housing, for both conventional and unconventional production.

(The questions have been designed using the Theory of Perceived Risk, those risks being; social, financial, physical, performance, time and psychological)

The questions were arranged in two stages, firstly to find information in regard to attitudes to housing generally. The second round sought attitudes after being appraised of sustainability issues for conventional housing and non-conventional housing options (off-site examples), which have claimed superior characteristics for cost and time. The risks as stated are social, financial, physical, performance, time and psychological (cognitive). The questions were asked in the same order for both stages to enable direct co-relation. The questions were printed and given to the participant as well as verbally presented. Permission to record the interview was restated.

Probe questions for the interviews are shown in italics and were not given to the participant on the question sheet.

STAGE 1 questions to find attitudes to housing generally.

SOCIAL

1. Some people suggest that houses can express the personality of its owner? What is your view?
   What do you think your house says about you?
   What do you think people say about you and your house?

2. It has also been said that people label others by the type of a house they live in. What do you think about this statement?
   Labels could include wealthy or not so wealthy, being of a certain class, ethnicity, unusual lifestyle, trendy lifestyle.

FINANCIAL

3. Do you regard your house primarily as a place to live or as an investment?

Describe how you see the balance of a house as a living experience and as an investment.
What reasons do you have for your answer?

4. In your opinion what are the financial implications when housing has elongated construction times?
   Some of the issues could include two mortgages or rent expense, what is your view?

PHYSICAL

5. What have you heard about health risks in houses?
   Have you ever lived anywhere where there were problems with mould and spores? What do you think caused them?
   Volatile organic compounds (VOCS) found in some paint and textiles can cause headaches and dizziness, are you aware of this fact? What will you do to reduce this risk?
6. When choosing a house, what aspects in regard to being safe from injury do you think might concern you in regard to your family?
   The issues are for example; hard-wired smoke alarms, electrical cut-out switches, hot water tempering devices, and safety glass in doors, stairs and trip-hazards, can you describe your level of interest in these risks.

PERFORMANCE

7. Please describe your views in regard to the need for repairs to and improvements of a house.
   Have you considered the possibility of roof leaks and windows which are not weathertight?
   What is your view in regard to the standard of workmanship in the houses you have occupied?

8. What in your view improves the performance of houses for sustainability, for example, energy and water usage?
   What are the features you look for in regard to optimum use in your house?
   Tell me about energy use provisions for your future house.

TIME

9. What things are most important to you in the function of houses, how they work?
   How would you describe the way in which a house can have effect on your leisure or work time?

10. What is your opinion in regard to the importance on flexibility in housing, for example accommodating change in family size or the way you live?
    What experiences have you in finding aspects of a house not to your convenience and then undergoing alterations to remedy the problem? Would you describe this as a necessary part of housing? Is this a pleasurable experience?
    Many people have changed their houses to satisfy different needs, what are the stories you have heard about alterations and additions to houses?

PSYCHOLOGICAL

11. Can you describe your preferences for housing in regard to:
    a. Appearance the style and presentation,
    b. Size for example the number of rooms,
    c. Materials such as external finishes, internal features in bathrooms or kitchens.
    How do these qualities affect the way you feel about a house?

12. What is it in a house which gives you the sense of security and privacy?
    Of the factors you mention, which is most important?
    What aspects of a house provide for a comfortable family home?

Thank you for your answers to this part of the interview. Do you have anything else you would like to add?

Stage 2 of the interview comprised showing the participant a power point presentation showing three examples of companies producing housing using off-site methods commonly called OSM or prefabricated. For each company three examples of their housing models together with their sustainability attributes were obtained from their websites. The three companies' websites may be accessed through their addresses as listed.

http://www.archiblox.com.au/ http://www.habitech.com.au/

http://ecoliv.com.au/

This second set of questions sought to understand the participant's reaction to examples of houses produced by non-conventional off-site methods.

STAGE 2 questions to find reactions to off-site produced housing.

I am interested to understand how you view these housing options and in particular how aspects of cost (affordability) and time (productivity or efficiency) might affect your attitudes.

SOCIAL

13. Often sustainability in our society is defined by three aspects; social (our social obligations to each other), environmental (global warming and climate change) and financial (a successful economy). Can you describe your attitude to these goals?
    Which of the goals is more important to you?

14. What is your understanding of the term 'sustainable housing'?
    Can you expand on your understanding of other people's reaction to this housing?
    What are your comments in relation to the alternative houses I have shown you compared to conventional houses?

FINANCIAL

15. Of the three examples of houses that demonstrate good sustainability practices, what are your views about attractiveness, form, materials and overall appearance?
    Can you describe any positive/negative features of the houses?
    What are your views in regard to these houses as an investment?

16. The three houses shown here are offered with a fixed price and a fixed delivery date. As we have discussed, these attributes are not common found in conventional housing offers. How would you describe your reaction to the differences?
    Please discuss why you would accept/reject the sustainable housing.

PHYSICAL

17. Would you have any physical concerns in regard to buying one of the three houses for example stress or anxiety?
    Of the concerns you have, which of those in most important/unimportant?

18. The three houses shown claim to have design characteristics which reduce the occurrence of mould, and all three avoid volatile organic compounds (VOC's). What is your reaction to knowing that?
    Would these factors affect your housing choice?

PERFORMANCE

19. One of the factors listed in talking about issues of productivity in building houses is the problem of poor working conditions. Accidents for conventional construction sites result in the highest rates of permanent injury and workers disability claims of any industry. How important do you think these factors would be in the overall decision about the type of housing you might opt to build?

20. We talked about flexibility before. If we focus on the capacity to adjust to climatic conditions and meet individual energy goals, what is your view of the three models shown when they claim to have the flexibility to adjust to meet any climatic condition and meet individual energy goals?
    How would these factors affect your housing choice?

TIME

21. The sustainable houses claim low maintenance regimes offering time savings for the occupants. Would this be a positive /negative influence on your housing choice?
    Please tell me why you decided on your answer.

22. The three models claim short manufacture and assembly times. How would this affect your housing choice?
    Please enlarge on your answer and if possible rank for importance.

PSYCHOLOGICAL

23. With your own preferences for housing established in question 11, in the previous section for materials, size and appearance, please describe the positive attributes in the sustainable models shown.
    What are the negative attributes?
    What changes would you make to the model for you to accept them?

24. How would you regard people who purchased one of the three housing models discussed today?
    What would persuade you to follow their example?

Thank you for your participation in this interview. Your responses have been extremely helpful.

Before we go is there anything else you would like to add or comment on?