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Overcoming psychological barriers to widespread acceptance of mass timber construction in Australia

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Forest & Wood Products Australia

PNA309-1213: Overcoming Psychological Barriers to Widespread Acceptance of Mass Timber Construction in Australia

Prepared for

Forest & Wood Products Australia

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Executive Summary

As an alternative building material and a process for commercial buildings, up to 30 storeys, Mass Timber Construction (MTC) has the potential to disrupt the current equilibrium of construction in Australia. However, despite reported benefits in terms of on-site costs and sustainability the potential remains unrealised, due at least in part to a lack of understanding across a number of stakeholders in the building and construction process. This Forest Wood Products Australia project seeks to determine the psychological barriers to a wider uptake of MTC in Australia. The two studies aim to offer various industry stakeholders (Builders, Developers, Architects, Designers, Manufacturers and Suppliers etc.) an opportunity to resolve identified barriers. The present study first considers relevant international literature and describes the concept of punctuated equilibrium and theoretical predictions of how new technologies become widespread. The adoption of a mixed methods approach delivers two research projects. At the end of each study, a number of recommendations are provided addressing identified barriers.

Study One, A survey explores Australian consumer's (N =281) attitudes toward a number of identified factors that may constrain the widespread adoption of MTC in Australia. Specifically, this study explores the relationship between timber use in construction, factors relating to property purchasing decisions and environmental attitudes. Results from this study suggest anthropocentric attitudes mediate the relationship between positive attitudes toward timber use in construction (sustainability, durability, structural properties, economics) and financial factors involved in making a property purchasing decision, such as monthly repayments, interest rates, return on investment and cost of insurance.

Study Two, A qualitative study (in-depth interviews) examines perceived barriers and suggested strategies for overcoming them, relating to the widespread adoption of MTC from a number of stakeholders within the Australian building and construction industry. Results from this study identify that barriers can be categorised into two domains, 'material' and 'method'. Material based barriers include the considerable difference in the way timber structures are designed and delivered compared with more traditional forms of construction. The often lacking and prejudicial perceptions of MTC present considerable challenges because of questionability concerning the technology's durability in terms of fire, rot and structural integrity, whereas method based barriers include a lack of open source financial and commercial information for risk management purposes.

These should assist industry stakeholders to progress MTC technology with the Australian market. Findings from the studies suggest that regardless of the barriers to the widespread acceptance of MTC, as a material and method, it should have a future in the Australian construction market. In order to forecast a 'future state' or at least to secure lead indicators of MTC's potential, Australian stakeholders need only look at the emerging trends for the material/method in Europe.

The following 16 recommendations were developed from the two studies and offer various industry stakeholders (Builders, Developers, Architects, Designers, Manufacturers and Suppliers etc.) an opportunity to resolve identified barriers by selecting, adopting and adapting suggestions provided here.

1. *Developing data and information exchange programs/collaborations with European organisations*. Data relating to the considerable amount of work performed using MTC in Europe would certainly benefit Australian construction, particularly the influence of the insurance industry. The insurance industry participants suggest that if developers can demonstrate the integrity of this product then they will certainly take that on board, indicating that premiums would potentially remain on par with ferroconcrete. Industry education and training providers could be commissioned to assist in disseminating research findings etc.

2. *Participate in overseas study tours*. Australians can visit a huge range of projects in Europe and Canada. Projects from the very small to very large now provide a sense of what is achievable. Forest

and Wood Products Australia, in conjunction with the Timber Development Association (New South Wales) have offered several such trips to industry over the last few years.

3. *Leverage financial service premiums (insurance and investment) by using global organisations*. It is evident from the present study that local financial services organisations load premiums. Builders, developers and associated stakeholders could locate international finance and insurance organisations that provide services to customers working with MTC. This might result in a completely different view of the product and their premium might be cheaper. Many project case studies list the associated companies supporting the development. This may include insurance and financial services organisations. This is a suggested starting point for Australian developers to secure competitive services.

4. *Use brokerage firms*. Builders, developers and associated stakeholders could use brokers for insurance and finance. Brokers shall communicate with organisations and recommend financial and insurance services that match the clients' expectations. Industry insiders suggest that brokers are able to reverse-auction premiums for services that benefit the client. Pooling projects and clients together provides brokerage firms with leverage. Buyer bargaining power is a useful strategy to secure lower premiums.

5. *Manufacturers could produce a series of product specific applications using MTC*. These applications could be promoted through specific marketing material. For example, a cross laminated timber lift shaft or stair system.

6. *Case study scenarios specific to builders at various tiers/levels*. In collaboration with key stakeholders, Australian manufacturers and industry suppliers could develop a series of easy to understand non-commercial in confidence cost saving case studies. These can be developed and disseminated to tier one, two and three builders expressing interest in using MTC, avoiding the requirement of costly quantification comparisons to more traditional forms of construction.

7. *MTC portable displays.* Suppliers and manufacturers of MTC, and its various stakeholders and component manufacturers/suppliers could develop walk-through showcases or displays that could be mounted on the back of a trailer. Such displays would represent a cross-section of an actual building with internal linings, external cladding, wiring and plumbing etc. Such displays could be parked at common meeting areas, such as a University or other institutions, trade shows and conferences allowing people to walk in and see how MTC actually works.

8. *Full-scale testing.* Research conducted by internationally credible sources, such as FM Global, could be commissioned to undertake large-scale testing. Approvals may be granted if product applications are tested and replicated on-site. Approved methods of construction may satisfy the insurance and financial services industries.

9. *Pre-fabricated solutions for complex on-site problems*. MTC manufacturers and distributors could formulate ideal and optimal designs using mass timber components solving some of the more complex problems found on building sites. The specifics for the designer, the shop drawings and the detailers, provide very specific information that makes it very easy to use the product.

10. *Green Information*. The present study suggests it is insufficient for property developers etc. to provide a 'Green Star' rating in isolation to additional information. Australian consumers indicating such a rating system were not a great influence in property purchasing decisions. The present study supports the development of a composite of 'green' information about the environmental attributes and sustainable design practices inherent within MTC buildings. Consumers want to understand and

be educated about the qualities of the property they intend to purchase and how this contributes to environmental efforts.

11. *Addressing Durability*. Associated with recommendation one, the present study suggests that overcoming prejudices about the durability of timber in construction through clearly articulated marketing communication messages is vitally important. It appears Australian consumers do not understand how MTC are covered with interior and exterior cladding, nor do they understand the inherent fire resisting properties of timber as used in construction. In order to overcome prejudices from consumers about MTC projects promoted as 'timber structures', developers and realtors could educate consumers about abating any fear – see Recommendation One.

12. *Age Matters when it comes to Attitudes.* Differences in attitudes between older and younger adults - toward structural soundness and construction components (bricks, timber, steel and concrete) - provides some evidence of a potential generational shift in thinking about building and construction. As such, it appears important to present messages to younger adults about the structural soundness and environmental benefits of MTC, yet for older adults there appears to be an inherent support for timber use in construction. Targeting specific marketing messages by age segmentation (as well as along environmental attitudinal lines) could be used to great effect in marketing MTC to Australian consumers.

13. *Potential Opportunity for Price Premiums*. It is conceivable that property developers could attract price premiums for MTC properties based on educating interested parties (with info graphics, videos, education walk-throughs, advertising etc.) about the benefits of the timber and how it will benefit their lives - comfort, running cost reductions etc.

14. *The Promotion of Timber as the Primary Construction Material in Building.* It is conceivable that Builders and Developers might not mention the use of timber as the primary construction material and simply promote the benefits of a revolutionary new construction method. Since the external and internal treatment of the structure is similar to that of conventional construction, consumers might not notice the timber structure at all. However, not mentioning the use of timber eliminates the ability to promote a number of the environmentally sustainable design features and benefits (carbon sequestration and lower emissions) which consumers in the present study expressed are important in property purchasing decisions.

15. *Marketing and Green Messages.* Communications about MTC and 'green messages' about the technology should focus on anthropocentric approaches to environmental resource use because anthropocentric attitudes are maintaining the middle ground between not caring about and completely protecting the environment. As such, anthropocentric attitudes mediate both attitudes toward the use of timber in construction and financial influences in property purchasing behaviours. It, therefore, seems logical to promote the benefits of the technology in anthropocentric ways.

16. *Rationalising Differences in Environmental Attitudes*. Finally, it is conceivable that consumers who are educated about MTC, and timber more generally, may resolve/rationalise differences in environmental attitudes (ecocentrism and/or apathy) in order to achieve a degree of environmental utilitarianism – achieving the maximum benefit possible from an environmental resource. This might represent a shift in thinking from 'we should not use timber resource at all' toward support for a low impact substitute technology, such as MTC, in lieu of environmentally costly alternatives such as concrete and steel.

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Introduction

Mass Timber Construction (MTC) is a technological innovation with the potential to disrupt the construction industry in Australia (Kremer & Symmons, 2015). MTC uses engineered wood products as the primary structural material of choice. Typically, MTC can be substituted for concrete, whether it is wet-poured, steel reinforced or solid section 'tilt-slab' for low- to medium-rise building for utilitarian applications such as libraries and housing construction projects. MTC is an umbrella term and includes specific products such as, Cross Laminated Timber (CLT), Glue Laminated Beams (GluLam) and Laminated Veneer Lumber (LVL). CLT is typically the product that comes to mind when talking about massive timber structures. As components are pre-fabricated, off-site MTC manufacturing ensures labour on-site is kept to a minimum (Yates, Linegar & Dujic, 2008), resulting in significant site-based labour costs. MTC use has a number of environmental benefits compared with traditional construction (typically concrete and steel) methods and approaches, including carbon sequestration (Depro, Murray, Alig & Shanks, 2008). Timber manufacturing also uses less energy than concrete or steel, equating to less carbon produced or otherwise known as embodied energy consumption (Lehmann & Fitzgerald, 2012) and it is a more readily renewable and recyclable resource when compared with alternative materials.

There are a number of clear advantages, and a solid (though not yet mature) market in some European countries, however MTC development in Australia is lagging behind markets including the United States and Canada. Some of the challenges or barriers of entry to expanding MTC in Australia include a lack of local expertise – especially in design and construction. Whilst a great deal of interest is being shown in MTC technology in Australia, anecdotally suppliers of MTC products are facing difficulties in the promotion of its use because of the very different approach required in the design and construction of timber as the primary material compared with steel and concrete. Construction with timber is not as simple as replacing concrete and steel components. It requires a considerable shift in design that is somewhat counter intuitive to that of traditional building. For example, lift shafts are typically the first core structural items in steel and concrete construction, whereas in MTC, this may be reversed and the shafts may be produced, or assembled, last.

Advancing MTC as a new technology in Australia, and many countries, requires an understanding of what influences uptake and demand. An important factor identified by Forest and Wood Products Australia (2015) is an understanding of the social acceptance and perceptions associated with the use of wood, or timber, as an alternative construction material. Parry-Husbands and Parker (2014) discovered for Australian consumers a paradox exists between the negative perceptions of harvesting trees, particularly from international non-plantation forests without chain of custody certification, and attitudes toward timber as a natural, aesthetically pleasing and environmentally friendly product. Consumers also raised concerns about risk factors associated with the use of wood, such as fire and durability, including wood rot and decay and attack from termites (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014; Parry-Husbands & Parker, 2014). Such concerns do not arise in the public mind when thinking about steel and concrete as building materials. It is argued that negative consumer perceptions about wood can affect the development of MTC in Australia.

The present paper explores the punctuated equilibrium of traditional construction - methodology and material use - identifying MTC as a disruptive technology. It then reviews the current research and lessons learned from international MTC projects with a specific focus on stakeholder influences (investors, builders, developers, designers and insurers) and the progression of MTC. Previous research by Kremer & Symmons (2015) identified a particular 'gap' in the current knowledge requiring an examination of consumer perceptions about the use of wood as a construction material and how this affects MTC uptake in Australia. A better understanding of attitudes and beliefs amongst consumers and those of construction industry stakeholders (investors, builders, developers, designers and insurers) about MTC can inform procedural guides detailing what industry can do to progress MTC in Australia. Such an output is useful in formulating strategies relating to how MTC may penetrate the current domination of traditional construction methods and dispel mis- and pre-conceptions regarding robustness, quality and fire resistance of MTC wood as a structural building material on a large scale.

Punctuated equilibrium

Punctuated equilibrium (Eldredge & Gould, 1972) is the theory that animal and plant species exhibit periods of evolutionary stasis interrupted by short periods of rapid evolutionary change. Applied in the context of industry transformation, the model portrays industries as a collection of ever-evolving organisations operating over long periods of time and enjoying periods of relative stability or equilibrium. Equilibrium periods are characterised by a continual stasis of existing structures and patterns of activity in which micro adjustments account for environmental changes without deep structural change (Gersick, 1991). This equilibrium can be punctuated by short intense episodes of upheaval, known as revolutionary periods (Romanelli & Tushman, 1994). Revolutionary periods involve reactions to significant change in the environment leading to considerable upheaval in which the deep structure is prised apart (Gersick, 1991), creating chaos while the various stakeholders within the industry in question resist, adapt, adopt and potentially promulgate. The revolutionary period may be resolved with a new regime (in terms of product or process or dominating organisation/company) or a return to previous practices.

The framework of punctuated equilibrium has been applied to understanding upheavals in several industries, including the airline industry (Tushman and Anderson, 1986; Romanelli and Tushman, 1994). The airline industry previously enjoyed, relative to today's rapid change, stable periods of evolutionary change. A few major players held the market ensuring a certain degree of stasis. However, new entrants with a 'no frills', 'low cost', 'cheap fare', strategy created a considerable disruption. Even Qantas, Australia's national airline, was forced to add a new 'low-cost carrier' (Jetstar) to combat new entrants such as Virgin Australia.

The results of a 'low-cost carrier' disruption are evident today. Consumers are capitalising on opportunities to secure low airfares due to, in part, diminished services provided at check-in (new technology allows a self-check-in process reducing staffing numbers) and in-flight (either through reduced meal services, or a requirement to pay for meals). The airline industry stalwarts experienced a considerable disruption from new entrants embracing new technology and implementing efficiency strategies. Consumers were offered more affordable air travel and reacted quickly, *en masse*, to secure flights, thus creating an industry-wide change.

Key components of punctuated periods are major economic and environmental change triggered by technological innovation (Romanelli & Tushmna, 1994). In order for technologies to be disruptive, they need to be significant. In order to be successful, the change needs to generate new business models and alternative methods of achieving an end objective of out-performing existing practices, altering ongoing industry practice. The change can be so rapid and advances occur so quickly that industry cannot adapt, and customers convinced by the new paradigm move quickly to the new model, abandoning the old (Lucas, 2012). As can be seen in the demise of the Kodak Company and its refusal or inability to adapt to the relatively sudden switch from film to digital in the consumer photography market (Kotter, 2012). Here disruptive technology activates a period of instability that is capped off by the arrival of a dominant paradigm that is characterised as either competence enhancing, or competence destroying (Anderson & Tushman, 1990), or perhaps competence obsolescence as the old way of doing things is no longer valued as highly.

Mass Timber Construction as a disruptive technology

MTC is a building process that uses engineered wood products as the primary structural material. It can be directly substituted for many of the concrete elements, including ceiling and walls, whether it is wet-poured, steel reinforced or solid section 'tilt-slab' for high-end residential and major low- to medium-rise construction projects. A hallmark product within the MTC arsenal is Cross Laminated Timber (CLT). CLT was originally invented in the 1970's (Canadian Wood Council, 2014) and is fabricated by bonding timber panels together in transverse and longitudinal layers.

MTC provides many benefits compared with traditional construction materials, including sustainability of resource use through improved utilisation of sawn log production (particularly when comparing engineered timber to solid section production), wood used in MTC sequestrates carbon (Depro, Murray, Alig & Shanks, 2008), and it is a renewable and recyclable resource. A primary advantage, according to Kremer & Symmons (2015), is found in a reduction of the project timeframe due to off-site

manufacturing and reduced on-site assembly. Large engineered timber elements are designed and produced in manufacturing facilities and delivered to site at which time they are craned into place resulting in the construction of a final form. Given the natural characteristics of the timber species used in the manufacture of MTC, and the grade of the adhesives used in its manufacture, these structural members can achieve similar strength properties to that of concrete for a similar thickness (Wood Solutions, 2013), allowing for akin substitution in design.

A site at which MTC is used is not dissimilar in appearance to that of other commercial construction sites, although it may be a building site for a reduced period due to the off-site pre-fabrication process for the MTC panels and members. Yet the fundamental approach to design for engineered timber panels that create the floor, walls and ceilings is considerably different.

Depending on the context, traditional construction methods – in existence for nearly 150 years (Nedwell, 1994) - employ steel reinforced concrete, or ferroconcrete (Bellis, 2013). Ferroconcrete construction requires the assembly of formwork systems, typically a plywood base and sides supported by bearer and joist systems capable of holding wet-poured concrete with embedded steel mesh, which is used for reinforcement. Once cured and dried the formwork assembly is removed leaving the structural core of the building.

McGowan (2011, Wood & Design, 2011) found that MTC provides an 11 percent cost reduction over concrete and steel depending on a number of factors, including location. For example, savings would be lower when exporting/importing product from Austria to Australia as compared with Italy. The six-storey Remy apartments in British Columbia (BC) – developed by the Oris Development Corporation – realised a 12 percent overall cost saving when the lightweight steel and concrete frame was replaced with timber (Walker, 2010). It is important to note that Walker (2010) does not provide precise detail regarding where the savings were achieved, for example in a cost reduction for materials, project timeline savings or labour savings etc. Furthermore, the McGowan examples all exist in a location – BC – with considerable expertise in construction with mass timber. In 2009, along with the inception of BC's Wood First Act, the BC Building Code was amended to increase the allowable height of timber-framed residential building from four to six storeys. The alignment and support, from government and industry, accelerates the practice of using an alternative construction method with timber as the primary resource (Kremer & Symmons, 2015).

In countries where MTC is a burgeoning technology, challenges await the uptake of MTC, including establishing supply chains, amassing assembly and engineering expertise, and a required shift in accepted marketing and sales models. As with any new technology, new routes to market need to be established for MTC. In Australia, the supply chain/s for MTC are currently very insular (Kremer & Symmons, 2015). Typically, the developer or builder contain and action the entire process from design, engineering, procurement, and installation in order to manage the risks that would otherwise be associated with a more disparate supply chain.

The adoption of MTC as a mainstream process or method requires a differentiated approach in terms of sales and marketing. Methods for quoting more traditional projects have established over many years, such processes are not entirely appropriate for quoting massive timber structures. An important consideration for the promotion of MTC is the 'total cost of ownership' or 'business case' calculation that includes not only the material costs (the substitution of timber for ferroconcrete), however anticipated savings based on reductions in project scheduling and on-site labour costs.

In terms of material costs comparisons, a primary difference in marketing MTC concerns the accurate calculation of material volume. If estimates are not accurate the cost may be grossly exaggerated, anecdotally up to 10%. In order to accurately quote MTC projects the use of computer-aided 3D modeling is required. Computer designs are able to assist with costing estimates, including; connection details of each panel, structural thickness of members and required spanning, number of panel lifts required on-site (craning panels into place), optimisation of panel design in accordance with the overall architecture of the project, and detailing the effective containerisation and shipping of panels internationally – if required.

Such differentiated channels to market require a shift in thinking and take time to establish and functional adequately for MTC to become widely accepted. Presently MTC occupies a niche position in the global construction market. MTC construction is somewhat established in the United Kingdom and more so in the European Union, however is yet to gain a significant foothold in other locations such as the United

States and Canada. Elsewhere a very small number of commercial building projects are underway, with many developers adopting a wait-and-see stance. In the United Kingdom, a country in which MTC has taken hold, Yates, Lingar and Dujic (2008) note that Telford Homes, the developer for the Murray Grove building, "naturally needed to be convinced of its [MTC] viability at all levels having never procured a building in this way before" (p. 1).

The potential impact on traditional construction methods

MTC has its roots as a construction method for domestic dwellings in Europe. More recently, it has been shown to be very efficient financially in certain contexts and geographies for the construction of buildings up to about 10 stories (van de Kuilen, Ceccotti, Xia & He, 2011). However, new advances are pushing the boundaries in design offering solutions for 30 storey buildings (Green & Karsch, 2012). The development of MTC solutions across varying tiers of construction (domestic dwelling, mid-rise and high-rise buildings) poses a considerable disruption to traditional concrete and steel construction.

Dunn (2015) calculated the theoretical savings to be gained from using MTC when compared to purely traditional forms of construction. A comparison of four commercial building types assessing the differences in costs associated with using timber as opposed to traditional materials – concrete and steel. The report assessed a seven-storey office building, an eight-storey apartment building, a two-storey aged care facility and an industrial shed.

Each of the projects were designed and independently assessed (costs and other input factors) using timber as the primary construction material with a comparison material/s (conventional concrete framed or steel framed building) in an urban location – Sydney, Australia. Overall, the results of the study revealed constructing in timber had lower costs than non-timber solution. The cost advantage for the eight-storey apartment building was 2.2%, the single-storey industrial shed (9.4%), the seven-storey office building (12.4%) and the two-storey aged care facility (13.9%). The precise location of the savings varied along with the unique qualities of the projects. For example, timber columns within the office building cost more than concrete (+41%), yet the requirement for columns within the apartment building was negligible (due to a different approach to design) resulting in considerable savings (-92%). The cost savings for the office and apartment building were generally in the costs associated construction program savings (generally 6 weeks) over the concrete solution. Dunn (2015) also reports that costs savings would have been greater had it not been for the fire protection to some structural components, additional fire engineering costs and the costs of termite protection.

A few case studies provide actual cost differentials using MTC compared with traditional construction approaches. An assessment of the Murray Grove MTC project in the United Kingdom reveals that whilst there was a 30% increase in material costs for the cross laminated timber components compared to ferroconcrete, there was a considerable 17-week saving in the expected overall construction program (Yates, Linegar & Dujic, 2008). This time saving resulted in reductions in on-site costs, hire costs of crane, rigging and other plant and equipment, and reduced risk from external factors including inclement weather. In the United States the first CLT building, The Long Hall, was constructed as a mixed-use project replacing an existing structure in Whitefish, Montana (Byle, 2012). A case study by Byle (2012) compared cross laminated timber with concrete and masonry for the 2-storey construction. Byle (2012) found MTC to be more economical by approximately 6 percent of the overall cost if materials were sourced internationally, and approximately 12% if materials were locally produced (see Table 1). In both projects, a considerable cost advantage is gained through an accelerated construction program.

Table 1. *Cost comparison of traditional construction vs. mass timber construction*

Item	Traditional Construction	Cross Laminated Timber
Initial Costs (Whole Scheme)	$665,000	$616,000
Shipping	$0	$40,000
Structural engineering	$7,000	Included
Time to closure of facility	22 weeks	12 weeks
Total	$712,000	$671,000
Savings		$41,000
If product was domestically sourced		-$35,000
Savings		$76,000

Source: Adapted from Byle (2012).

In a related example from Australia, the Lend Lease construction company built the 10 storey Forté building – the largest MTC apartment complex in the world at the time- and it "was 30% faster to build, safer and with higher precision than traditional construction materials. It also resulted in reduced construction traffic to and from site, caused less disruption to the community and produced less waste" (Patterson in Walsh, 2013, para. 6). However, for developers such as Lend Lease, there are important commercial considerations that must be factored into the overall calculation given that MTC is an alternative construction method and may attract prejudice. Such factors include securing finance, securing insurance, and allaying potential consumers concerns around issues such as fire rating and termite attack.

The diffusion of MTC as an innovation in Australia

It is the adoption by key influencers - developers, builders, and consumers - that shall ultimately shape the future of MTC in Australia. As such, industry innovators will collectively be required to devote considerable effort to promoting the technology and highlighting the virtues of MTC, whilst individually ensuring they capitalise on the opportunities created to ensure MTC gains mainstream acceptance. The *new product diffusion curve* is based on Rogers' (1962) 'diffusion of innovations' theory that explores why, how and what rate new technologies and innovations permeate various industries. Diffusion is the process by which innovations are communicated through particular channels over time among social systems (Rogers, 1962). An innovation must be widely adopted in order to become self-sustaining. MTC is an adopted technology within, arguably, the *innovation* (Rogers, 1962) period, with companies such as Lend Lease at the vanguard. There is certainly space though for further innovation, particularly developments that would see MTC as a more specific fit to the Australian environment. For example, the *early adopter* (Rogers, 1962) period may not begin in Australia until stronger signs are present. Signs including that the product is being well received amongst clients, regulators, financiers, etc. There is also room for innovation in terms of the supply chain and adaptations to the product that make it a more particular fit to the geographical and climatic environment.

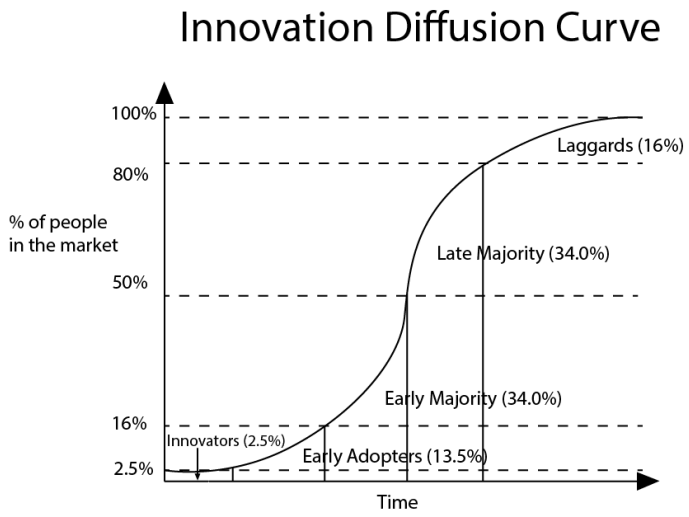

Figure 1. Innovative product diffusion curve. Adopted from Rogers (1962).

Progressing adoption

The Survey of International Tall Wood Buildings (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014) is the first research project to explore opinions from stakeholders engaged in MTC use around the world. The Binational Softwood Lumber Council report identifies a number of important considerations in developing future markets for MTC.

Builders who responded to the Binational Softwood Lumber Council survey expressed that early collaboration with pivotal stakeholders, including specifiers and manufacturers, to secure timber engineering and erection expertise is vital. Builders need to work closely with suppliers for the off-site fabrication of structural elements coupled with on-site logistics. The report noted that careful planning of trades is essential to ensuring an overall reduction in the production schedule with MTC compared with traditional forms of construction (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014).

Of the ten projects reviewed in the Survey of International Tall Wood Buildings (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014), four required an alteration to exiting insurance policies. These changes related to the developers' requirement to carry "third party liability insurance and contractors' all risks insurance" and "professional indemnity, public liability, employee insurance and construction insurance" (p. 19). For design teams, the main alteration related to public liability and professional indemnity. Advising insurance entities about intentions to use MTC allows for the segregation of the risks associated with a prototype design and gaining sufficient coverage. The cost to stakeholders for policies alterations averaged about 25% more than that for a conventional construction development. As the product and process continues to improve and there is a lack of adverse outcomes, it is likely that competition will gradually erode this premium.

There appears to be a relationship between 'self-funding' and prototype MTC. Participants within the Survey (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014) did not indicate any unusual financing practices or discuss any challenges they faced when securing finance associated with MTC projects. However, 60% of projects listed within the survey were self-financed (by the developer) and a further 20% obtained finance through governmental programs. Traditional builder-owner financing situations accounted for an additional 10% of projects listed (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014).

Developers indicated to the Binational Softwood Lumber Council that in order to progress the MTC market a key component was an understanding of markets and negative perceptions associated with its use, including fire risk, acoustic performance and robustness (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014). Participants expressed that it is of considerable importance that developers actively seek out solutions in order to resolve market perceptions to foster MTC as an alternative construction method.

The Survey of International Tall Wood Buildings (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014) provides valuable insights to advance MTC when reviewing the supply chain and the stakeholders in the construction process, however it fails to explore the key drivers for consumers. It could be argued that for MTC to be accepted in emerging markets, including Australia, consumers must be willing to reside and utilise buildings constructed using structural timber as a more substantial component than previously encountered.

Attitudes toward logging and wood as a construction material

The environmental movement holds a great deal of conservatism when addressing the issue of the earth's natural resources, in particular deforestation (Espinoza, Buehlmann & Smith, 2012; Damette & Delacote, 2011). Increasing demand for agricultural land has accelerated the deforestation process in a number of places (Damette & Delacote, 2011). Such concerns do not apply exclusively to developing countries. For example, there is a common perception in Australia that Victorian and Tasmanian authorities are guilty of not just allowing, but also profiting from, the wholesale destruction of old-growth forests. Importantly MTC production relies, predominately, on low-grade sawn log material, which can be sourced from certified forestry plantation sources.

A review of the environmental psychology literature is helpful for exploring possible psychological barriers to larger-scale timber usage. A concept known in the timber industry as the "slaughter-house effect" suggests that attitudes to logging amongst an increasingly environment- and sustainability - sensitive population will be a significant hurdle for increased timber use in construction projects. Concerns about durability -termites, mold, water damage – (Taylor, Lloyd & Shelton, 2016), fire hazard (Dunn, 2015), and anecdotally the view that constructing in timber is an 'old' construction method (and material) compared with concrete and steel, will all provide potential hurdles for an uninformed public.

Social acceptance of wood

According to Castaldo, Perrini, Misami, and Tencati (2009) of the many findings within the body of literature relating to Corporate Social Responsibility (CSR) consumers are interested in the social behaviours of organisations promoting products and services and this potentially influences purchasing behaviours. For example, the consumer backlash against products from large companies employing cheap labour in improvised areas like Bangladesh. For consumers, a pivotal connector in the purchase decision-making process is the level of trust between the organisations brand and reputation and the consumers purchasing their products (Castaldo, Perrini, Misami, & Tencati, 2009). The authors concluding that organisations with a socially oriented philosophy are able to leverage their reputation to market products with an increased symbolic value – such as being more sustainable.

A study by Ford, Williams, Smith, and Bishop (2012) exploring public perceptions about forestry management practices in Tasmania concluded that when individuals judge the concept of 'environmental management' they apply personal values (beliefs), situational context (experience), and psychological processes (methods of calculating subjective values) in responses. Whilst the Ford study did not focus specifically on the building industry, the structural equation modeling revealed a significant relationship between three important factors: 'trust', 'what is good for the environment' and 'what is good for the [timber industry]'. 'Trust' moderates the other two factors, a lesson that should form part of strategies for the promotion of MTC in Australia. For example, when consumers procure timber that has been certified under environmentally credible schemes it builds trust and demonstrates support for the timber industry as a whole (Rametsteiner, 1999).

A longitudinal study by Parry-Husbands and Parker (2014) exploring everyday Australian consumer (N =1534) attitudes toward wood products compared with other materials reveals that wood has a high positive rating when compared to alternative materials, including steel and plastic, over a seven year period. Respondents (n = 1031) scored wood, based on its look and feel, significantly higher when compared to alternative materials such as bricks, concrete, steel and plastic. An individual's intention to purchase wood products increases if wood has been sustainably produced. Respondents indicated they are 'somewhat more likely' and 'much more likely' to purchase wood products from sustainable sources. The use of concise marketing messages about sustainable forest harvesting, including forest stewardship and chain of custody

certification schemes, is vitally important to ensuring acceptance of wood products in the market (Rametsteiner, 1999).

An important consideration for importers of wood products is respondents indicated that sourcing sustainable timber from within Australia is preferred to importing wood from overseas (Parry-Husbands & Parker, 2014). As the majority of products under the MTC umbrella are currently imported, a suggested strategy for importers to remove any negative connotations about imported timber is to focus on the promotion of MTC as an innovative process and not an amassing of timber elements imported from Europe. Such a strategy still presents challenges around convincing consumers about wood in terms of its durability and robustness.

Perceptions about wood durability

Consumer's rate wood as a natural, warm, and versatile material, however they equate materials such as bricks, steel and concrete as holding greater strength (Parry-Husbands & Parker, 2014). Further, consumers view wood as being vulnerable to termite attack and susceptible to degradation due to rot and mould (Lehmann, 2012; Parry-Husbands & Parker, 2014). Anecdotally, much of our perceptions regarding wood appear to come from what behavioural science call 'instincts'. Instincts are innate patterns of human behaviour that exist without training or education (Spink, 2010). Instincts, according to Spink (2010), can be considered "evolved cognitive mechanisms" (p. 27) or the genetic adaptation of specific traits that predispose humans to engage in specific behaviour under certain conditions.

It is conceivable that consumers' responses to questions about wood as it relates to fire, water and termites are a consequence of instinctive motivations and hence automatic in nature; a cognitive short cut, or heuristic, based on experience. For example, when asking a friend or colleague 'what would happen to wood if set alight?' the immediate response would be that the wood would burn. In structural applications making allowances for the 'char rate'– the amount of wood material that is scarified to fire - ensures the structural integrity of wood members (Engineered Wood Products Association of Australia, 2013). The results of such application of wood in construction is that wood is equivalent to or better than ferroconcrete and steel constructions (see Australian Standards, AS1720.4 Timber Structures: Fire-resistance of structural timber members).

Similarly, a response to the question 'what would happen if wood remained wet for long periods of time?' or 'what happens when termites attack wood' the response would certainly include that the wood would rot, decay or be eaten away. The implicit meaning of this response is that the wood will become unstable and not able to perform its function. Therefore, consumer perceptions about structural members or panels within a building of 10 storeys that are rotting and decaying will not provide a safe environment in which to live. This would also most certainly lead to the conclusion that MTC is not a wise investment choice when parting with hard-earned cash.

The reality is that timber elements, unless exposed for aesthetic reasons, are mainly hidden and protected from the elements and the ingress of termites by cladding and lining the building in a similar method to that of traditional ferroconcrete construction. If constructed in the appropriate way, mass timber components are not exposed to the weather and thus are not vulnerable to conditions that jeopardise the integrity of the structure.

Educated responses concerning wood and durability seem consistent with consumer perceptions. Schmidt and Griffin (2013) conducted a relatively small study of architects, engineers, developers, and builders ($N = 63$) and found that knowledge about durability, especially to fire, was poor. When participants were asked to compare two methods, mass timber or ferroconcrete, only 15% recognised mass timber would perform better in a fire. Participants recognised that fire protection could reduce the risks of fire in timber structures.

Consumers' negative perceptions concerning wood and decay, or rot, are similar in Australian (Parry-Husbands & Parker, 2014) and European (Rametsteiner, Oberwimmer & Gschwandtl, 2007) studies about wood as a construction material. In the European study by Rametsteiner, Oberwimmer and Gschwandtl (2007), consumer responses indicate a belief that considerable maintenance is required in the prevention of wood decay; such perceptions may be inhibitory to an acceptance of MTC.

The need for this research

MTC has significant potential in the Australian construction market (Kremer & Symmons, 2015). Nevertheless, anecdotally there is hesitation amongst stakeholders to adopt it. There is a paucity of consumer-based research concerning MTC adoption in Australia. Therefore, a targeted assessment is required. Such a project would seek to not just determine barriers and hurdles, but also explore acceptance of methods specifically designed to overcome them. The present study adopts a mixed methods approach and delivers two research projects. The first, a survey explores Australian consumers' attitudes toward a number of identified factors that may inhibit a widespread adoption of MTC in Australia. Specifically, this study explores the relationship between timber use in construction, factors relating to property purchasing decisions and environmental attitudes. The second, a qualitative study (interviews) examines perceived barriers and suggested strategies for overcoming them from a number of stakeholders within the Australian building and construction industry.

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Study One – Consumer Survey

The aim of Study One was to ascertain if the attitudes of Australian consumers toward environmental issues and the use of timber in construction are related to factors involved in property purchasing behaviours. The following predictions were tested.

H1: Participants exhibiting greater anthropocentric and apathetic environmental attitudes rather than ecocentric environmental views will express greater attitudes toward timber in construction.
H2: Participants shall indicate strong attitudes relating to the durability of timber use in construction.
H3: Apathetic and anthropocentric attitudes toward the environment will significantly predict attitudes toward timber in construction whilst controlling for attitudes toward environmentally sustainable design of products and services.
H4: Apathetic and anthropocentric attitudes toward the environment shall mediate the relationship between the use of timber in construction and financial influences in property purchasing decisions. However, ecocentric attitudes shall not.

Method

Participants

A convenience sample was collected. Participants were 281 individuals (145 males and 136 females) aged 19 - 82 years with a median age of 52 years (M = 51.64, SD = 15.26). The data was split by age into two groups older (n = 213, 39 years +) and younger (n = 74, 18-38 years) adults for comparisons purposes. Of these, 71 participants (34%) indicated they worked within the building industry, employed as architects, engineers, building designers, wholesalers or manufacturing representatives. In terms of family, participants indicated they had no children (n = 27), dependent children at home (n = 46), independent children not at home (n = 50) and children however not at home (n = 23). In addition, 46% of participants indicated they recently made a property purchase, are in the process of making a property purchase or will make a property purchase within the next 2 years. Participants indicated the type of property they would have/will purchase: House n = 177 (63%), Townhouse/Unit n = 63 (23%), an Apartment in a complex n = 23 (8%), other n = 13 (5%) (Land, Factory, Commercial Property) and, no response n = 4 (< 1%).

In terms of residence, n = 105 (38%) reside in Victoria, n = 83 (30%) in New South Wales, n = 4 (1%) in the Australian Capital Territory, n = 50 (18%) in Queensland, n = 14 (5%) in Tasmania, n = 37 (13%) in Western Australia, n = 40 (14%) in South Australia, and none from the Northern Territory. The total number of responses exceeds the total number of participants because of the option to select multiple locations, for example, residing in a CBD unit/apartment and owning a rural holiday/weekend house.

Measures

Ecocentric and Anthropocentric Attitudes toward the Environment scale (EAATE). The EAATE is a 33-item instrument developed by Thompson and Barton (1994) to measure an individual's attitudes and apprehension for the environment. The instrument is administered in the present study using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). The instrument is composed of three subscales, which include, Ecocentric, Anthropocentric and Environmental Apathy. The Ecocentric subscale measures attitudes toward the environment at an intrinsic level. Thus, individuals holding ecocentric views expressing attitudes concerning protection over the environmental as a resource because of the intrinsic value. An example of a question in this subscale, "*I can enjoy spending time in natural settings just for the sake of being out in nature*". The ecocentric subscale within the present study achieved a Cronbach's alpha of α = .831. The Anthropocentric subscale, in contrast, measures attitudes toward the environment at an extrinsic level. Consequently, expressing protection over the environment as a resource for maintaining or enhancing the quality of life. An example of the question in this subscale, "*The thing that concerns me most about deforestation is that there will not be enough lumber for future generations*". The anthropocentric subscale within the present study achieved a Cronbach's alpha of α = .64 which is acceptable given the instruments

non-clinical nature (Chakrapani, 2004). Thompson and Barton (1994) suggest that both Ecocentric and Anthropocentric oriented individuals express concern over preserving the environment, however their motives are distinguishable. The Environmental Apathy subscale measures an individual's indifference to environmental issues. An example of the question in this subscale, "*Environmental threats such as deforestation and ozone depletion have been exaggerated*". High scores indicate strong attitudes toward a particular measure. The environmental apathy subscale within the present study achieved a Cronbach's alpha of $\alpha = .92$. The authors chose this scale as it appeared to be the most suitable for addressing attitudes toward timber use and the paradoxes inherent in the environmental sustainable design debate.

Timber in Urban Construction Scale - Revised (TUCS- R). The TUCS-R is a modified 16-item instrument originally developed by Bysheim and Nyrud (2008). The original questionnaire was designed to understand the intentions of architects for the use of timber as a structural material in urban construction. The instrument has been adapted to measure consumer attitudes toward the use of timber in construction. In particular, items explore perceived disadvantages relating to Material Durability "*I am concerned about the durability of timber*", Constructions Cost "*The total cost of building is higher when using timber compared to alternative products*", Environmental Attributes "*CO2 emissions are lower when processing and constructing with timber when compared to alternative materials, such as construction with concrete and steel"*, Aesthetics "*Timber is visibly appealing*", and Physical/Mechanical Properties "*I would ensure my builder uses structural timber (for supporting the overall building) in the construction of my next home*". The instrument is administered using a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Items 3, 7, 8, 9, and 11-15 were reverse scored. Cronbach's alpha for the revised instrument in the present study $\alpha = .67$, which is acceptable given the instrument's non-clinical nature (Chakrapani, 2004). This instrument was chosen as it was deemed the most suitable in assessing attitudes toward the use of timber in construction.

Buyer Preference in Residential Property Revised (BPRP-R). The BPRP-R is a modified 50-item instrument originally developed by Ratchatakulpat, Miller and Marchant (2009). The original questionnaire was designed to measure attitudes toward purchasing residential property in Queensland, Australia. The instrument was reduced from 86-items to 50 for convenience. The original instrument was developed using a modified Delphi technique. Ratchatakulpat, Miller and Marchant (2009) assembled research relating to factors they wished to measure. A panel of real estate professionals reviewed the questionnaire. That questionnaire was then tested in a pilot study. The revised instrument used in the present study explores five subdomains and participants were asked to rate the level of importance of each item in property purchasing decisions The domains were: Physical Attributes "*Dwelling size*", Location "*Distance to work*", Environment "*Attractiveness of the area*", Financial Considerations "*Maximum monthly repayments I can repay*" and Psychological Influences "*Opinion of significant other (family, friends etc.)*". The instrument is administered in the present study using a 5-point Likert scale from 1 (unimportant) to 5 (very important). This scale was chosen for its suitability in measuring a holistic and comprehensive set of property purchasing attitudes specifically for an Australian population.

Design

Mediation analysis has been found to be beneficial when seeking to answer the question of 'how' variables interact with each other (Hayes, 2007; MacKinnon, Fairchild & Fritz, 2007). Therefore, the present paper employs, amongst other techniques, a mediation analysis using an SPSS add-on called PROCESS (Preacher & Hayes, 2004). PROCESS uses a bootstrapping analysis in calculating mediation models. Bootstrapping is a non-parametric technique, which involves resampling the data to provide confidence in outputs.

Procedure

Ethics approval was received from the Monash University Human Research Ethics Committee. Approval was given to promote the study through pre-approved adverts posted on various industry supplier websites. Members of the reference group committee were contacted via email and asked to send the survey through social networks throughout the participant recruitment process. Participants who were sent a link within an email, or responded to an advert on a website accessed an online survey hosted by Qualtrics (www.qualtrics.com). The author's also engaged the use of a third party service to distribute the survey to their panel of individuals who commonly respond to 'consumer-oriented' surveys. These participants were identified as having just purchased a property or who indicated they were going to within a projected two-year period from the time of participating in the survey. Participants completed the questionnaire within 20 minutes on average.

Results

Preliminary Analysis. Data were screened for missing values, outliers and normality. Missing data were given the mid-point rating of three (3) indicating a neutral response on the Likert scale of 1-5 employed on all major measures. All tests were conducted using a 95% confidence level and two tail tests using SPSS 22.

Knowledge of Mass Timber Construction. Participants were asked about their knowledge of MTC with 224 (80%) responding 'no knowledge' and 57 (20%) responding 'I had prior knowledge'. Participant knowledge was gained from television shows such as Grand Designs (United Kingdom), within the workplace (within the construction industry), working on CLT projects, via various media channels (including social media), through university research studies, and via industry conferences/exhibitions.

Environmental Sustainable Design and Attitudes toward Purchasing. Participants were asked to rate their level of knowledge about the Australian Green Building Council Green Star Program. The average rating (M = 1.9, SD = 1.27) indicates poor knowledge of the program. Participants indicated the extent of influence an Environment or Sustainability Rating System would have on their decisions to purchase an apartment/home/ investment property. The average rating (M =2.88, SD =1.22) indicates a neutral acceptance of such programs. Finally, participants indicated how important Environmental Sustainable Design Building practices are in decisions to purchase products and services, the average rating (M = 3.29, SD = 1.28) indicating that sustainable building practices are somewhat important to participants.

Construction Materials and Attitudes toward Purchasing. Participants indicated how important the 'structural soundness of the building' (M = 1.51, SD = .70) and the 'construction type e.g. brick, timber, concrete' (M = 2.20, SD = .70) are in the purchasing decision of a property. Participants were also asked 'if they would direct their builder to use structural timber (for supporting the overall building) in the construction of my next home' (M = 2.80, SD = .86). 13% (n = 36) of participants indicated it was important or very important, 60% (n = 167) indicated a neutral response, and 28% (n = 78) indicated it was unimportant or very unimportant to them to have the builder use structural timber in the construction of their next home.

In terms of durability, participants were asked to rate their level of agreement with the following statement 'I am concerned about the durability of timber' (M = 2.61, SD = .95). 53% (n = 148) of participants indicated they agreed or strongly agreed, 27% (n = 77) indicated a neutral response, and 20% (n = 58) indicated they disagreed or strongly disagreed that they are concerned about the durability of timber. Participants were also asked their level of agreement with the following statement 'using timber increases the risk of fire' (M = 3.49, SD = .93). 54% (n = 154) of participants indicated agree or strongly agree, 31% (n = 88) indicated a neutral response and 13% (n = 38) indicated they disagree or strongly disagree that using timber increases the risk of fire.

Environmental and Attitudes toward Purchasing. Participants were asked if 'CO2 emissions are lower when processing and constructing with timber when compared to alternative materials, such as construction

of concrete and steel' (M = 2.53, SD = .76). 6% (n = 17) indicated they agreed or strongly agreed, 40% (n = 111) indicated a neutral response and 29% (n =82) of participants disagreed or strongly disagreed that CO2 emissions are lower when processing and constructing with timber when compared to alternative materials, such as construction of concrete and steel. In order to make a comparison between the sustainability of timber and commonly purchased environmental products, participants were asked 'how important are the use of solar panels' in their decision to purchase a property (M = 2.42, SD = .95). 11% (n = 32) indicated they are important or very important, 36% (n = 101) indicated a neutral response and 53% (n =150) responded unimportant or very unimportant. Results indicate timber may not be considered by participants to be as 'environmentally friendly' as products such as solar panels, however timber - within the context of the present study - is not a retail product and therefore possibly not front of mind.

Financial Attitudes toward Purchasing. Participants were asked if 'the total cost of building is higher when using timber compared to alternative products' (M = 2.08, SD = .78). 26% (n = 71) indicated they agreed or strongly agreed, 57% (n = 160) indicated a neutral response and 18% (n =50) of participants disagreed or strongly disagreed the total cost of building is higher when using timber compared to alternative products. Participants were also asked if 'when using timber, energy costs (in the construction of the building and in running the building - heating and cooling) were higher compared to alternative materials, such as concrete and steel' (M = 2.01, SD = .81). 23% (n = 63) indicated they agreed or strongly agreed, 55% (n = 157) indicated a neutral response and 22% (n =61) of participants disagreed or strongly disagreed that using timber, energy costs (in the construction of and in running the building - heating and cooling) were considered higher compared to alternative materials. Results indicate the perceived costs associated with the use of timber in construction, energy consumption and running costs are higher.

Older and Younger Adult Attitudinal Comparison. An analysis of differences in attitudes between older (38+) and younger adults (18-38) revealed that older adults (M = 3.53, SD = 1.31) had statistically significant (Levene's test was violated, unequal variance assumed $t(92.95) = -3.36$, p = .001, Cohen's d = .47 a medium effect) lower scores on attitudes toward the importance of structural soundness and construction components in property purchasing decisions than younger adults (M = 4.19, SD = 1.49). Participants responses about the use of structural timber (for supporting the overall building) in the construction of their next home, results indicate older adults (M = 3.72, SD = 1.10) had statistically significant ($t(279) = 2.38$, p = .018, Cohen's d = .31 a medium effect) higher scores than younger adults (M = 3.38, SD = 1.06). However, an analysis of differences in attitudes toward the influence of environmental sustainable design in property purchasing decisions revealed that older adults (M = 26.20, SD = 4.97) had near statistically significant ($t(279) = -1.92$, p = .056, Cohen's d = .23 a small effect) lower scores than younger adults (M = 27.5, SD = 4.86). Whilst this difference was not strictly statistically significant it is an interesting finding.

Environmental Attitudes. All participants completed the Ecocentric and Anthropocentric Attitudes toward the Environment Scale. Responses to the survey revealing participant's preferences for one or more of the subdomains. The following statistics represent the participants' responses for scores above the midpoint on the 5-point Likert scale by subdomain.

- 9% (n = 24) of participants indicated scores above the mid-point on all three subdomains.
- 31% (n = 86) of participants indicated scores over the mid-point on the Ecocentric and Anthropocentric subdomains.
- 13% (n = 37) of participants indicated scores over the mid-point on the Ecocentric and Apathetic subdomains.
- 22% (n = 63) of participants indicated scores over the mid-point on the Anthropocentric and Apathetic subdomains.
- 51% (n = 143) of participants indicated scores over the mid-point on the Ecocentric subdomain.
- 51% (n = 145) of participants indicated scores over the mid-point on the Anthropocentric subdomain.

- 48% (n = 137) of participants indicated scores over the mid-point on the Apathetic subdomain.

The analysis reveals participants can hold more than one attitude about the environment. The strongest combinations are Ecocentric and Anthropocentric, and Anthropocentric and Apathetic attitudes. Such analysis is important to understanding the likely proportions of 'consumers' environmental attitudes occurring in the wider population of all consumers throughout Australia. This information may better inform those seeking to develop marketing messages because of this report.

Knowledge of MTC, Environmental Attitudes and the Relationship with Timber in Construction. An exploration of the relationship between participant's prior knowledge of MTC, various attitudes toward the environment and attitudes toward the use of timber in construction was undertaken. Table 1, below, provides the descriptive statistics for the analyses.

Table 1.

Descriptive Statistics for the domains Ecocentric, Anthropocentric, Apathetic and Timber in Construction

Variable	Prior MTC Knowledge	Mean	Standard Deviation	Range	*N*
Ecocentric	No	25.74	6.36	12-60	224
Anthropocentric	No	29.63	4.93	11-55	224
Apathetic	No	32.73	7.22	9-45	224
Timber in Construction	No	41.58	5.11	16-80	224
Ecocentric	Yes	25.25	5.60	12-60	57
Anthropocentric	Yes	30.35	4.95	11-55	57
Apathetic	Yes	34.96	7.04	9-45	57
Timber in Construction	Yes	42.58	7.00	16-80	57

In order to find the strength, or not, of the relationship between environmental attitudes and participants knowledge of MTC and attitudes toward timber in construction a correlation analysis was undertaken. A correlation analysis revealed a significantly moderate relationship for participants without prior knowledge of MTC and the relationship between Anthropocentric views and attitudes toward the use of Timber in Construction (r = .33, p=<.001, r^2 = .11). Similarly, a significantly weaker relationship exists for participants without prior knowledge of MTC and the relationship between Ecocentric environmental attitudes and attitudes toward the use of Timber in Construction (r = .22, p=<.001, r^2 = .05). Combined, participants without prior knowledge of MTC holding Ecocentric and Anthropocentric views about the environment explained 16% of participant's attitudes toward timber in construction – a moderate effect.

Whereas, for participants without prior knowledge of MTC, there was no significant relationship between Apathetic environmental attitudes and the use of timber in construction.

Further analyses revealed a significantly moderate relationship for participants with prior knowledge of MTC and the relationship between Anthropocentric environmental views and attitudes toward using timber in construction (r = .29, p=.013, r^2 = .08) which explained 8% of the data. However, for participants with prior knowledge of MTC and the relationship between Ecocentric or Apathetic environmental attitudes and the use of Timber in Construction was not significant.

Factors Predicting Attitudes toward the use of Timber in Construction. The results from a Hierarchical Multiple Regression analysis revealed Ecocentric, Anthropocentric and Apathetic attitudes toward the environment significantly predicts attitudes toward Timber in Construction whilst controlling for the influence of Environmentally Sustainable Design in Building Products and Services. Table 2 provides the descriptive data for the variables used in the analyses. Age, gender and working in the construction industry factors were non-significant and removed from the analysis.

Table 2

Descriptive statistics for Ecocentric, Anthropocentric, Apathetic, ESD Influence and Timber in Construc

Variable	Mean	Std. Deviation	Range	Skewness	Kurtosis
Timber in Construction	41.78	5.50	16-80	-.24	.77
ESD in Products/ Services	2.89	1.22	0-5	-.14	-.66
Ecocentric Attitudes	25.64	6.20	12-60	-.11	-.36
Anthropocentric Attitudes	29.78	4.94	11-55	-.21	.54
Apathetic Attitudes	33.18	7.22	9-45	.22	-.61

Note: N = 281

Intercorrelation analyses revealed a significant relationship between participant's attitudes toward the use of Timber in Construction, Environmentally Sustainable Design (ESD) in Building Products and Services, and Ecocentric and Anthropocentric. See Table 3 for intercorrelational outputs.

Table 3

Intercorrelational Data for Hierarchical Multiple Regression

Variables	*Comparison*	*N*	*r*	*Sig.*	r^2
Timber in Construction	ESD in Products and Services	279	.12	.025	.01
Timber in Construction	Ecocentric Attitudes	279	.16	.003	.03
Timber in Construction	Anthropocentric Attitudes	279	.33	<.001	.11
Timber in Construction	Apathetic Attitudes	279	.08	.08	.01
ESD in Products and Services	Ecocentric Attitudes	279	-.01	.422	<.001
ESD in Products and Services	Anthropocentric Attitudes	279	.02	.395	<.001
ESD in Products and Services	Apathetic Attitudes	279	.05	.191	<.01
Ecocentric Attitudes	Anthropocentric Attitudes	279	.29	<.001	.08
Ecocentric Attitudes	Apathetic Attitudes	279	-.56	<.001	.31
Anthropocentric Attitudes	Apathetic Attitudes	279	.13	.02	.02

A hierarchical multiple regression analysis was performed to examine whether the influence of Ecocentric, Anthropocentric and Apathetic attitudes toward the environment would predict attitudes toward Timber in Construction whilst controlling for Environmentally Sustainable Design. The analysis revealed that Environmentally Sustainable Design in Building Products and Services significantly predicted Timber in Construction, $F(1, 277) = 3.91$, $p = .049$, accounting for 1% (adjusted $r^2 = .01$) of the variability. This predictor explains a very small portion of the data and is on the border of statistical significance. Adding Ecocentric, Anthropocentric and Apathetic significantly improved the prediction of Timber in Construction, $\Delta F(3,274) = 13.83$, $p < .001$, accounting for an additional 12% (adjusted $r^2 = .13$) of the variability. Ecocentric, Anthropocentric and Apathetic and Environmentally Sustainable Design in Building Products and Services significantly predicted timber use in construction, $F(4, 274) = 11.48$, $p < .001$, explaining 14%

(adjusted r^2 = .14) of the variability. Age and Gender were not found to be predictors of timber use in construction.

The data indicates Environmentally Sustainable Design in Building Products and Services on its own is a significant, however with poor effect, predictor of timber use in construction. However, when Ecocentric, Anthropocentric and Apathetic domains are added, these three additional predictors account for 9% of the variance in the data suggesting attitudes toward the environment are good predictors of Timber in Construction. Yet, a significant amount of the variability in the data is unexplained. Table 4 details the regressions coefficients for the analysis.

Table 4

Regression Coefficients for Hierarchical Multiple Regression Analysis

Variable		*B*	*SE B*	β	sr^2	*Sig*
Step 1						
	Constant	40.29	0.85			
	ESD in Products/ Services	.54	.27	.12	.01	.049
Step 2						
	Constant	23.44	3.08			
	ESD in Products/ Services	.48	.25	.11	.01	.05
	Ecocentric	.17	.07	.19	.01	.011
	Anthropocentric	.30	.07	.27	.06	<.001
	Apathetic	.12	.06	.15	.02	.038

Mediation Analysis. A meditation analysis was conducted to determine if Ecocentric, Anthropocentric and Apathetic attitudes toward the environment were mediators of the relationship between the use of Timber in Construction and Financial Influences in property purchasing decisions. Following an initial analysis two variables, Ecocentric and Apathetic environmental attitudes did not significantly predict Financial Influences in property purchasing decisions and were removed from further analysis.

Intercorrelation Analyses. A Pearson's Correlation Coefficient analysis was run to determine the relationship between the variables (see Table 5. below).

Table 5

Intercorrelation Analyses for Mediation Variables

Variables	Comparison	*N*	*r*	*Sig.*	r^2
Timber in Construction	Anthropocentric Attitude	281	.33	<.001	.11
Timber in Construction	Financial Influences	281	.22	<.001	.05
Anthropocentric Attitudes	Financial Influences	281	.33	<.001	.11

Note: 95% confidence interval.

Mediation analysis based on 10,000 bootstrapped samples using bias-corrected and accelerated 95% confidence intervals (as per Preacher & Hayes, 2004) revealed attitudes toward the use of Timber in Construction had a highly significant total effect on the importance of Financial Influences in property purchasing decisions (*TE* = .40, *se* = .07, *p* = <.001), a significant residual direct effect (*DE* = .34, *se* = .07, *p* = <.001), a significant indirect effect for Anthropocentric Attitudes toward the environmental (*IE* = .06, *se* = .03, *LLCI* = .01, *ULCI* = .12). Figure 2., below, provides details about the variables used in the mediation analysis.

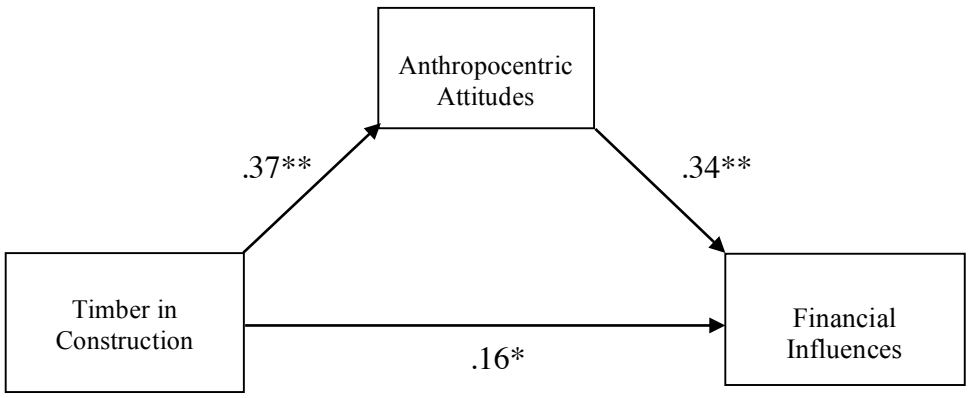

Figure 2. Diagram of mediation analysis coefficients between the variables, * *p* = .011, ** *p* = <.001.

As zero is not in the 95% confidence interval, the indirect effect for Ecocentric environmental attitudes is significantly different from zero at *p*= < .05 (two tailed). Therefore, Anthropocentric attitudes toward the environment mediates the relationship between participant's attitudes toward the use of Timber in Construction and Financial Influences in property purchasing decisions. However, with a small effect of 5% (k^2 = .051; Preacher and Kelley, 2011).

Discussion

Study One aimed to ascertain if the attitudes of Australian consumers toward the environment and the use of timber in construction are related to factors involved in property purchasing behaviours.
As expected with a burgeoning technology, knowledge of MTC was limited to a small portion of the population of interest, the majority of who were involved in the building industry. Of those who were not aware of the MTC, the media - specifically television - played an important part in informing participants about the technology.

Participants expressed a poor knowledge of the Green Star rating system, which is understandable given that the majority of the property types considered whilst responding to this questionnaire were detached houses. There is no current 'Green Star' rating system for detached housing in Australia. Therefore, awareness of the program is limited to, typically, commercial or very large multi-residential projects. Responses were neutral with respect to the amount of influence a 'rating system' would have on their purchasing decisions. As Young, Hwang, McDonald, and Oates (2010) suggest, green consumer's product purchasing decisions comprise a multitude of factors not just a single rating. Such factors include, context, environmental knowledge, values, feedback and certain 'green criteria' - or the sustainable/green rating of the product.

Participant's responses indicate that environmentally sustainable design in building practices as important in their decisions to purchase products and services. Combining this finding with the aforementioned results concerning rating systems there is an opportunity to explore effective communication mechanisms for those promoting 'green' information to consumers. Perhaps providing a broader array of communication for consumption, such as that preferred by Young, Hwang, McDonald, and Oates (2010), that is suitable for consumers to make property-purchasing decisions.

In terms of construction materials and factors relating to durability of timber, the present study found structural soundness was not important to participant's property purchasing attitudes. Overall, the use of timber as a building material was not considered an important or unimportant factor in the construction of a purchased or future purchase property. However, just over half of all participants were concerned about the durability of timber, specifically relating to an increased risk of fire. Similar to Schmidt and Griffin (2013), it appears participant's knowledge concerning the natural characteristics and treatment of timber improves fire resistance is poor. In order to overcome such prejudices marketing communication messages should make it very clear how the timber is treated (internal and external cladding) and the inherent fire resisting properties of timber.

Regarding environmental attitudes toward timber in construction, it appears a lack of general knowledge about emissions and energy consumption as it relates to timber use in construction is poor. The perception that costs associated with the use of timber in construction, energy consumption and running are high should be challenged. In the present study, participants do not perceive that timber contributes to the buildings overall 'greenness' through lower emissions and the storage of carbon. In order for property developers to achieve the potential to attract price premiums, misconceptions associated with the use of timber need to be dispelled. Turning now to each of the predictions detailed in the introduction.

H1: Participants exhibiting greater anthropocentric and apathetic environmental attitudes rather than ecocentric environmental views will express greater attitudes toward timber in construction.

Evidence from the present study suggests, regardless of prior knowledge about MTC, participants holding stronger anthropocentric environmental attitudes - a protection over the environment as a resource for maintaining or enhancing the quality of life - revealed a moderate correlation toward the use of timber in construction. The positive relationship between these two variables is somewhat expected given anthropocentrically oriented individuals perceive the natural environment as a resource and timber as a byproduct from within resource. Anthropocentrism refers to the notion that humans are the centre of the universe (Casey & Scott, 2006). For example, comfort, quality of life, and health may all depend upon preserving natural resources. Thompson and Barton (1994) suggest anthropocentric individuals are less likely to act to support the environment as it may threaten other personal values, such as the accumulation of

wealth or quality of life. Thus, anthropocentrically oriented individuals have a lower rate of conserving behaviours compared to ecocentric people.

Participants without prior knowledge of MTC holding ecocentric attitudes toward the environment reported weaker positive attitudes toward the use of timber in construction. Ecocentrism refers to an individual's intrinsic beliefs about the value of the environment, or nature. Individuals holding ecocentric attitudes believe the environment deserves protection irrespective of its utility to humans. Thompson and Barton (1994) assert individuals holding ecocentric environmental attitudes are more likely to act in support of the environment even if this action creates discomfort, inconvenience and expense.

H2: Participants shall indicate strong attitudes relating to the durability of timber use in construction.

As predicted, participants were concerned with the durability of timber, specifically relating to a perceived increased risk of fire. This finding supports previous research about how consumers view timber as being vulnerable to termite attack and susceptible to degradation due to rot and mould (Lehmann, 2012; Parry-Husbands & Parker, 2014). Findings from the present study also support similar findings from a European study by Rametsteiner, Oberwimmer and Gschwandtl (2007) in which consumers expressed that considerable maintenance is required to prevent wood decay when using timber. As such, education campaigns about timber treatment in MTC is vitally important in preventing negative connotations and putting off potential MTC property buyers.

H3: Apathetic and anthropocentric attitudes toward the environment will significantly predict attitudes toward timber in construction whilst controlling for attitudes toward environmentally sustainable design of products and services.

Contrary to the hypothesis, all environmental attitudes (ecocentric, anthropocentric and apathetic) significantly predicted attitudes toward the use of timber in construction whilst controlling the influence of environmental sustainable design in products and services. However, it was anthropocentric attitudes toward timber use that accounted for the largest portion of the variance explained. The control variable, the influence of environmental sustainable design in products and services, was marginally significant and accounted for a very small portion of the variance in attitudes toward timber in construction. Additional variables age and gender did not significantly predict attitudes toward the use of timber in construction. Thus messages about MTC are not age or gender dependent.

H4: Apathetic and anthropocentric attitudes toward the environment shall mediate the relationship between the use of timber in construction and financial influences in property purchasing decisions. However, ecocentric attitudes shall not.

Whilst all environmental attitudes significantly predicted the use of timber in construction, only individuals with anthropocentrically oriented attitudes significantly mediated the relationship between attitudes toward timber in construction and financial factors in property purchasing decisions. Evidence from the present study suggests holding anthropocentric attitudes, expressing protection over the environment as a resource for maintaining or enhancing the quality of life, mediates the relationship between the use of timber in construction (sustainability, durability, structural properties, economics) and financial factors involved in making a property purchasing decision - such as monthly repayments, interest rates, return on investment and cost of insurance.

This finding is important as it provides a context for marketing and communications messages concerning MTC and its promotion. Anthropocentric attitudes are somewhat wedged in between ecocentric and apathetic attitudes maintaining the middle ground between not caring about and completely protecting the environment. Therefore, as anthropocentric attitudes mediate both attitudes toward the use of timber in construction and financial influences in property purchasing behaviours it seems logical to promote the benefits of the technology in anthropocentric ways. For example, individuals who are educated about MTC,

and timber more generally may resolve/rationalise differences in environmental attitudes (ecocentrism and/or apathy) in order to achieve a degree of environmental utilitarianism - achieving the maximum benefit possible from an environmental resource. This might represent a shift in thinking from 'we should not use timber resource at all' toward support for a low impact substitute technology, such as MTC, in lieu of an environmentally costly alternative (concrete and steel). Importantly, participants with favourable attitudes toward timber use are significantly related to financial concerns in property purchasing decisions. However, if the timber constructed property is not able to offer sufficient financial returns, or is not a good investment, people may be less likely to commit to buying.

Research is now just beginning to recognise the benefits for consumers living in timber constructions. These benefits include, lower running costs (economic factors) for air conditioning/heating etc., timber has a great 'green message' (environmental factors), timber is harvested from plantation resources (mitigating illegal logging risk mitigation). Future research into the lived environment of MTC – economics, subjective comfort, acoustics and other related health matters - is an important next step in the evolution MTC development in the Australian market.

Limitations

Whilst the findings from the present study are important for understanding consumer attitudes and habits in purchasing relating to MTC properties – houses, apartments etc. – some results explain only a small portion of the data collected. For example, the influence of environmental sustainable design in products and services was predictive of attitudes toward the use of timber in construction, however it only explained 1% of the variability in attitudes. Thus, 99% remains unknown and is likely to comprise many additional factors that influence purchasing decisions. Therefore, inferences about findings with low effect size to the wider population of Australia consumers' needs to be carefully considered.

Recommendations

The following recommendations resulting from Study One offer industry stakeholders an opportunity to resolve identified barriers for a more widespread adoption of MTC in Australia.

1. *Green Information*. The present study suggests it is insufficient for property developers etc. to provide a 'Green Star' rating in isolation to additional information. Australian consumers indicating such a rating system was not a great influence in property purchasing decisions. The present study supports the development of a composite of 'green' information about the environmental attributes and sustainable design practices inherent within MTC buildings. Consumers want to understand and be educated about the qualities of the property they intend to purchase and how this contributes to environmental efforts.

2. *Addressing Durability*. Associated with recommendation one, the present study suggests that overcoming prejudices about the durability of timber in construction through clearly articulated marketing communication messages is vitally important. It appears Australian consumers do not understand how MTC are covered with interior and exterior cladding, nor do they understand the inherent fire resisting properties of timber as used in construction. In order to overcome prejudices from consumers about MTC projects promoted as 'timber structures' developers and realtors could educate consumers about abating any fear – see Recommendation One.

3. *Age Matters when it comes to Attitudes.* Differences in attitudes between older and younger adults - toward structural soundness and construction components (bricks, timber, steel and concrete) - provides some evidence of a potential generational shift in thinking about building and construction. As such, it appears important to present messages to younger adults about the structural soundness and environmental benefits of MTC, yet for older adults there appears to be an inherent support for timber use in construction. Targeting specific marketing messages by age segmentation (as well as along environmental attitudinal lines) could be used to great effect in marketing MTC to Australian consumers.

4. *Potential Opportunity for Price Premiums*. It is conceivable that property developers could attract price premiums for MTC properties based on educating interested parties (with infographics, videos, education walk-throughs, advertising etc.) about the benefits of the timber and how it will benefit their lives - comfort, running cost reductions etc.

5. *The Promotion of Timber as the Primary Construction Material in Building.* It is conceivable that Builders and Developers might not mention the use of timber as the primary construction material and simply promoting the benefits of a revolutionary new construction method. Since the external and internal treatment of the structure is similar to that of conventional construction, consumers might not notice the timber structure at all. However, not mentioning the use of timber eliminates the ability to promote a number of the environmentally sustainable design features and benefits (carbon sequestration and lower emissions) that consumers in the present study expressed are important in property purchasing decisions.

6. *Marketing and Green Messages.* Communications about MTC and 'green messages' about the technology should focus on anthropocentric approaches to environmental resource use because anthropocentric attitudes are maintaining the middle ground between not caring about and completely protecting the environment. As such, anthropocentric attitudes mediate both attitudes toward the use of timber in construction and financial influences in property purchasing behaviours. It, therefore, seems logical to promote the benefits of the technology in anthropocentric ways.

7. *Rationalising Differences in Environmental Attitudes*. Finally, it is conceivable that consumers who are educated about MTC, and timber more generally, may resolve/rationalise differences in environmental attitudes (ecocentrism and/or apathy) in order to achieve a degree of environmental utilitarianism – achieving the maximum benefit possible from an environmental resource. This might represent a shift in thinking from 'we should not use timber resource at all' toward support for a low impact substitute technology, such as MTC, in lieu of environmentally costly alternatives such as concrete and steel.

Study Two – Industry Stakeholder Interviews

The aim of Study Two was to conduct a qualitative study (in-depth interviews) with stakeholders from the Australian building and construction industry examining the perceived barriers, and suggested strategies for overcoming them, concerning the widespread adoption of MTC. In what follows, a thematic analysis examines patterns or themes within data. Each participant interviewed provides a unique insight about his or her perceptions of the technology and how identified barriers might be overcome.

Method

Participants

Participants were 9 men with an average of 21 years' experience (*SD* = 5.6 years) in the Australian construction, building, or forestry industry sector. Participants had diverse professional backgrounds including the architecture, design, building, forestry, and insurance industries. Participants were recruited either via a snowballing process – referral through networks – or through direct targeted contact initiated by the authors. The response rate for the interviews was approximately 9% of all individuals invited to participate. No invitees from the finance sector agreed to participate in the study. Several participants occupied multiple domains of expertise thus the number of opinions offered exceeds the number of actual participants. For example, several participants are trained architects but were also working in a project management capacity as the builder. The many roles within which participants exist reflects the multi-disciplinary nature of their activities within their sector.

Measures

Semi-structured interviews included questions concerning awareness of MTC as a material/method, perceptions about MTC's utility compared to traditional forms of construction, and how identified barriers such as perceptions about durability might be overcome in order to increase the large-scale use of MTC in Australia. Examples of the questions include: "What impact do you think this alternative construction method might have on your particular product or service?", "What might industry do to increase the level of awareness?", and "What do you perceive are some of the more general challenges facing the more widespread use MTC in the construction industry?"

Procedure

Following ethics approval (Monash University Human Ethics Research Committee - CF 15/458 – 2015000227), participants were sourced and sent an email in advance of the interview with an explanatory statement, consent form and the semi-structured questions. Participants also received a written vignette describing MTC - this was identical to that used in the associated quantitative study. Participants accepted an invitation to participate via return email and attaching their signed written consent form. Participants contributed data through a recorded interview or responded to the series of semi-structured questions in writing. The authors conducted phone interviews using an MP3 recording device to capture the data. All data handling was in accordance with Monash University data handling and management policies.

Design

The present study adopted Braun and Clarke's (2006) qualitative methodology; specifically, coding and extracting common elements, identifying, analysing and reporting patterns (themes) within the data. The authors aimed to produce both a descriptive and explanatory analysis of the findings. Descriptive outputs relate to similarities and differences between themes, whilst explanatory elements sought to provide new insights into how participants would resolve barriers to widespread adoption of MTC.

Results

Knowledge of MTC

The majority of participants (90%) had some prior knowledge of MTC as a method or group of material technologies (Cross Laminated Timber, Laminated Veneer Lumber, Glue Laminated Beams). Many participants (70%) indicated that their knowledge came as a result of the first and second commercial MTC projects in Australia – the Lend Lease Forte apartment building and the Library at The Dock (both projects are located in the Docklands, Melbourne).

> "[My understanding came] through the various demonstration projects that have been constructed around Melbourne. So, from a development point of view, I see it as an interesting and usual addition to the range of products available and it has some specific and definitive uses in its place." *Property Developer*

> "I am aware of the 'Library at the Dock' project in Melbourne, which is an exciting step forward" *Designer*

Whilst another indicated, although knowledge of MTC may be widespread, the impact the technology is having on industry at present appears small,

> "Well there is not enough of it around at the moment to be concerned with it at this stage." *Property Underwriter*

Perceptions of MTC

The two representatives from the insurance industry considered the technology to attract higher premiums due to the nature of the material it is constructed from – timber,

> "From an insurance perspective, one of the things insurance companies look at when determining premiums is the construction materials used. In very simplistic terms, a building with more timber construction generally attracts a higher premium than a building constructed with brick or concrete. So, I guess, initially my thoughts are, any construction, any building with this sort of material in it would most likely incur a higher premium." *Insurance Broker*

> "Historically, well, the insurance industry is very conservative. We tend to sit back and wait and see what things do. You would not find insurers going out promoting new products or things like that. Historically, there was a category of products called massive timber construction. It covered very old buildings with large timber beams. We [insurance assessors] would treat this category as non-combustible, but that is only a beam, that's not a whole floor or a wall" *Property Underwriter*

However, for some, MTC is not a standalone solution. Rather it forms part of an integrated series of components along with other materials and technologies,

> "Looking overseas and looking at the technology, and the small sample we can judge in Australia, I think that the timber industry has kind of put forward cross laminated timber as a solution in its own right for building and construction… I was looking at a proposed building in Austria recently, which is going to be the tallest cross laminated timber building in the world. Because of the height of the building they are using other materials to ensure stability for instance" *Property Developer*

> "I see light timber as a much more traditional technique, and mass timber as the new kid on the block. Yes, they both have timber, but they are different. My bottom-line on cross laminated timber is that it has innate benefits structurally that don't necessarily apply across a whole building. It is great as a shear wall, if you want load bearing walls, that may have a timber finish." *Product Manufacturer*

> "I think the catch word for every engineer when they go to school is 'elegant design'. An elegant design means you use suitable materials for the design of the job" *Architect*

From a supply point of view, the interest is building however faces some competition,

> "There is a ground swell of interest in MTC, particularly looking at the low and mid-rise to high rise, anything from four to 10-15 storey buildings and that is obviously the sweet spot for the massive wood. I think that people recognise that for single-storey, one-to-two storey family homes that a timber frame building is ultra-competitive and works extremely well. The interest in this product [mass timber] is across the board, architects, engineers and developers." *Supplier*

> "It is a different type of building process that we really need to rethink the entire process to see the full benefits from off-site pre-fabrication and how that impacts the total building process." *Supplier*

Another views the technology as,

> "Inevitable for medium to large scale projects" *Architect/Builder*

Whilst the opposing view that MTC may have a place outside of the large-scale commercial and multi-residential market, is offered by this participant,

> "I believe that [volume] builders shall be interested in massive timber as an alternative construction method. This, with many construction items, relies upon availability, cost, and ease of construction. However, I do believe that both my builder and individual clients, are very interested in more environmentally responsible products within their homes" *Designer*

The mixture of participant responses concerning knowledge about MTC is not surprising given the technology is yet to take hold in Australia.

Perceived benefits of MTC

The consensus amongst participants was that there are many benefits from MTC over traditional forms of construction.

> "It [MTC] would bring far greater sustainability benefits to our service and allow for faster project delivery resulting in higher revenue and margins with a reduced number of site personnel" *Architect/Builder*

> "I strongly believe that the environmental features are a key selling point for this product, both in terms of its manufacture and its reusability at the end of building life. Costs are of course an issue, but like most new technology, as demand increases productivity reduces costs in both manufacture and streamlining the process. I also believe that reducing time in installation and construction is a key component in making the product a viable option, as time in construction relates directly to cost." *Designer*

In relation to the industry as a collective, some suggest,

> "Architects can definitely claim a benefit [from MTC] and claim that they are at the leading edge of design and thinking by using cross laminated timber. It ticks all those boxes." *Architect*

> "The advantages come from the lighter weight and speed of building" *Supplier*

> "My bottom-line on CLT is that is has innate benefits structurally… it's great as a panel that can be delivered as an exterior facade, with a window already fitted, not that we can do that yet. But if that were the case, then we can compare apples with apples with some of the other systems in the market, and that would be a good use of it" *Product Manufacturer*

Barriers to widespread acceptance

Professional Indemnity and Public Liability insurance are an important component of risk management for MTC, specifically for developers and design teams (Forestry Innovation Investment and Binational Softwood Lumber Council, 2014). Participants from the insurance industry had this to say about MTC and the impact this new technology has on premiums.

> "The insurance industry rates things based on historical data. Traditionally timber constructed buildings have a higher propensity to have larger losses than a building constructed out of brick or concrete. I understand that this product by the nature of it probably has, umm, is different to a standard piece of timber. However, they [insurers] will probably charge higher premiums purely on the basis that a lot of these systems are new. Insurers simply ask brokers' input about the construction material and if you select 'timber' they are going to load the premiums. This is because insurance companies work on historical data and they have all these actuaries looking at data over years and obviously the data on any type of timber construction tend to have more claims, and higher claims, hence they do charge higher [premiums]" *Insurance Broker*

> "Well, the insurance industry is very conservative. We tend to sit back and wait and see what things do, you wouldn't find insurers going out promoting new products or things like that." *Property Underwriter*

It seems important to ensure that the entire supply chain is onboard with the technology,

> "I think the biggest hindrance is the unknown. People do not have enough understanding or knowledge about it [MTC], and even though you get the Developer, Architect and Engineer to support it [MTC]. Then there is the Quantity Surveyor, who says that "I am not so sure about this" and places some contingency funding into the project - extra costs - and then that blows the costs of the project right out…Sometimes the Developers say, 'I hear what you say, I see the logic. Nevertheless, I am not sure. Is it actually going to happen that fast? Can it happen as you claim it is going to happen?' So another hindrance" *Supplier*

On the subject of durability, specifically relating to fire, participants had this to say,

> "Historically, there was a category of products called massive timber construction. Basically, it covered very old buildings with large timber beams…we were very comfortable with how that category was managed. Premiums depended upon fire loads in the building. If it has a low fire load and a large timber beam then we were comfortable enough that beam would withstand the fire and no structural collapse would occur in a fire. Our concern comes more when the building starts being clad with timber, or the walls are clad with timber, and you start loading it up with a lot of furniture and other things that burn. We have concerns over what the wood is going to do once it is exposed to a longer term fire." *Insurance Broker*

> "Every material has its strong points and let's be fair, CLT, or GluLam, or LVL is not the 'be-all-and-end-all' to solve all the problems in construction. Therefore, we have to work with everyone to work out how best to combine the materials to work for the advantage of the client. Having said that, when you combine different types of materials you have different behaviours and this can become quite a challenge, especially from a design point of view – including fire engineering, for example." *Supplier*

> "I think there is a big perception problem, it is true that if you wet timber it isn't constructed or engineered to cope with wet, and it will cause a problem, and it will likewise burn if flame is applied." *Forestry Academic*

> "It is probably going to take some years for them to gather that data on MTC to see if this product should attract a higher premium. However, it might be shown that after 'x' number of years that it is not as combustible as normal timber and from a fire prevention point of view it might perform the same as concrete or a brick constructed building. I think that is going to take some years before they attract enough analysis and enough data to be able to make that judgement as to whether the premiums should be loaded. At the outset I just get the feeling that they will probably charge higher premium because it will fall into the timber construction rather than the brick or concrete." *Insurance Broker*

Other impediments include the savings using an alternate technology,

> "At this point its [cost is] higher, and even on a 'total cost of construction' the margin of saving is so small. I mean what is being quoted in the media at the moment is about 4%. Nobody will make a buying decision

> on 4% overall. Because builders simply don't quantify their time, um, unless they are a larger organisation with the procedures and the people in place and they have the technology." *Property Developer*

Whilst the risk of attempting to use an alternative method might be too great because it's a 'new technology',

> "I am saying there is no positive reason to think well 'I should definitively consider this because I might get a benefit'. You have got to have that upfront willingness to try it. To go through a design process, which is cost; before you can figure out whether or not it is suitable and so you have to motivate people across that first hump. We don't have that. So, we are behind the eight ball compared to an EU country." *Property Developer*

> "There is a perceived complexity associated with MTC." *Architect/Builder*

> "The only way to get a new product's measure from an insurance perspective, to be honest, is to have some fires in these buildings. We understand that the building code is designed to allow everyone to get out of the building in a controlled manner, and recently in the Docklands [Melbourne, Australia] there was a fire. It went up the façade of the building. The insurance industry has been warning about such failures for years. The product meets regulatory compliance at the moment but yet the fire happened. If you simply say 'oh its fully BCA compliant' well the insurance industry would simply turn around and say ' well, we have had enough examples of things that are BCA compliant and we have had issues'" *Property Underwriter*

Ultimately, larger projects attract considerable cost and associated risks. For developers and builders, assurances are needed that they won't make losses using the new technology – requiring a proof of concept. Such barriers are overcome by the release of case studies with actual financial forecasting models, however such 'commercial in confidence' material is not readily available,

> "I agree that is always going to be the challenge. Everyone will be private about the projects and financial aspects." *Supplier*

In terms of establishing a MTC manufacturing presence in Australia there are some hurdles that must be overcome,

> "I think one of the big problems we have had in the forestry industry is the idea that you need these massively large scale plants to support massively large-scale industry… I think it is really important to be flexible. Australia was for a while increasing its plantation resource and now it's sort of going backwards. Plantations are now being ripped out and turned into grasslands, croplands, and part of that is basic insecurity of industry and not foreseeing a future market. If we had some way of being able to reclaim those plantations, instead of replant them that would be great. I understand a number of them are just being knocked over and burnt which is just a disaster. So, if we had a flexible system then we could use a variety of input sources that could be a way they could take some profit out of the plantation when they knocked it down." *Forestry Academic*

Consumer perceptions are a constant reminder of the work ahead for industry marketing teams in dispelling or addressing concerns and advance MTC and more generally timber,

> "I think there is an obvious concern [amongst consumers] in Australia about termites and other infestations for timber products. This would need to be addressed along with cost effective and easy solutions for not only the builders and clients but also for insurance purposes. I also think that external durability may be an obvious concern." *Designer*

> "Timber is not durable when exposed to weather and any failure of waterproofing may lead to significant repair costs and poor reputation of the product" *Architect/Builder*

Suggested strategies for overcoming barriers

Participants were unanimously united that education campaigns about MTC technology are important in addressing many of the obstacles,

> "If anyone has some evidence of the performance of this product from overseas studies, and if it has been in Europe for 10 years, they will have 10 years' worth of data. Therefore, we are talking about the same material but just in a different country. That data could come from overseas and would certainly help the insurance industry here. Most of the larger firms have overseas offices anyway so they should be able to get such data. It is all based on these actuaries and the data. Therefore, if we can demonstrate the integrity of this product then insurers will certainly take that onboard. If it's new and they have no data, 'oh it's a new product' and it falls into the timber category then bang you get lumped in the timber classification, rather than the brick and the concrete hence higher premiums." *Insurance Broker*

> "Australia is in a far better position than Europe. This is because Australians can actually go and visit a huge range of projects - from small to very large - so there is not an unknown anymore. Therefore, the hurdles to progressing mass timber are not as high anymore. The fact that it is new over here and will take a little bit of time to convince people that 'it does what is says on the box'. There are publications on a regular basis, industry based, with very detailed articles about mass timber projects etc. for Architects and Engineers, more architectural in nature. Obviously, there are no commercial details in there but designs, drawings, and connection details etc. Plus, how they overcome several challenges and they are readily available through searching online." *Supplier*

> "I guess as brokers, it one of those things that we find that out during the marketing of our clients' insurance program was this product [MTC] involved, and that the only time we find out about it. We might come across a client that has construction in their building and we might find the local insurance companies are loading the premium and then we might find that some of the US or EU companies that we deal with they might have a completely different view of the product and their premium is substantially cheaper. They won't tell us that it is substantially cheaper because they have historical data on this product and reading between the lines I would suggest that's why their premium is cheaper because they have some data that says this product does perform better than standard timber product. Once we find this out, we will go to those organisations and recommend insurance premiums that match the clients' expectations." *Insurance Broker*

> "I think we need to create a series of product specific applications promoted through specific marketing material. For example, a cross laminated timber lift shaft. Develop a product for that application. That is an excellent example of how cross laminated timber can be used in a hybrid model with steel framed construction. Case scenarios. My gut feel is that and a combination actual cost savings, because we don't quantify those savings until you have designed the building…people [could] naturally turn to their MTC handbook for real solutions for construction projects." *Architect*

> "An extreme example, when I have taken a sample [of cross-laminated timber] to an architect even after half an hour conversation it is clear that he or she has not understood the concept that it [mass timber] could be a whole wall or whole ceiling. Then the penny drops. The ideal solution could be to develop a walk-through model that you could mount on the back of a van or trailer and meet at a University or other institutions and allow people to walk in and see how it would work." *Supplier*

Yet some concede that such campaigns will not be easy or come at a significant cost,

> "There could be a very major training or educational campaign exercise that competing industries are going to hate, and unfortunately the mining industries have much more money than the timber." *Architect*

> "Until there is a fire and we can see the effects [of MTC] I don't think the opinions will shift from combustible to non-combustible. It could influence but it might not shift opinions. We have many industry advocates asking us to endorse products and we do not recognise them. What we do recognise is 'large-scale factory testing', the loss-prevention certification board approvals, so they tend to get more weight however come at a considerable cost. I think you would get your best buy-in from the insurance industry by someone like an FM Global doing large-scale testing and say 'yes we provide an approval if it's used in

this way and in this manner'. However, I am not sure if they can do large scale testing of multi-storey buildings. Even that might be too big for them. Get an insurer recognised certification board to do their own testing is one way to overcome the barrier." *Property Underwriter*

Promoting the core economic benefits of MTC and appealing to industry stakeholder's sense of 'commercialism' was another popular strategy,

"[If builders] have got a lift shaft and they could build it out of timber, because my span is say seven metres and I could use a timber solution for a 4 storey building, do I really want to bring in the concrete trucks if I can do it with my carpenters? Plus, it will go up in days, not in weeks, and the labour component is reduced compared to concrete, not wet trades etc." *Architect*

"They could go to a broker and the insurers would be played-off against each other. In the first instance, we would provide our risk advice, a premium based on what we thought the risk was. The other insurers would do the same. If one of the insurers decided that they would treat this as a non-combustible building, their premium would be a lot cheaper. However, they would not immediately get it on those terms. The broker would then go to the other insurers and say 'I can get it for this amount, are you prepared to do it as well?' That would drive the discussion further. Each underwriter would have to say 'are we prepared to take that risk'." *Property Underwriter*

"You could work in with them [MTC manufacturers and distributors] to formulate the ideal and optimal design to make the most of the complex problems found on site. The specifics for the designer, the shop drawings and the detailers, you can go to them with some very specific information that makes it very easy to use the product." *Architect*

"[Builders] would have to make a significant investment into terms of resources in order to up-skill to be able to get the answers in the first place. So, you know, a second tier or large second tier - close to first tier builder, they would have a difficult time in quantifying and proving to themselves that if they make this buying decision they won't end up losing money at the end. Because they just simply don't have enough resources to do it, so industry has to do that for them, and that is a big task." *Property Developer*

"I spoke with some engineers, we worked out the amount of work required to each one of their beams to satisfy the existing range of steel technologies, could be avoided using our timber/steel composite. They could actually expand their grid, and with timber and steel composite it could have been a match made in heaven." *Product Manufacturer*

Using a brokerage and a 'leverage strategy' to secure lower premiums,

"In fact we are heavily involved in the timber industry. We have a pool of clients and we are able to leverage premiums and demand better fees and better policy conditions. The more you have got of something the more discount and competitiveness you are going to get from the under-writer and the insurer." *Insurance Broker*

Another suggesting that,

"I would draw the conclusion based on the steady progress of massive timber year on year that despite the lack of openness about [confidential] project costings etc., there is strong evidence that MTC is a viable alternative to ferroconcrete with significant benefits. There has to be a driver behind it. They [Builders and Developers] do it because there is a commercial beneficial." *Supplier*

From a forestry industry perspective, this participant provides a solution addressing barriers in advancing MTC production and suitable resource acquisition,

"If we can bring [MTC plant and equipment] the scale down and make things portable or transportable, then the scale changes and then you can take the plant to where the current resource is. I think there are many advantages in making the plant smaller and transportable… If you can move around a bit that is a

brilliant move, I think there are some real advantages to making things smaller and transportable and capitalising on the resource and outputs." *Forestry Academic*

With reference to durability, participants had this to say,

"If we are talking about timber durability, I tend to think that the earthquakes in Christchurch offer some salient examples of how timber structures survived [when] concrete did not. Other examples include that if you happen to burn half of the cross-section of a beam you still have half the strength left, but if you have a fire under a cement or steel beam and it heats it, you have to risk the whole thing coming down." *Forestry Academic*

"[We] are doing one demonstration project after another… showing structurally its capable and it meets all the requirements" *Property Developer*

"The only way to really understand the product is to do a full-scale test and literally load one of these building up and see what happens." *Property Underwriter*

A final word

Participants from varying sectors of the building and construction industry offer a few final words for contemplation of the advancement of MTC in Australia,

"So, in my opinion, selling MTC as a solution is a very long-term prospect, and I don't think it's going to be successful. Simply because it will take to so long that everybody will get sick of trying by the time they get some runs on the board" *Property Developer*

"When the product hits critical mass then the change will occur. The CEO's and Senior Managers will start to put pressure on and things will change - if there is enough building activity with this product. Insurance will always trail behind what industry does. I don't think insurance will be a leader, or try to create change for MTC" *Property Underwriter*

"You need to convince the insurance industry, a very conservative industry that this product can perform. Now you really only have two options, concrete and steel/ brick or timber. The minute you talk timber, bang it goes into the timber classification. Providing the data that demonstrates the integrity of the product is the most important thing. I am not sure if they have that data. It's also very early stages for the product, we haven't seen any clients constructing out of MTC so it will be interesting to see their reaction when we try a couple in the near future." *Insurance Broker*

"My bottom-line on cross laminated timber is that is has innate benefits structurally that don't necessarily apply across a whole building. It is great as a shear wall, where you want load-bearing walls, that may have a timber finish. It's great as a panel that can be delivered as an exterior facade, with a window already fitted, - not that we can do that yet - but if that was the case, then we can compare apples with apples with some of the other systems in the market, and that would be a good use of it. I think from my own reading that is not good as a floor, to get a span that meets most situations it has to be very thick, and even then, you have to add extra systems to it for sound and fire and you have no access for services." *Product Manufacturer*

"[MTC] is perfect. The development economics in an institutional building or a commercial building are quite different. For a start, in Australia, you have Green Star applicable to commercial buildings that has a cost benefit to the developer if they have that [a Green Star rating]." *Architect*

Discussion

Despite MTC's reported benefits in terms of on-site costs and sustainability the potential remains unrealised, due at least in part to a lack of understanding across a number of stakeholders in the building process. The present paper sought to determine some of the barriers affecting a wider uptake of MTC for the Australian building and construction industry.

Many participants in this study expressed they had some idea of the concept of MTC as either a material or method prior to the study. Participants attributed their knowledge to the few MTC projects in

Melbourne, Australia – the Forte apartment building and the Library at The Dock. Similarly, many participants expressed that there are considerable advantages to MTC over alternative construction methods in the form of environmental advantages and construction efficiency - namely construction program time reductions. Those without an awareness of MTC, particularly participants from the insurance industry, offered a risk-averse evaluation of the product. Such responses, they expressed, reflect the ultra-conservative nature of their industry.

Several participants offered insights into how they think other industry stakeholders perceive MTC. One participant submits that people encountering MTC for the first time require more than a simple verbal explanation in order to understand the technology. Explanations relating to what MTC is and how it fits into the existing paradigm of construction and design are influenced by the frame of reference of the person communicating the ideas. Some participants in the present study viewed MTC as a series of discrete components with the sole benefit of integrating with traditional materials. Yet others see MTC as a total solution devoid of alternate materials sources – such as concrete and steel. The key message from these findings is that MTC as a material/method is difficult to define because of its versatile nature. This, it is argued, is what makes communication about the technology difficult. This is especially true when attempting to explain what MTC is to people who have never been exposed to the technology.

Participants within the present study offered a myriad of barriers that they believe are hindering the widespread adoption of MTC in Australia. Such barriers are categorised into two domains, 'material' and 'method'. Material-based barriers include the considerable difference in the way timber structures are designed and delivered compared with traditional forms of construction. The often lacking or prejudicial perceptions of MTC present considerable challenges because of uncertainty concerning the technology's durability in terms of fire, rot and structural integrity, as well as considerable decline in employment within the Australian forestry industry (Australian Bureau of Agricultural and Resource Economics and Sciences; ABARES, 2013). Method-based barriers include a lack of open source financial and commercial information for risk management purposes. However, there is a common thread to the solutions recommended by industry to break down barriers. The primary approach recommended centers around credible, accurate and timely information gathering and dissemination.

Limitations

Several limitations must be considered when reviewing the findings from the present paper. First, considerable difficulty was experienced in securing a sufficient number of participants prepared to speak openly and candidly about their thoughts and perceptions and how they might progress, or not, MTC. Second, the majority of participants that did respond to a request for an interview were already advocates for the technology, which may mean the findings are not reflective of the true position of MTC in the market. However, this limitation is somewhat mitigated as MTC technology has now become a truly global movement and whilst the present study is limited to findings from Australia, anecdotally messages from this industry correlate with those of Europe.

Recommendations

The following recommendations resulting from study two offer industry stakeholders an opportunity to resolve identified barriers.

1. *Developing data and information exchange programs/collaborations with European organisations*. Data relating to the considerable amount of work performed using MTC in Europe would certainly benefit Australian construction, particularly the influence of the insurance industry. The insurance industry participants suggest that if developers can demonstrate the integrity of this product then insurers will certainly take that on board, indicating that premiums would potentially remain on par with ferroconcrete. Industry education and training providers could be commissioned to assist in disseminating research findings etc.

2. *Participate in overseas study tours*. Australians can visit a huge range of projects in Europe and Canada. Projects from the very small to very large now provide a sense of what is achievable. Forest and Wood Products Australia, in conjunction with the Timber Development Association (New South Wales) have offered several such trips to industry over the last few years.

3. *Leverage financial service premiums (insurance and investment) by using global organisations*. It is evident from the present study that local financial services organisations load premiums. Builders, developers and associated stakeholders could locate international finance and insurance organisations that provide services to customers working with MTC. This might result in a completely different view of the product and their premium might be cheaper. Many project case studies list the associated companies supporting the development. This may include insurance and financial services organisations. This is a suggested starting point for Australian developers to secure competitive services.

4. *Use brokerage firms*. Builders, developers and associated stakeholders could use brokers for insurance and finance. Brokers shall communicate with organisations and recommend financial and insurance services that match the clients' expectations. Industry insiders suggest that brokers are able to reverse-auction premiums for services that benefit the client. Pooling projects and clients together provides brokerage firms with leverage. Buyer bargaining power is a useful strategy to secure lower premiums.

5. *Manufacturers could produce a series of product specific applications using MTC*. These applications could be promoted through specific marketing material. For example, a cross laminated timber lift shaft or stair system.

6. *Case study scenarios specific to builders at various tiers/levels*. In collaboration with key stakeholders, Australian manufacturers and industry suppliers could develop a series of easy to understand non-commercial in confidence cost saving case studies. These can be developed and disseminated to tier one, two and three builders expressing interest in using MTC, avoiding the requirement of costly quantification comparisons to more traditional forms of construction.

7. *MTC portable displays.* Suppliers and manufacturers of MTC, and its various stakeholders and component manufacturers/suppliers could develop walk-through showcases or displays that could be mounted on the back of a trailer. Such displays would represent a cross-section of an actual building with internal linings, external cladding, wiring and plumbing etc. Such displays could be parked at common meeting areas, such as a University or other institutions, trade shows and conferences allowing people to walk in and see how MTC actually works.

8. *Full-scale testing.* Research conducted by internationally credible sources, such as FM Global, could be commissioned to undertake large-scale testing. Approvals may be granted if product applications are tested and replicated on-site. Approved methods of construction may satisfy the insurance and financial services industries.

9. *Pre-fabricated solutions for complex on-site problems*. MTC manufacturers and distributors could formulate ideal and optimal designs using mass timber components solving some of the more complex problems found on building sites. The specifics for the designer, the shop drawings and the detailers, provide very specific information that makes it very easy to use the product.

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