Dissertationes Forestales 325

Wooden multistory construction as perceived by Finland's municipal civil servants overseeing land use planning

Florencia Franzini

Department of Forest Sciences

Faculty of Forestry and Agriculture

University of Helsinki

ACADEMIC DISSERTATION

To be presented, with the permission of the Faculty of Agriculture and Forestry of the University of Helsinki, for public examination in Lecture Hall 107, Athena, on 23 March 2022, at 12 noon.

Helsinki 2022

Title of the dissertation: Wooden multistory construction, as perceived by Finland's municipal civil servants overseeing land use planning

Author: Florencia Franzini

Dissertationes Forestales 325

https://doi.org/10.14214/df.325

Thesis Supervisors:
Dean Ritva Toivonen
Faculty of Agriculture and Forestry, University of Helsinki, Finland

Professor Anne Toppinen
Faculty of Agriculture and Forestry, University of Helsinki, Finland

University Lecturer Sami Berghäll
Department of Forest Sciences, University of Helsinki, Finland

Pre-examiners:
Professor Asta Salmi
School of Marketing and Communication, University of Vaasa

Kerstin Hemström, Ph.D. (Civil Engineering)
Gothenburg Centre for Sustainable Development, University of Gothenburg

Opponent:
Professor Mark Hughes
Department of Bioproducts and biosystems, Aalto University

ISSN 1795-7389 (online)
ISBN 978-951-651-740-0 (pdf)

ISSN 2323-9220 (print)
ISBN 978-951-651-741-7 (paperback)

Publishers:
Finnish Society of Forest Science
Faculty of Agriculture and Forestry of the University of Helsinki
School of Forest Sciences of the University of Eastern Finland

Editorial Office:
Finnish Society of Forest Sciences
Viikinkaari 6, FI-00790 Helsinki, Finland
http://www.dissertationesforestales.fi

Franzini, F. (2022). Wooden multistory construction, as perceived by Finland's municipal civil servants overseeing land use planning. Dissertationes Forestales 325. 84 p. https://doi.org/10.14214/df.325

ABSTRACT

For the past 25 years, the Finnish state has supported the diffusion of wooden multistory construction into the construction sector. Given the socio-cultural and economic value of Finland's forest sector, there is precedent to do so. Nonetheless, wooden multistory construction remains a niche construction practice in its formative phase. This dissertation researches the diffusion of wooden multistory construction by analyzing perceptions from municipal civil servants tasked with overseeing land use planning in Finland. Despite being gatekeepers of local construction activities, their perceptions towards wooden multistory construction are understudied. To access these perceptions, this research applies the theory of planned behavior. At the root of this theory lies the notion that beliefs underpin human action. Specifically, this dissertation research identifies (Article I) and operationalizes (Article II-III) the attitudes and beliefs that municipal civil servants hold towards wooden multistory construction. The results are distilled into three empirical accounts. Why not wood? (Article I) reframes elicited beliefs as barriers and benefits to wooden multistory construction. Benefits include a variety of holistic topics ranging from improving the lifestyles of citizens and supporting local wood-based businesses, to facilitating aspects of building construction. On the other hand, multiple barriers coalesce to form a risky and costly environment that results in project aversion. Wood versus concrete (Article II) analyzes how outcomes of implementing wooden multistory buildings are relativized against concrete multistory buildings. In large part, wooden multistory buildings are believed to possess several superior qualities (e.g., environmental performance, economic development outcomes). Nevertheless, apprehensions persist (e.g., they are more expensive to build and maintain, they are more susceptible to fire). Background experiences, especially occupational profession, play a key role in shaping several beliefs. Planning for wood (Article III) studies the relationship between how beliefs (i.e., environmental performance, economic development, cost-related attributes, technical qualities) form attitudes towards wooden multistory buildings. The prioritizations of beliefs vary according to occupational profession. Planning practitioners form attitudes holistically, based on the building's environmental performance, technical qualities, and economic development outcomes. Other administrators form attitudes primarily based on the project's economic development outcomes and technical qualities. Ultimately, municipal civil servants appear receptive towards implementing wooden multistory buildings in their municipalities, but this receptiveness hinges on project outcomes and the "societal goods" prioritized by the individual respondent. Even if wooden multistory buildings are perceived to possess superior qualities (e.g., environmental performance), these qualities may not strongly impact an individual's attitude towards favoring the project. Different prioritizations among municipal civil servants might lead to planning tensions within the municipal administration, but it remains to be seen how these tensions enable (or hinder) wooden multistory construction diffusion.

KEYWORDS: Wooden multistory construction, Building materials, Municipal civil servants, Public administration, Land use planning, Finland

TIIVISTELMÄ

Puukerrosrakentamisen leviämistä rakennusalalla on Suomessa tuettu yli 20 vuoden ajan, mikä on ollut perusteltua ottaen huomioon metsäsektorin kulttuurisen ja taloudellisen arvon. Edistämistoimista huolimatta puukerrostalorakentamisen markkinaosuus on edelleen matala Suomen koko kerrostalorakentamisen markkinoilla. Väitöskirjassa tutkitaan puukerrostalorakentamisen leviämistä analysoimalla suomalaiskuntien maankäytön ja rakentamisen suunnittelusta vastaavien asiantuntijoiden käsityksiä sekä laadullisen haastattelu- että määrällisen kyselytutkimuksen menetelmin. Tämän henkilöryhmän näkemyksiä on toistaiseksi tutkittu kansainvälisestikin vain niukasti huolimatta heidän keskeisestä merkityksestään paikallistason suunnittelussa ja rakentamisessa. Kuntatason asiantuntijanäkemysten analysoinnissa tutkimuksessa sovelletaan suunnitellun käyttäytymisen teoriaa (ns. Theory of Planned Behavior), jonka ytimessä on käsitys asenteista ja uskomuksista ihmisen toiminnan perustana. Tämä väitöstutkimus tunnistaa (artikkeli I) ja kuvaa (artikkeli II-III) kuntatason asiantuntijoiden puukerrostalorakentamiseen liittyviä asenteita ja uskomuksia. Artikkeli I hahmottaa puukerrostalorakentamiseen liittyviä uskomuksia siihen liittyvien esteiden ja hyötyjen kautta. Hyötyjen nähdään kohdistuvan asukkaiden elämänlaadun parantamiseen ja paikallisen puuhun liittyvän liiketoiminnan edistämiseen. Sen sijaan käsitykset esteistä yhdistyvät toimintaympäristöön, joka koetaan puurakentamisen suhteen edelleen riskialttiiksi. Puurakentaminen mielletään myös kalliiksi. Näiden tekijöiden nähdään johtavan siihen, että puukerrostaloprojektien markkinaosuus ei ole kohonnut merkittävästi. Artikkelin II mukaan puukerrostalorakentamisen toteutus vertautuu betonirakentamiseen. Suurilta osin puukerrostaloilla uskotaan olevan useita erinomaisia ominaisuuksia ja laajempia myönteisiä vaikutuksia esimerkiksi ympäristölaadun tai aluetaloudellisen kehityksen kautta. Näistä myönteisistä seikoista huolimatta vallitsee edelleen käsityksiä riskitekijöistä (esim. rakentamisen ja ylläpidon kalleus, tulipaloalttius). Asiantuntijoiden taustatekijät, erityisesti heidän ammattinsa, ovat avainasemassa useiden uskomusten muovautumisessa. Artikkeli III mallintaa vastaajien uskomuksien (mm. puukerrostalorakentamisen ympäristösuorituskyvystä, vaikutuksista taloudelliseen kehitykseen, kustannuksista, teknisistä ominaisuuksista) ja asenteiden muodostumisen yhteyksiä. Tulosten perusteella kuntatason asiantuntijoiden ammatillinen tausta vaikuttaa siihen, miten puukerrostalorakentamiseen liittyviä uskomuksia painotetaan. Vastaajien alaryhmänä suunnittelijoiden asenteet muodostuvat kokonaisvaltaisesti perustuen näkemyksiinsä puukerrostalojen ympäristöllisten ja teknisten ominaisuuksien sekä taloudellisten vaikutusten perusteella. Muissa tehtävissä toimivien asiantuntijoiden asenteet rakentuvat ensisijaisesti näkemyksiin hankkeiden taloudellisista vaikutuksista ja puukerrostalojen teknisistä ominaisuuksista. Kaikkiaan kyselyyn vastanneet asiantuntijat näyttävät olevan myönteisiä puukerrostalorakentamiselle kunnissaan, mutta alan jatkokehitys riippuu rakentamishankkeiden tuloksista ja siitä kuinka eri vastaajat painottavat hankkeiden tuottamia yhteiskunnallisia hyötyjä. Vaikka puukerrostalorakentamisella katsottaisiin olevan erinomaisia ominaisuuksia, kuten rakennusten hyvä ympäristösuorituskyky, eivät nämä ominaisuudet välttämättä vaikuta riittävän voimakkaasti puukerrostalorakentamisen lisääntymiseen. Kuntatason virkahenkilöiden erilaiset uskomukset ja asenteet puurakentamiseen liittyen saattavat lisätä rakennetun ympäristön suunnitteluun liittyviä jännitteitä. Jää siten nähtäväksi, miten nämä jännitteet vaikuttavat tulevaisuudessa puukerrostalorakentamisen yleistymiseen Suomessa.

ABSTRACTO

Durante los últimos 25 años el Estado finlandés ha difundido firmemente la construcción de edificios de madera de varios pisos en el sector de la construcción. Dada la importancia sociocultural y económica del sector forestal de Finlandia, existen razones para hacerlo. No obstante, la construcción de edificios de madera de varios pisos sigue siendo en el sector una práctica incipiente. Esta disertación investiga la difusión de edificaciones de varios pisos de madera mediante el análisis de las percepciones de los funcionarios públicos municipales encargados de supervisar la planificación del uso del suelo en Finlandia. A pesar de que dichos funcionarios son clave en las actividades de construcción local, sus percepciones sobre la construcción de edificios de varios pisos con madera no han sido suficientemente estudiadas. Para conocer esas percepciones esta investigación aplica la teoría del comportamiento planificado, cuya base es que las creencias sustentan la acción humana. Específicamente, la investigación para esta tesis identifica (Artículo I) y organiza (Artículo II-III) las actitudes y creencias que los funcionarios municipales tienen respecto a la construcción de varios pisos de madera. Los resultados se extraen en tres relatos empíricos. Artículo I replantea las creencias asumidas como barreras y beneficios para la construcción de edificios de madera de varias plantas. Los beneficios incluyen una variedad de temas comprensivos que van desde mejorar el estilo de vida de los ciudadanos y apoyar a las empresas madereras locales, hasta facilitar ciertos aspectos de la construcción de edificios. Por otro lado, varias barreras se combinan para que el proyecto sea considerado como arriesgado y costoso, lo cual provoca su rechazo. Artículo II analiza las respuestas a la encuesta para evaluar cómo los resultados de la implementación de edificios de madera de varias plantas se relativizan frente a los edificios de varios pisos de hormigón. Mayoritariamente, se cree que los edificios de madera de varios pisos poseen varias cualidades superiores (por ejemplo, desempeño ambiental, resultados de desarrollo económico); sin embargo, las aprensiones persisten (por ejemplo, son más caros de construir y mantener, son más inflamables). Los conocimientos y experiencias, especialmente la profesión, juegan un papel clave en el desarrollo de varias creencias. Artículo III describe la relación entre cómo las creencias (esto es, el desempeño ambiental, los resultados del desarrollo económico, los resultados relativos a los costos, las cualidades técnicas) determinan las actitudes respecto a los edificios de madera de varios pisos. La forma de establecer las prioridades de las creencias se establece según la formación profesional de los servidores públicos. Los profesionales de la planificación establecen sus actitudes de manera holística, en función del desempeño ambiental del edificio, sus cualidades técnicas y los resultados del desarrollo económico. Las actitudes de otros administradores se basan principalmente en los resultados de desarrollo económico y las cualidades técnicas del proyecto. En última instancia, los funcionarios públicos municipales parecen receptivos a la implementación de edificios de madera de varios pisos en sus municipios, pero tal receptividad depende de los resultados del proyecto y los "bienes sociales" priorizados por el encuestado individual. Aun cuando se considere que los edificios de madera de varias plantas tengan cualidades superiores (p. ej., desempeño ambiental), es posible que tales cualidades no impacten fuertemente en las actitudes de un individuo para favorecer el proyecto. Las diferentes formas de establecer prioridades por parte de los funcionarios públicos municipales pueden conducir a tensiones en la planificación dentro de la administración municipal, pero queda por ver cómo esas tensiones permiten (o dificultan) la difusión de la construcción de edificios de varios pisos de madera.

ACKNOWLEDGEMENTS

Where there is a long list of individuals that I should like to thank for standing by me throughout this incredible period of my life, I hope you will forgive me for being unable to do so. At the risk of appearing ungrateful, allow me to apologize and explain. In the months leading up to the finalization of this thesis, I found myself thinking about what made this opportunity possible. It is true that I could not have accomplished my research goals without the support of brilliant academic colleagues, peers, examiners, reviewers, and a special set of outstanding friends, but before all this came a unique opportunity. My journey began with a humanitarian act of free education. I moved to Finland in 2016 to attend an international master's program that levied no tuition fees even though I was a citizen of Uruguay. It turns out, this was the last time non-EU students received tuition-free admission. And so, I've thought about this fact almost daily, wondering where I would be today without humanitarianism. The hard truth is, I would likely have forgone my education, despite my deep desire to learn. When I finalized my master's thesis during May 2018, I wrote:

> "*I wake up every day and think about the good fortunate I had to end up in Finland. The system allowing me to study free of charge, regardless of not being from an EU state, puts on me a social burden that I cannot know I will ever repay—but I will strive to do so. I plead to those who are doubtful or against this system, reconsider. There is a necessity to promote humanitarian acts which establish freedom of education for individuals regardless of where they come from. If I were Finnish, I would be proud to know I supported someone in coming closer to achieving their dreams. Because indeed, that is what Finland has done for me.*"

Today, these feelings remain unchanged. Yet, my sense of urgency towards the reestablishment of free tuition has strengthened. As I find myself fulfilling the very dream hinted at in an acknowledgement letter written four years ago, I contemplated whether to fill this page yet again with the names of those who helped me reach my dream. But truthfully, a dignified gesture by the state of Finland and the University of Helsinki is my raison d'être. Thus, I cannot shake the feeling I ought to also acknowledge in being among the last few students afforded this dignity. Of course, this acknowledgement comes with the hefty realization that this same dignity is unavailable to others who wish to stand where I am today. I am constantly haunted by this feeling, so I would take this moment to restate my plea: reconsider imposing tuition fees onto non-EU students. Do this, and signal to the world that acts of welfare are not privileges and dignities granted on the basis of where we are born; but rather something to which all humans are entitled.

Florencia Franzini
February 17, 2022
Helsinki, Finland

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Franzini F, Toivonen R, Toppinen A (2018) Why not wood? Benefits and Barriers of Wood as a Multistory Construction Material: Perceptions of Municipal Civil Servants from Finland. Buildings 11, article ID 159. https://doi.org/10.3390/buildings8110159.

II Franzini F, Berghäll S, Toppinen A, and Toivonen R (2021) Comparing wood versus concrete: An exploratory study of municipal civil servants' beliefs about multistory building materials in Finland. Forest Prod J 71: 65–76. https://doi.org/10.13073/F PJ-D-20-00038.

III Franzini F, Berghäll S, Toppinen A, and Toivonen R. Planning for wood: Insights from a belief-attitude model of Finnish municipal civil servants. Manuscript currently under peer review with European Planning Studies.

The publications are referred to in the text by their roman numerals.

DIVISION OF LABOR IN CO-AUTHORED ARTICLES

	I	II	III
Concept and design	FF, RT	FF	FF
Data collection	FF	FF	FF
Data analysis	FF	FF	FF, SB
Writing manuscript	FF	FF	FF
Editing and reviewing	FF, AT, RT	FF, SB, AT, RT	FF, SB, AT, RT
Overall responsibility	FF	FF	FF

FF - Florencia Franzini, SB - Sami Berghäll, AT - Anne Toppinen, RT - Ritva Toivonen

CONTENTS

GLOSSARY

(CMSB) **Concrete multistory building**. A residential building of at least three stories whose structural load-bearing frame primarily utilizes concrete materials.

(TPB) **Theory of Planned Behavior.** A behavioral psychology theory that explains and predicts human behavior according to an individual's beliefs.

(WMC) **Wooden multistory construction**. In this dissertation research, the term is used as an aggregate to denote all current technologies and building solutions used to construct wooden multistory buildings. This includes both engineered wood products (e.g., cross-laminated timber, laminated veneer lumber, and glulam) and construction techniques (e.g., post and beam; mass timber; modular). Synonyms across the literature: *timber frame engineering; wooden multi-storey construction*

(WMSB) **Wooden multistory buildings**. A residential building of at least three stories whose structural load-bearing frame primarily utilizes engineered wood products. This includes hybrid frame structures. Synonyms across the literature: *wooden multi-storey building; multistory wooden building; multi-storey wood building; multi-storey apartment houses; multi-story timber apartment buildings; multi-storey apartment blocks, tall wood buildings* (note: tall wood buildings typically suggest more than 8 stories).

1 INTRODUCTION

In 2020, the building sector generated just under 40% of total energy-related global carbon emissions (UNEP 2021). The major portion of this figure is attributed to operational emissions, produced by consuming energy for everyday functions such as heating and air conditioning. These emissions accounted for 28% of total global emissions (ibid). In addition, building construction generates embodied emissions through the production, distribution, and use of construction materials (see e.g., Ibn-Mohammed et al., 2013; Lützkendorf et al., 2014). Reduction of both embodied and operation emissions is necessary to tackle climate change; however, effort has been historically placed on reducing operational emission (e.g., by optimizing building efficiency) rather than reducing embodied emissions (Ibn-Mohammed et al., 2013). Neglecting to lower embodied emissions avoids decreasing a significant portion of global emissions. For perspective, the production of construction materials accounted for 10% of global energy-related carbon emissions in 2020 (UNEP, 2021).

In response to the large portion of embodied emissions generated by building construction, several organizations recommend the substitution of construction materials with energy-intensive production processes for lower-carbon construction materials (e.g., C40, 2019; CNCA, 2020; GlobalABC, 2020). The potential to reduce embodied emissions will also depend on the type of building in question, as a building's design, procurement, lifespan, and end-of-life scenarios all affect total embodied energy (Ibn-Mohammed et al., 2013). With this in mind, residential multistory buildings (i.e., apartment buildings of three or more stories) are an important building type to consider, as they require large quantities of construction materials to erect. Furthermore, multistory buildings are increasingly constructed to address housing demand in localities experiencing rapid urbanization or limited space for expanding horizontal development (see: Ali and Al-kodmany, 2012).

Several residential multistory buildings rely on concrete as the primary structural load-bearing frame material. These concrete multistory buildings are a dominant construction industry output. Life cycle analysis of such buildings report major emissions associated with the production of concrete (e.g., Heravi et al., 2016). One prospect for lowering embodied emissions is to deploy a lower carbon structural frame material; thus, wooden multistory buildings[1] are an alternative receiving increased advocacy in the academic literature (e.g., Gustavsson and Sathre, 2006, 2011; Hildebrandt et al., 2017; Tollefson, 2017; Churkina et al., 2020). The caveat is that the diffusion of wooden multistory construction[2] is met with inertia and low rates of adoption, as it relies on a relatively novel set of construction technologies and practices refined over the last 30 years (see: Dangel, 2016: pg. 75-127; Hemström et al., 2017a; Hurmekoski et al., 2015; Lindgren and Emmitt, 2017; Mahapatra and Gustavsson, 2008; Mahapatra et al., 2012; Ramage et al., 2017; Salvadori, 2021). The differences between wooden– and concrete– multistory construction technologies are sufficient to label wooden multistory construction as a novel innovation (see: Mahapatra et al., 2012).

[1] Multistory buildings whose structural load-bearing frames and elements are made from timber, typically an engineered wood product. For more information see: Ramage et al. (2017).

[2] Herein, the term wooden multistory construction is used as an aggregate to denote all current technologies used as building solutions to construct wooden multistory buildings. This includes engineered wood products (e.g., cross-laminated timber, laminated veneer lumber, and glulam), as well as construction techniques (e.g., post and beam; mass timber; modular).

The adoption of novel innovations is commonly beset by challenges. Such challenges stem not only from competitive forces and the market activities of incumbent firms preventing the entry of new competing technologies, but broader societal interactions (see: Hughes, 1987; Bruland, 1995; Rip and Kemp, 1998; Geels, 2002). Societies and technologies co-evolve together in socio-technical configurations wherein human actors adopt patterns of production, distribution, and uses of technology that are self-reinforcing, mutually dependent, and stable (Geels, 2002, 2004). As societies co-evolve with technologies, they can become locked-in to using the incumbent technologies rather than readily accepting radical new technologies that require upending preexisting patterns of distribution, consumption, or technological use. Geels (2004) discusses lock-in mechanisms according to whether they are caused by *rules* that guide actors towards self-replicating activities (e.g., perceptions, beliefs, values), *interdependent networks* that self-reinforce activities (e.g., mutual reliance, coalitions, social power), or a sociotechnical system's *hardness* that ossifies as a technology becomes entrenched within society through resource investments (e.g., knowledge, capital, infrastructure).

The slow diffusion of wooden multistory construction is predominantly framed around the path-dependency of the construction industry (e.g., Mahapatra and Gustavsson, 2008; Mahapatra et al., 2012; Hurmekoski et al., 2015; Hemström et al., 2017a, 2017b; Lazarevic et al., 2020). They are locked-in to using technologies and practices associated with concrete multistory construction To give some examples of observed lock-ins, in Sweden, incumbent construction industry actors are constrained by *formal industry rules* (e.g., "standard practices," views towards development cost and riskiness) that result in a reiterative behavior to elect concrete multistory construction (see: Bysheim and Nyrud, 2009; Roos et al., 2010; Hemström et al., 2017a, 2017b; Markström et al., 2019). In the UK, the incumbent construction industry's *mutually dependent actor network* limits potential cooperation with the smaller and more fragmented timber product supply chain (Wang et al., 2014; Hurmekoski et al., 2015). In Australia, technical lack of human resources (e.g., know-how and knowledge of wooden multistory construction) form barriers requiring "practical education" strategies to accelerate adoption (Xia et al., 2014; Marfella and Winson-Geideman, 2022). This example also crystalizes the *hardness of the incumbent sociotechnical system*, as large amounts of resources are invested in developing industry standards and educational systems to provide professionals with the skills and competencies needed to carry out incumbent industry practices. Diverting educational practices towards new technologies and skills would, in essence, destroy previously sunk investments (see: Geels, 2004: pg. 911).

Identifying lock-in's is an important means to breaking path-dependencies because it helps develop solutions to accelerate diffusion (e.g., Mahapatra and Gustavsson, 2008). On the other hand, inertia is not automatic and resistance to technologies may also form (Geels, 2014). One major shortcoming with the literature on wooden multistory construction diffusion is that it primarily focuses on studying production-side actor-networks (e.g., incumbent construction industry and niche wood construction industry) (Jussila et al., 2021). While these viewpoints are undoubtedly important, sociotechnical interplays are understood to encompass dynamics among a whole regime of actors who have "*established practices and associated rules that enable or constrain incumbent actors in relationship to an existing system*" (Geels, 2002, 2004, 2014: pg. 23). Excessive attention to industry may result in solutions only geared at modifying the behaviors of production-side actors. In other words, limiting research to one group of actors inadvertently dismisses the search for lock-ins or resistance among other actors maintaining the sociotechnical regime (e.g., Geels, 2012). Furthermore, the limited research scope also prevents the discovery of sociotechnical

tensions. Tensions represent areas where the system is primed to incorporate changes to incumbent practices, or "windows of opportunity", are where wider diffusion is achievable (Geels, 2002: pg. 1262). An exemplary tension is mismatched values between actor group.

To tackle the limited research on wooden multistory construction diffusion, this dissertation research proposes expanding research focus onto public authorities fundamental to maintaining sociotechnical systems (e.g., Geels, 2012). In the context of construction technologies, one relevant public authority would be those governing land use planning. Land use is understood as "*the total of arrangements, activities and inputs applied to a parcel of land, including the social and economic purposes for which land is managed.*" (IPCC, 2019: pg. 817). Construction activities (e.g., development) represent just one of many possible uses of land. Hence, land use planning refers to "*the public policy intervention related to the ordering and regulation of land use*" (Baker, 2012). In essence, land use planning is the process of organizing land use. The instruments, approaches, and priorities of land use planning processes vary between localities (ibid). Given the local dimensions associated with both land use governance and sociotechnical regimes, I propose studying the relationship between local public authorities and wooden multistory construction diffusion through a country case-study. Despite bearing unique and contextual findings that cannot be generalized to other localities, a country case-study can nevertheless provide lessons learned to other countries attempting to understand the impacts of public authorities on the diffusion of wooden multistory construction.

This dissertation research approaches the diffusion of wooden multistory construction through the perspective of local public authorities in Finland. Finland's national government has supported the development and scaling up of wooden multistory construction over the past 25 years. This support is driven by policy agendas that, on the one hand, seek ambitious solutions for climate change, and on the other, seek to stimulate the domestic forest sector and national economy (Lazarevic et al., 2020; Toivonen et al., 2021b). These formal institutions and regulations allow for wooden multistory construction to develop investments, knowledge, and competency networks outside of the incumbent concrete-dominated market (Hurmekoski et al., 2015; Lazarevic et al., 2020; Vihemäki et al., 2019). Nevertheless, market shares of wooden multistory dwellings are estimated to account for only 6% of Finnish multistory dwellings (Hurmekoski et al., 2018). Overall, only 66 projects, totaling 117 buildings, were finalized between 1995 and 2021 (See: Supplementary Info, S5). Ultimately, the inert rate of diffusion is labeled as a failure to mainstream wooden multistory construction into the residential housing market (e.g., Hurmekoski et al., 2015; Vihemäki et al., 2019; Lazarevic et al., 2020; Toppinen et al., 2020a). The contrast between high degree of support and low rates of diffusion makes Finland an especially interesting case for research.

The literature identifies several constraints to the diffusion of wooden multistory construction in Finland. There are challenges with the operating environment, as the wood construction industry lacks standardized building systems and is highly fragmented. Furthermore, they experience limited opportunities to collaborate within the incumbent construction actor network (Riala and Ilola, 2014; Ruuska and Häkkinen, 2016, Toppinen et al., 2018a, 2018b, 2019a, 2019b; Viholainen et al., 2020). While construction industry attitudes towards various aspects of wooden multistory construction appear to be improving (e.g., Kitek-Kuzman et al., 2018), the sector still has trouble accepting industry practices viewed as unnecessarily risky and costly (Aaltonen et al., 2021; Hurmekoski et al., 2021; Ilgin et al., 2021; Karjalainen et al., 2021; Riala and Ilola, 2014; Ruuska and Häkkinen, 2016; Toppinen et al., 2019b). These constraints make the path-dependent nature of the construction industry a perpetual barrier in Finland.

On the consumer-side, the situation is opaque due to limited research, but (wood) construction professionals generally perceive limited demand for wooden multistory construction (e.g., Toppinen et al., 2018a). Consumers tend to share similar housing priorities as developers, such as apartment location, cost, and quality rather than material selection (e.g., Viholainen et al., 2020a). In this sense, the users and producers are in a tightly aligned relationship sharing similar rules (e.g., priorities). Yet, consumers are given little leeway to impact frame material selection, and neither concrete- nor wood- construction industry value chains place emphasis on incorporating end users into their value networks (Riala and Ilolla, 2014; Toppinen et al., 2019a; Viholainen et al., 2020b). Arguably, this emphasizes the priorities found meaningful by construction value chain actors over the creation of new priorities guided by consumer preferences. These priorities ultimately become self-reinforcing because "*as long as firms think they meet user preferences well, they will continue to produce similar products.*" (Geels, 2004: pg. 910 from Christensen, 1997). In actuality, consumers are found to have a variety of perceptions towards the use of wood in construction (e.g., Viholainen et al., 2021) with preferences for wooden multistory buildings being linked to consumer spending habits (Kylkilahti et al., 2020).

On the public side, views from local public authorities responsible for land use planning (i.e., municipalities) are all but absent from the literature (exceptions include: Lähtinen et al., 2019; Salmi et al., 2022). This constitutes a major gap in the literature, given that municipalities are legally legitimized to steer local construction activities. According to Finland's Land Use and Building Act (132/1999), municipalities are responsible for overseeing land use development, ratifying zoning plans, providing building inspection, awarding building permits, and procuring public service projects (e.g., schools, libraries, nursing homes). Due to this, I argue that municipal civil are the gatekeepers of construction. Through their legally legitimate role, municipalities may (in)directly influence construction activities and selectively promote wooden multistory construction. For example, they can commission public wooden multistory building projects, subsidize the cost of a land lease to clients developing a wooden multistory building on municipally owned land parcels, or draft zoning plan regulations that force the development of wooden multistory buildings (see: Riala and Illola, 2014; Hynynen, 2016; Vihemäki et al., 2019; Salvadori, 2021). Typically, municipalities are found to promote wooden multistory construction through public-private partnerships (Salvadori, 2021: pg. 178-182). However, public-private partnerships are a two-way street through which municipal civil servants can also accede to private sector lobbying efforts (see: Mäntysalo et al., 2011), for example, against wooden multistory construction (see: Lähtinen et al., 2019b). Ultimately, what remains unexamined is the rationale underpinning why municipalities may (or may not) engage in promotional activities that would lead to the implementation of wooden multistory buildings in their municipalities. This begs the question, which perceptions could drive municipalities to action?

The purpose of this thesis is to investigate the current state of wooden multistory construction in Finland through the perceptions of municipal civil servants responsible for overseeing land use planning in Finland. The dissertation research explores this matter by juxtaposing these perceptions against broader forces impacting the diffusion of wooden multistory construction. The work provides foundational research as well as novel insights on how local public institutions governing land use planning (e.g., municipalities) interact within the broader sociotechnical regime to uphold (and challenge) the incumbent residential (concrete) multistory construction technologies and practices. As *action* represents a key aspect of sociotechnical interactions, the dissertation research applies the theory of planned behavior (Ajzen, 1991) as the overarching conceptual framework for collecting perceptions

from municipal civil servants. The theory posits that human action results from a combination of attitudes, subjective norms, and perceived behavioral control, are underpinned by an individual's beliefs. Specifically, this dissertation research identifies (Article I) and operationalizes (Article II-III) the attitudes and beliefs municipal civil servants hold towards wooden multistory construction. The collected attitudes and beliefs are distilled into three nuanced empirical accounts: *Why not wood?* (Article I), *Wood versus concrete* (Article II), and *Planning for wood* (Article III). Altogether, the accounts demonstrate the existence of complex interrelationships and tensions. Separately, each account addresses one of the following sub-questions respectively:

RQ1. What do municipal civil servants perceive as the barriers and drivers to wooden multistory construction in their municipality?

RQ2. How do municipal civil servants view various attributes of wooden multistory buildings against concrete multistory buildings?

RQ3. Which ideologies (i.e., sets of beliefs) influencing land use planning priorities underpin municipal civil servant attitudes towards implementing wooden multistory buildings?

2 CONTEXTUAL BACKGROUND

This chapter provides a short account on the establishment of wooden multistory construction as a niche set of building technologies and practices in Finland. The focus is especially on the drivers pushing its diffusion and uptake into Finland's construction sector. Following is a description of the legal responsibilities that municipal administrations hold over land use planning, how these responsibilities coincide with the promotion of wooden multistory construction through planning practices, and how this promotion may be opposed by incumbent actors with diverging land use planning priorities.

2.1 Rise of wooden multistory construction in Finland

The diffusion of wooden multistory construction in Finland is multi-faceted as it represents the converging of two traditional sectors—forest and construction—under an atmosphere of divergent institutional ambitions. As a starting point, this thesis takes the European Union's (EU) harmonization of construction products (89/106/EEC) and structural building codes (EN, 1995). The EU's justification for harmonization was increasing the EU's global competitiveness, but also improving the construction industry's sustainable development actions (Tykkä et al., 2010). The policies instigated replacement of prescriptive building code regulations for performance-based building regulations, thus widening material selection in the building product markets (Östman and Källsner, 2011). Through this opening, sawmill firms entered the construction sector as material suppliers of timber frames (Tykkä et al., 2010). For Finland, this opening held far-reaching consequences.

Between 1991 and 1993, Finland experienced a strong recession. The Finnish state reacted through rigorous political actions to bolster international competitiveness and position Finland as a global player ready to capture transnational capital (Ahlqvist and Moisio, 2014). A "third investment era" thus began in the 1990's, with the state investing heavily in research and development specifically for purposes of increasing Finland's international competitiveness (Moisio and Leppänen, 2007). Included among the expenditures were 60 million euros for wooden multistory construction development programs running from 1992-1998[3] (Lazarevic et al., 2020). These nascent programs were the seeds of Finland's wooden multistory construction activities. Program objectives included establishing an "*internationally competitive*" wood construction sector (TEKES, 2000: Summary) and enabling the wood industry to shift from a primary- to secondary-product industry (Lazarevic et al., 2020).

Between 1996 and 1997, 18 wooden multistory buildings were finalized, totaling roughly 200 apartment dwellings. Future market development opportunities were ensured, as the nascent programs facilitated the revision of building fire codes regulations in 1997. Prior to this, deploying wood as a structural load bearing frame material was restricted to two-story construction projects (see: Lazarevic et al., 2020). Thus, the fate of multistory construction was employing concrete load-bearing frames, a tradition dating to the post-war

[3] See: Lazarevic et al. (2020, Table 2). Programs include: Wood Finland 1992-1994; Wood Processing Technology Program 1992-1996; Wood Based Panels Technology Program 1992-1996; Wood in Construction Technology Programme 1995-1998; and Year of Wood 1996.

reconstruction era, marked by rapid growth and urbanization, wherein the state financed social housing projects relying on prefabricated standardization and concrete elements (Stjernberg, 2019: pg. 5-15). The new fire code regulations permitted construction of wooden multistory buildings up to four stories, and with 75% of Finland's multistory buildings being less than five stories tall, this was perceived as a successful opportunity (Karjalainen, 2002).

Between 1998 and 2010, the promising situation deteriorated. A period of inactivity took hold, evidenced by the finalization of merely 12 new wooden multistory buildings, summing roughly 300 apartment dwellings (Fig. 1). The inactivity would not break until a "second wave" of wooden multistory buildings materialized in 2011 (see: Hurmekoski et al., 2015). This re-uptake would coincide with the global forest sector's economic downturn; put another way, in the face of decreased global demand for pulp, Finnish forest companies seeking new business opportunities turned to wooden multistory construction as a measure to improve their market situation (Lazarevic et al., 2020). The significance of this event cannot be understated, as the inability of wooden multistory construction to penetrate the construction sector was partially ascribed to disinclination from large construction companies to adopt the new technologies (TEKES, 2000). Since nascent wood construction development programs primarily enabled small firm experimentation, the legitimacy of wooden multistory construction remained questionable up until the arrival of larger forest industry firms (see: Hurmekoski et al., 2015; Lazarevic et al., 2020). These forestry firms pushed through into the construction sector value chain and stirred up collaborations, but not unaided. The Ministry of Employment and the Economy introduced the 2011-2015 Strategic Programme of the Forest Sector with objectives to alleviate the forest sector downturn. The program acknowledged wood construction as the "biggest opportunity" to create new businesses and ergo increase the use of wood (TEM, 2012: summary). As a result, the program included targets for increasing the annual market shares of wooden multistory buildings to 10%. To carry out these targets, the 2011-2015 Wood Construction Program was launched. The focus was on developing internationally competitive wood construction business collaborations that would enable regional employment and produce energy-efficient buildings that could *"fight back climate change*" (TEM, 2015a, 2015b: pg. 2).

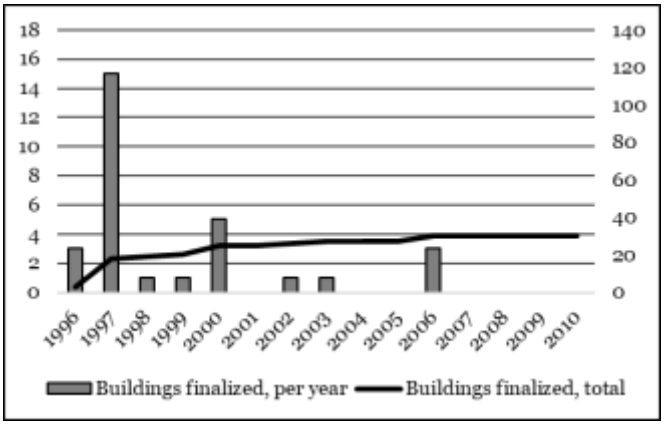

Figure 1 - The "first wave" of wooden multistory construction in Finland. Statistics available in Supplementary Info 4.

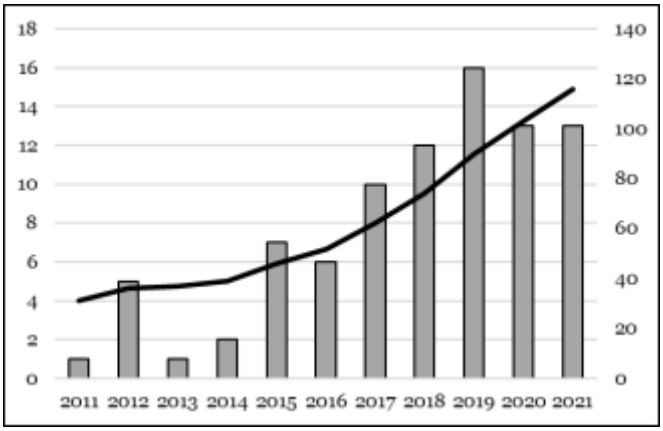

Figure 2 – The "second wave" of wooden multistory construction in Finland. Statistics from Supplementary Info 4.

Policy discourses favoring climate change mitigation over economic growth were mounting, for example, within Finland's science-policy interface (Kukkonen and Ylä-Anttila, 2020), and debates about achieving a carbon neutral Finland by 2050 were surfacing (Karhunmaa, 2019). Alongside these discussions, carbon lifecycle analysisanalyze of structural frame materials (e.g., Gustavsson and Sathre, 2006, 2011; Gustavsson et al., 2006; Dodoo et al., 2014) emerged as centerpieces for promoting wooden multistory construction (Lazarevic et al., 2020; Vihemäki et al., 2020). Importantly, these justifiers did not centralize overnight; instead, they evolved gradually and increasingly blended with the pre-existing economic growth objectives[4].

A short two years later, Finland's 2014 Bioeconomy Strategy emerged in the political landscape and reframed preexisting forest-policy narratives in Finland altogether (Toivanen et al., 2021). Implemented under the 2011-2015 Strategic Programme of the Forest Sector, the Bioeconomy strategy boasted a societal transition towards markets relying on renewable resources rather than fossil-fuel based resources. According to the strategy, this could be achieved while creating new jobs, growth, and exports within the bioeconomy sector. It did not go unnoticed that the strategy largely emphasized forest sector activities for achieving such aims (e.g., TEM, 2015, 2017; Ahlqvist and Sirviö, 2019). And perhaps for this reason, wooden (multistory) construction entered the bioeconomy strategy as an exemplary "low-carbon product" (TEM, 2014: pg. 14-15) dubbed "the most interesting new business opportunity in the emerging forest bioeconomy" (Toppinen et al., 2018a: pg. 3).

Between 2011 and 2016, some 22 wooden multistory buildings totaling nearly 740 apartment dwellings were constructed (Fig. 2). This successful development was as much a result of the technological developmental push yielded by national development programs

[4] An exemplary item blending environmental (i.e., climate change) discourse with Finnish economic growth objectives is found within the 2010 Working Group Report "The international promotion of wood construction as a part of climate policy" commissioned by Minister of Foreign Trade and Development, Paavo Väyrynen. During the report's press release, Väyrynen commented that, "*Wood construction could become the new Nokia Finland has hoped for*." (UM, 2010).

and policies, as it was a result of forest industries' capacity to form vertical cooperation within the (wood) construction value chain (see: TEM, 2015a; Hurmekoski et al., 2015; Toppinen et al., 2019b; Vihemäki et al., 2019; Lazarevic et al., 2020). In addition, the operating environment for wooden multistory construction was secured at the regulatory level through the 2011 building code revisions that legally permitted wooden multistory buildings up to 8 stories tall (TEM, 2015b). In many ways, the potential for wooden multistory construction was opened, but one evident caveat appeared, as some actors begun rejecting the top-down practices associated with the second wave of promotional activities.

In 2012, the Concrete Industry Association (Betoniteollisuus ry) and constituents appealed against zoning plans for the upcoming neighborhood of Honkasuo, Helsinki at a public city council meeting (Päätokset, 2012). The plans included zoning regulations enforcing the use of wooden load bearing frames in (multistory) building construction. The opposition argued, among other things, that such regulations created material preferentialism that restricts trade, and conflicted with EU import laws. In 2013, Helsinki's Administrative Court rejected the claim, and the appeal was escalated to Finland's Supreme Administrative Court that, in 2015, ruled on multiple grounds that the zoning plans did not conflict with EU trade laws (KHO, 2015). Nevertheless, these actions crystalized the outlook of skeptical actors embedded within the construction sector; essentially, top-down measures supporting wooden multistory construction collided with the construction sector's path-dependent culture (see: Hurmekoski et al., 2015). Perhaps the threat of change created resistance. In the literature, this was framed as an "antipathy" for wooden multistory construction (Riala and Illola, 2014: pg. 371) and an "antagonism" between the wood construction sector and concrete solution providers (Toppinen et al., 2019b: pg. 208).

Despite the construction sector's opposition to top-down provisions like zoning regulations (e.g., see: Hurmekoski et al., 2018: pg. 3652), promotional activities for wooden construction continued (and they continued to be apprehended questionably, see: Vihemaki et al., 2020, pg. 445). Several major developments occurred from 2016 onwards. Of key importance was the launch of the 2016-2018 Wood Construction Programme, under the Ministry of Environment[5]. Their objectives remained largely in line with previous programmatic aims, except that the importance of buildings as carbon stocks was emphasized alongside climate change mitigation (YM, 2019). On the regulatory side, the programme helped enable "pro-wood" (Vihemäki et al., 2020: pg. 445) legislative changes to building fire codes. This was particularly important towards enabling construction of wooden multistory buildings taller than 8 stories through functional fire safety designs (848/2017). The most striking action, however, arrived only after the introduction of the new Finnish government in 2019.

In 2019, the new Prime Minister's government pledged a transition to a Climate Neutral Finland by 2035[6] (PMO, 2019a). Alongside this development, a discursive shift repositioning wooden (multistory) construction activities from "low-carbon building solution" towards a "carbon neutrality" strategy has been occurring. This shift is evidenced in the changing language used by the 2016-2022 Wood Building Programme. A year after Finland's carbon neutrality pledge, the Ministry of Environment announced ambitious national level targets aiming to increase the market share of publicly procured construction projects to be built

[5] The Ministry of Environment doubles as the body responsible for overseeing national guidelines for land use planning in Finland (see: Chapter 2.2).

[6] Sanna Marin's government upheld the pledge after Antti Rinne's resignation (PMO, 2019b).

from wood[7] (YM, 2020). Of more interest to this thesis, these targets were directed towards municipalities on the grounds that, "carbon neutrality targets set by the municipalities support wood construction" (ibid, pg. 4) and that "by selecting wood construction, public actors can allocate common funds to achieving social goals: to reduce emissions and support the domestic economy and local businesses" (ibid, pg. 2). This statement makes visible that the Ministry of Environment sees the role of municipalities to be the upholding of social goals, like reducing carbon and supporting local businesses. It also presupposes that municipalities share these same objectives, and more critically, that they have the power and resources to enable the procurement of public buildings from wood. Possibly due to this same reasoning, the report also provides municipalities with information on how to obtain financial support for wooden construction projects (ibid, pg. 7). Ultimately, the Ministry of Environment's targets invoke questions about the precise nature of municipal roles and responsibilities when it comes to land use planning in Finland, and how this coincides with their capacity to implement wooden multistory buildings. This matter is taken up in the following section.

2.2 Municipal land use planning in Finland

The role of Finnish municipalities overlaps with the development of wooden multistory construction primarily due to the formal legal responsibilities local public administrations have towards overseeing the land use planning process in Finland. But what do these responsibilities entail according to the legal stature, how do they translate into land use planning practices, and how do these land use planning practices ultimately coincide with wooden multistory construction? This sub-chapter attempts to briefly take these matters up.

2.2.1 The National Building and Land Use Act (1999)

Finland's land use planning process is codified within the National Building and Land Use Act (132/1999), wherein various responsibilities for land use planning are delegated to government administrations. Importantly, the Act operates with two primary objectives:

> "*That the use of land and water areas and building activities on them create preconditions for a favorable living environment and promote ecologically, economically, socially and culturally sustainable development*".
>
> "*That everyone has the right to participate in the preparation process [of land use planning]*".
>
> (Section 1).

These objectives represent the bedrock of the land use planning process; they must always be taken into consideration by administrations carrying out land use planning tasks.

Regarding the instruments of land use planning, Finland steers land use through a hierarchical three-tiered zoning plan system (Section 4). These are the regional, local master,

[7] Among the various targets is the aim to build at least 46% of new publicly procured residential multistory buildings as wooden multistory buildings by 2025 (pg. 7)

and local detailed zoning plans. All three zoning plans are guided by national land use objectives under the responsibility of the Ministry of Environment and ratified by the Council of State. These objectives are not legally binding, but rather, advisory in nature. The most recent revision was issued at the end of 2017 and came into force in 2018 (YM, 2017). It sought to address discussions on low-carbon transitioning, but also included promoting biodiversity and sustainable uses of land, seeking opportunities for renewing economic activities, and managing challenges and opportunities associated with growing urbanization.

At the top of the zoning plan hierarchy are regional plans (132/1999: section 25-34). They designate areas for regional development, for example by guiding regional densification or infrastructure projects (e.g., the "boulevardization" strategy of Helsinki, see: Granqvist et al., 2019). Regional plans are drawn up by the regional councils (18 in Finland) made up of representative members of the municipalities from the respective region. Whereas the Ministry of Environment previously ratified these plans, as of 2016, this is no longer the case. Planning authority was thereby transferred from the state scale onto the regional scale (see: Hytönen and Ahlqvist, 2019). Regional plans should, in theory, guide local master plans and local detailed plans. In practice, however, this is not always strictly the case (see: Purkarthofer et al., 2021; Hirvonen-Kantola and Mäntysalo, 2014).

In the middle of the planning hierarchy are the local master plans (132/1999: Section 35-45). These zoning plans designate land use for the whole municipal area while, in theory, observing the overarching guidelines of the regional plan. In many ways, the municipal master plan serves as the long-term instrument for steering land use in a municipality. The content requirements of a master plan include general preconditions that ensure a functional community with the necessary number of services. This highlights the municipality's responsibility to procure public services for their community (e.g., schools, libraries, nursing homes, prisons).

The final tier of the planning hierarchy are the local detailed plans (132/1999: Section 50-61). These plans provide granular information about specific land areas in the municipality. The plans include clear boundaries describing both public and private uses of land, building stock volumes, and any principles governing the building stock (e.g., the use of a building), or the construction of the buildings (ibid: Section 55). The plans should also observe the master guidelines of the local master plan. In many ways, the purpose of detailed plans is to direct local construction activities. Ultimately, the local master plan dictates land use within a municipality, and the local detailed plan steers land use through building and plot division. Municipal administrations are responsible for overseeing that both the local master plan and local detailed plans are drawn up, kept up to date, and presented to the local municipal council for approval (ibid: Section 52).

Because Finland's land use planning system is steered by zoning plans, the system is defined as a plan-led planning system. Under this system, building permits for development projects are awarded based on whether a development proposal fulfills the preexisting stipulations outlined in an approved zoning plan. To this end, municipal administrations oversee the awarding of building permits and are thus required to employ a qualified building inspector (ibid: Section 21). Building inspectors control building development by approving development proposals, granting building permits, and ensuring that local construction activities progress according to the technical guidelines of building practices.

2.2.2 Promoting wooden multistory construction

Due to their legal legitimacy to oversee land use planning in Finland, municipalities are often described as potential promoters for wooden (multistory) construction (Hynynen, 2016). Because of the limited research elucidating how municipalities may (in)directly influence wooden construction, this subsection discusses a few examples.

To start, there are two features within Finland's Land Use and Building Act (132/1999) that enable municipalities to control the development of wooden multistory construction. First, local master plans and local detailed plans may include the use of zoning regulations which dictate special land use guidance (ibid: Section 41, 57). Regulations help municipalities steer land use in a way that permits fulfillment of the municipality's overarching land use planning objectives. For example, the size of a retail shop may be limited, to ensure good availability of retail services (ibid: Section 57). These regulations allow municipalities to dictate material preferences in zoning plans. As mentioned earlier (Chapter 2.2.1), the City of Helsinki's zoning plan for the Honkasuo neighborhood includes regulations enforcing the use of wooden frames (HEL, 2012). Thus, to be awarded a building permit, the developer of the plot must comply with these regulations.

The second feature is associated with the role of building inspectors who issue building permits according to building codes. Recall that wooden multistory buildings are limited in height based on building fire codes. There are both prescriptive and design-based fire codes in Finland. The prescriptive "fire class" system limits wooden multistory buildings to a maximum of eight stories (848/2017: pg. 5). Alternatively, fire codes may be approved based on a "design fire scenario" system that demonstrates that the building can meet essential requirements for fire safety (ibid: pg. 3). Under this design-based mechanism, development proposals for wooden multistory buildings taller than eight stories may be approved. A prominent example is the Lighthouse Joensuu, a 14-story wooden multistory building located in Joensuu, Finland[8] (Joensuu, 2017). While the "fire design scenario" enables construction of otherwise restricted projects, construction industry professionals do occasionally view the flexibility associated with interpreting the fire design scenario as a barrier (see: Ruuska and Häkkinen, 2016; Korhonen et al., 2021: pg. 5). This is attributed to differences between how municipalities apply fire safety regulations. In this vein, Hynynen (2016) appears to suggest that more favorable building permitting is within the power of municipalities and could enable promotion of wooden multistory construction.

Aside from these regulatory provisions, the National Building and Land Use Act also assigns municipalities with the responsibility of providing basic public services to their communities (e.g., schools, residential buildings, nursing homes, libraries, etc.). It is these public procurement projects that are subject to the Ministry of Environment's targets for wooden construction (YM, 2020). Compliance with these voluntary targets is a means for municipalities to promote wooden multistory construction. Here, the Lighthouse Joensuu serves also as an example of a publicly procured residential multistory building, where the municipality later sold the finalized project to a city-owned limited company that produces, maintains, and rents out student housing (*Opiskelijaasunnot Oy Joensuun*) (Joensuu, 2017).

Apart from the tools outlined in the National Land Use and Building Act, municipalities have several other tools for promoting wooden multistory construction. Vihemäki et al. (2019) cite that municipalities can place "stipulations" to promote wooden construction. This

[8] Notably, the zoning plot for Lighthouse Joensuu requires tall wooden construction

refers to additional stipulations in the terms of a land lease or land sale (in Finnish: *tontinluovutusehdot*) (Kuntalitto, 2022a, 2022b). In theory, these stipulations can be applied in two ways. Firstly, they can be used to provide subsidies for clients developing wood multistory construction projects. Several wooden multistory construction pilot projects were subsidized this way (Vihemäki et al., 2019). Secondly, they can be used to demand clients to develop the plot using wooden construction. Note that these stipulations are not the same as regulations enforced through zoning plans. In addition, municipalities can host high-profile design competitions that require the use of wood on prominent plots of land[9] (Vihemäki et al., 2019). One example is the Eskolantie project in Helsinki, whose competition was organized by the city's housing office ATT (Salvadori, 2021). Similarly, the DAS Kelo project in Rovaniemi was designed for an architectural competition, however, the theme was circularity rather than wood construction *per se* (ibid). Municipalities can also leverage private-public partnerships towards forming networks that enable the municipality to implement wooden multistory construction. Hynynen (2016) comments that, "*In many cities land use planning and business development offices have been linked together for more efficient urban development*" (pg. 133), thereby suggesting that consultancy-based partnerships with wooden construction businesses are one means of enabling both parties. Here, it is interesting to point out that a major wooden multistory construction real-estate developer in Finland (*Lakea Oy*) is owned by 15 Finnish municipalities and is has developed four of the ten tall wooden buildings existing today in Finland (Salvadori, 2021: pg. 178-182). Lastly, municipalities can also signal support for wooden multistory construction by incorporating voluntary commitments to build with wood into strategic programs of the municipality (Hynynen, 2016; Vihemäki et al., 2019). For example, Ruuska and Häkkinen (2016) cite the City of Espoo's promotional program for wood construction as an example. Of course, how commitments are fulfilled in practice is another question altogether. This brings us to the next topic, whether municipalities have the means to implement action.

2.2.3 Land use planning practices

Finnish municipalities may be the gatekeepers of construction projects, but there are two fundamental questions underpinning this role: When do they open the gate? And do they have the means to pull the lever? Based on the previous section, it is clear there are numerous ways for a municipality to promote wooden multistory construction. What is less apparent is the extent to which external actors might dissuade (or empower) municipalities from engaging in these promotional activities. This subsection briefly outlines the complexities associated with governing local land use planning in Finland, in an effort to reveal some priorities found within municipal land use planning agendas in juxtaposition to the power they have in executing these agendas.

While Finland's Land Use and Building Act defines Finland's land use planning system and lays out the formal responsibilities of a municipality, there are no formalized decrees for *how* a municipal administration should arrange the preparation of local zoning plans (Valtonen et al., 2017). This is an intentional feature that functions to uphold local autonomous decision making by permitting the interpretation of legislation through the local municipality's political will (Hytönen, 2016). In theory, by enabling local autonomy and flexible decision making, the Land Use and Building Act set out to enable the participation

[9] See also Toppinen et al., 2019a for case study example.

of broader local interest into the municipal planning process (c.f. Hytönen, 2019). Inclusiveness, as a core aim of Finnish land use planning, is visible in the second object of the Land Use and Building Act, which states that, "*everyone has a right to participate in the process*" (132/1999: Section 1). Inclusivity as a principal ideal of land use planning stems from a philosophy of planning (i.e., Communicative Planning Theory) concerned with incorporating broader perspectives into land use planning practices through deliberation (Healey, 2003). This is part of a broader historic trend through which planning is made more democratic and transparent. By promoting inclusive deliberation, the planning process can balance uneven power relations among stakeholders possessing multiple environmental, economic, and social interests (ibid). Elements from communicative planning theory were consciously incorporated into Finland's Land Use and Building Act to enable flexible land use planning that permits inclusive local deliberation (Puustinen et al., 2017; Hytönen, 2019). But in contrast to the intention, studies observe that planning practices fail to live up to these ideals (e.g., see: Mäntysalo et al., 2011; Sager et al., 2009). Put another way, power dynamics are not always equalized in Finnish land use planning practices. Thus, power constitutes a critical dimension underpinning the outcomes of land use planning.

Because power dynamics are not always equalized, it is important to reflect on the flow of power within the current governance model for land use planning. Today, Finnish land use planning administrations function under the New Public Management model (Pollitt and Bouckaert, 2011). This model emphasizes management of the public sector through business sector concepts; thus, it privileges an economizing managerial perspective (e.g., Ahlqvist, 2013). In the context of Finland, the governance rules promote efficient and expedient planning outcomes that restrain expenditures (e.g., Juntunen and Leinonen, 2007). It is argued that under New Public Management, municipal planning practices succumb to reactionary market-driven planning practices at the expense of long-term goal-seeking (e.g., Hytönen and Ahlqvist, 2019). These occurrences are closely tied to increases in localized discretionary powers (e.g., relegation of central government powers to municipal authorities) in conjunction to Finland's neoliberal state transformation and state rescaling[10] (Hytönen and Ahlqvist, 2019; Hytönen, 2019). These events have left municipalities responsible not only for the provisioning of local services, but also for acquiring capital and investments to improve local development and employment opportunities (Hytönen and Ahlqvist, 2019; Moisio and Rossi 2020). To acquire capital, municipalities compete for new taxpayers and external investors (e.g., Hytönen et al., 2016). A chief concern is that the municipal civil servants overseeing land use planning are thus increasingly beholden to fulfilling the interest of a few select private market actors who can provide this capital, over the interest of the many (e.g., Puustinen et al., 2017, see also: Hytönen, 2019). This contrasts starkly with previous governance regimes (i.e., welfare distribution model, see: Ahlqvist and Moisio, 2014) where municipal civil servants, particularly planners, once described themselves as "guarantors of the public", whereas now they view themselves "in the service of private developers[11]" (Puustinen et al., 2017: pg.79-80). So, while every municipality holds equal amounts of legislative power (Hytönen, 2016), each control different sums of planning resources (Hytönen and Ahlqvist, 2019).

[10] For further reading on Finland's neoliberal state transformation, see: Ahlqvist (2013), Ahlqvist and Moisio (2014), Moisio (2018), and Moisio & Rossi (2020).

[11] The criticism here is not levied towards planners for being beholden to their community's interest, but rather that planners are in service of only a select *few* private entities in their community.

It is observed that municipal planning practices in Finland are increasingly incorporating market actors and private developers into the planning process (e.g., Mäntysalo and Saglie, 2010; Mäntysalo et al., 2011). While land use planning in Finland is legally structured as a planning-led system, it commonly resorts to development-led planning practices (Valtonen et al., 2017). Under development-led planning practices, local detailed plans are prepared by the municipality in conjunction with private developers. This arrangement can jeopardize accountability and equal opportunities for inclusion by creating informal spaces in the planning process (e.g., Mäntysalo et al., 2011, 2015). A typical problematic outcome of these informal spaces are public-private partnership projects where municipal planners intentionally limit the inclusion of public participation (ibid). Soft spaces with limited accountability and inclusion give privileged entities opportunities to lobby for their own benefits and interests. Considering that the Finnish construction industry is observed to be highly path-dependent (c.f. Hurmekoski et al., 2015), these soft spaces could theoretically function as unchecked areas for replication of incumbent construction practices. To this end, Lähtinen et al. (2019b) explored whether the lobbying of land use planners impacts perceptions between wooden- and concrete- multistory buildings, and it appears there is a relationship. Still, it remains unclear to what extent these informal spaces result in the replication of incumbent multistory construction practices.

In short, the literature observes Finnish municipalities maintain a strong political will, enabled by the National Building and Land Use Act that refrains from delimiting how a municipality should carry out local land use planning practices. While local municipal functions are clearly laid out (e.g., zoning provision, permitting, procuring services), procedural functions are open to interpretation. This "soft space" is where power dynamics over interests play out. Ultimately, these power dynamics evoke questions over *whose* interests a municipality is capable of deliberating upon. In the context of wooden multistory construction, it is important to recognize that the incumbent construction industry actor network (e.g., developers) is deeply ossified towards reiterating practices associated with concrete multistory construction (Hurmekoski et al., 2015). Possibly, municipalities may have limited option but to comply with the interest of these incumbent actors. This justifies paying close attention to power dynamics, including whether a municipality perceives certain actors as having influence over the municipality's decision to implement wooden multistory buildings, and whether those influential actors are viewed to be in favor or opposed to wooden multistory construction. At the same time, wooden multistory construction is promoted under the umbrella of supporting local (low carbon) domestic industries (Toivonen et al., 2021b). This could be considered an attractive proposition for municipalities seeking to find a new source of revenue investments (Hynynen, 2016). As a final point, Hytönen (2019) argues that long-term sustainability agendas are threatened by power dynamics unfolding as a result of intermunicipal competition for capital. This suggests that resource availability is also closely linked to a municipality's power to choose between the interest they would like to uphold, versus the interest of more powerful actors (i.e., actors with more resources).

All in all, whether a municipality wants to promote wooden multistory construction will depend not only on the objectives of the municipality's own land use planning agendas, but also on power dynamics playing out in the land use planning arena, and the resources at the municipality's disposal.

3 METHODS

This chapter describes the theory of planned behavior, justifies its use as a measurement tool for collecting perceptions, and details how the theory was applied. While the dissertation research only makes use of *two* dimensions collected by employing the theory (i.e., **attitudes** and **behavioral beliefs**), the whole process is outlined in detail to promote reproducibility. Furthermore, developing the measurement tool was met with challenges and limitations; these are outlined in detail to provide future researchers with opportunities to improve their own measurement tools. The chapter concludes with a discussion on ethical considerations.

3.1 The theory of planned behavior

The theory of planned behavior (Ajzen, 1991) is a theoretical model that explains and predicts human behavior. The theory postulates that an individual's behavior can be predicted from their intention to engage in a behavior. Intention is described as the "motivational factors" (e.g., willingness, effort) influencing a behavior. It is the primary antecedent of behavior, and thereby the most important dimension for predicting behavior. Alone, however, it provides little information as to why an individual intends to engage in a behavior (Ajzen and Fishbein, 2005: pg. 6). This is where the determinants of intention become crucial.

Intention can be predicted from three independent determinants, namely, attitudes toward the behavior, subjective norms, and perceived behavioral control. Attitudes are described as the individual's favorable or unfavorable evaluations of the behavior in question. Subjective norms are described as the individual's perceived social pressure to either perform or not perform the behavior in question. Lastly, perceived behavioral control is described as the individual's perceived ability to carry out the behavior. In essence, the relationship between the three predictors and intention assumes that the more positive the attitude towards the behavior, the more normative pressure to carry out the behavior, and the easier it is to do the behavior, the more likely one is to engage in the behavior. Put simply, if we like the behavior, if we think others like the behavior, and if we think we can carry out the behavior, then we probably intend to do the behavior.

The theory of planned behavior is concerned not only with predicting behavior, but also with explaining behavior. It does so by eliciting the determinants of attitudes, subjective norms, and perceived behavioral control. These determinants are an individual's beliefs. Beliefs are a representation of the information an individual has about the world (Ajzen and Fishbein, 1980: pg. 79). As such, this information may be either true or false, as it is completely subjective (Fishbein and Ajzen, 2010: pg. 221). Likewise, the process of belief formation is open to both rational and irrational formation (e.g., bias) because belief formation occurs through the acquisition of information by direct observation, from indirect outside sources, or through personal inferences (Fishbein and Ajzen, 2010: Chapter 7). In short, individuals acquire beliefs through experience, and individuals with different experiences (e.g., demographic differences) may form different beliefs.

According to the theory, each determinant of intention has its own set of causal determinant beliefs. Attitude is determined by behavioral beliefs. These beliefs reflect "the subjective probability that performing a behavior leads to a certain outcome". Thus, attitude

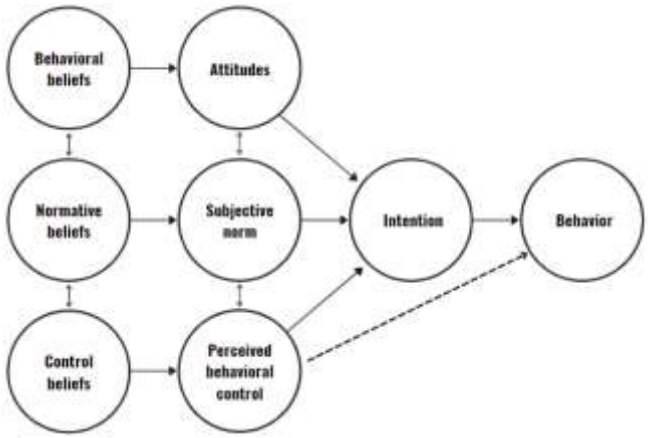

Figure 3 – Theory of planned behavior depicted as a causal chain structural diagram. Image adapted from Fishbein and Ajzen (2010).

towards a behavior is formed from an evaluation towards the object of the behavior (Fishbein and Ajzen, 2010: Chapter 3). Subjective norm is determined by normative beliefs. These beliefs reflect whether referents (e.g., friends, co-workers) approve or disapprove of the behavior in question and the individual's motivation to comply with the referent's prescription (ibid: Chapter 4). Perceived behavioral control is determined by control beliefs. These beliefs reflect whether the resources driving or hindering the behavior are present. Thus, if an individual believes themselves to possess many of the resources necessary to carry out the behavior, then their perceived behavioral control will be greater (ibid: Chapter 5). Figure 3 illustrates the causal chain between the theory of planned behavior's constructs, starting from beliefs and ending with behavioral action.

3.2 Justifying use of the theory

The theory of planned behavior is one of the most popular theories for the study of human behavior. It has been applied to several thousand studies and has been empirically confirmed across multiple cases (Ajzen, 2011; Bosnjak et al., 2020). The capacity to use the theory as both a predictive model and explanatory tool afford it unique versatility. The theory functions both as a causal model and a conceptual framework. As a model, it quantitatively explains the formative power between multiple constructs along a causal chain, from beliefs to behavioral action. As a conceptual framework, it provides dimensions for qualitatively examining the salient (i.e., most relevant) beliefs underpinning the formation of human behavior. Thus, even if the causal model fails to predict intention or behavior, the theory still provides an applicable framework for exploring the beliefs that underlie behavioral action.

Given the theory's versatility, it is common to find it applied to disciplines outside of human psychology. For example, the theory exhibits popularity in the fields of management, business, and environmental studies (Bosnjak et al., 2020). This popularity is attributed to the model's applicability to the study of any behavior (Ajzen, 2020). Furthermore, the

theory's constructs provide explanatory insights into the nature of the individual (i.e., attitude), social influences and power (i.e., subjective norm), and the factors affecting control (i.e., perceived behavioral control) (Ajzen, 2002: pg. 117). Even independently, these dimensions are robust concepts for exploring phenomena.

In this dissertation research, the theory is foremost applied as a heuristic for exploring *why* municipalities may choose to promote wooden multistory construction. Municipalities have various mechanisms to promote wooden multistory construction (Chapter 2.2.2), but the complex dynamics associated with governing land use planning may limit (or enable) municipalities from taking action (Chapter 2.2.3). The theory was selected because it could lend itself to examining three relevant dimensions that impact action: 1) why municipalities perceive wooden multistory construction as (un)desirable (i.e., attitudes), 2) how power relationships between municipalities and external actors affect implementation of wooden multistory buildings (i.e., subjective norm), and 3) how resources weigh impact capacity to implement these buildings (i.e., perceived behavioral control). The predictive model could pinpoint which of these dimensions is most significant to taking actions that promote building with wood. Furthermore, the theory requires also identifies the beliefs forming these three dimensions. In practice, that means exploring 1) what attributes lead municipalities to want to build with wood, 2) the actors that influence the municipality to build with wood, and 3) the resources necessary to build with wood. Thus, apart from using the theory as an explanatory tool and heuristic (Article I), the goal was also to model the relationship between theoretical constructs (Article III), and to find linkages between background factors shaping the formation of beliefs (Article II).

The theory has been previously used to explore factors underlying frame material selection for multistory buildings (e.g., Bysheim and Nyrud, 2009; Roos et al., 2010 Hemström et al., 2011; Markström et al., 2019). In these studies, the target groups are chiefly private sector professionals (e.g., architects, engineers, developers, contractors). The studies typically attended to only one professional group at a time, and do not assess differing perceptions between groups. These studies analyze only some theoretical constructs. The exception is Bysheim and Nyrud's (2009) study, testing the relationships between attitude, subjective norm, and perceived behavioral control on intention using regression analysis. While the studies share practical findings about how wood is perceived as a structural frame material (i.e., attitudes and behavioral beliefs), none of the studies analyze how background factors forming beliefs. Furthermore, none of the studies model the relationship between attitudes and behavioral beliefs. This dissertation research deviates from the previous studies by targeting a mix of publicly employed professionals (e.g., architects, planners, real estate agents, mayors, buildings inspectors). This allows comparison between the responses of different professional groups (Article II/III). Furthermore, it is the only study to apply structural equation modeling to measure which beliefs impact attitudes (Article III).

The largest caveat rests with justifying the application of the theory to study an organization's intention to carry out a behavior by using the organization's employees as a proxy for measuring the organization. Typically, the theory is applied to predict behaviors that individuals have effective behavioral control over (Ajzen, 2020: pg. 321). Because organizations function as a collective unit, a singular individual may hold low control over the organization's ultimate behavior. On the other hand, applying the theory to individual employees permits exploring whether there are contradictions between the beliefs of different employees. This is a core means for delimiting tensions, as differences in beliefs are tensions that can destabilize incumbent practices within actor-networks (Geels, 2002, 2004).

3.3 Applying the theory

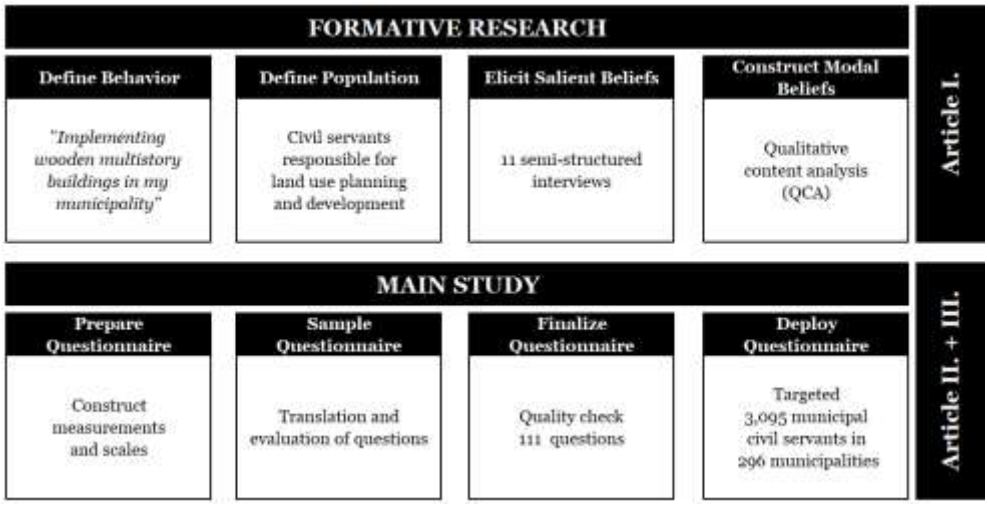

Figure 4 – An overview of steps carried out during the theory's application.

The process of applying a theory of planned behavior study is typically approached in two steps beginning with an elicitation study, followed by a survey study (Fishbein and Ajzen, 2010). Figure 4 outlines the process of applying the theory to collect data across this research. Data analysis is covered in the summary of the articles (Chapter 4).

3.3.1 Elicitation study

According to Fishbein and Ajzen (2010), the formative research sets out to define the behavior in question, specify the research population, formulate items for direct measure, and administer a pilot questionnaire. This research followed the suggestions but omitted the pilot questionnaire due to time constraints.

3.3.1.1 Defining the behavior

The first step towards applying the theory of planned behavior is to define the specific behavior in question. When specifying the behavior, the researcher applies the principle of compatibility (Fishbein and Ajzen, 2010: Chapter 2). This is done by detailing four elements: an action, a target, the context, and the time. The principle of compatibility serves to conserve robust predictive validity between the measurements of intention and the behavioral criteria; therefore, it is central to the theory's application (idib: pg. 44, 54). In this study, the behavior was defined as:

> "*Implementing* (action) *wooden multistory building projects* (object) *in my municipality* (context)."

To clarify, the action verb, "implementing" should not be confused to mean the process of *constructing* a wooden multistory building. The role of construction is carried out by builders, not municipal civil servants. The role of municipal civil servants is to oversee land use planning and steer municipal construction activities (Chapter 2.2). Implementation of a project refers to various functional duties of land use planning[12], some of which include the promotional actions discussed in Chapter 2.2.3. The choice to use a general verb to define the action is appropriate when attempting to capture a *category of behaviors* (Fishbein and Ajzen, 2010: pg. 31). Because there are several behaviors a municipality can engage in to enable the construction of a wooden multistory building (Chapter 2.2.2), a general verb seemed appropriate. Note that the timeframe of the behavior went unspecified. This approach was chosen because of the volatile nature of timing associated with the implementation of construction projects[13] (see e.g., Sanni-Anibire, 2020). The choice is justified because too narrow a definition of a behavior leads to limited practical importance. On the other hand, it is argued that a time element should be employed (Fishbein and Ajzen, 2010: pg. 31). Nevertheless, the most important aspect of the principle of compatibility necessitates consistently referring to the same target, action, context, and time element throughout the multiple measures deployed in the study (Ajzen, 2005: pg. 88). While this research excluded a time element, this omission was consistent across the measurements.

3.3.1.2 Defining the research population

Following the definition of the behavior, the targeted research population is defined. The research targeted civil servants responsible for municipal land use planning and decision making. In other words, the research focuses on municipal civil servants who perform tasks directly associated with the Land Use and Building Act (e.g., tasks related to zoning and drawing up zoning plans, tasks related to construction supervision and building inspection) and the tasks associated with the process of land use planning deliberation (e.g., senior management tasks, tasks related to property management and real estate).

3.3.1.3 Eliciting modal salient beliefs

When applying the theory of planned behavior to study a population, modal salient beliefs are collected (Fishbein and Ajzen, 2010: pg. 102-103). Salient beliefs constitute, "*the prevailing determinants of a person's intentions and actions*" (Ajzen, 1991: pg. 189). Essentially, an individual's intentions are determined only by the few sets of beliefs they are capable of "attending to" or "readily accessing" at any given moment. Therefore, the recommendation is to elicit these readily accessible beliefs through a free-response form (Fishbein and Ajzen, 2010; pg. 100-101). The researcher is recommended to inquire about:

1) The advantages and disadvantages of engaging in the behavior.

---

[12] Healey (2002) describes the activities underpinning the "implementation" of land use plans, and comments that implementation should not be confused with the "traditional conception of a plan as a spatial blueprint, which would steadily be translated into built form on the ground" (pg. 102).

[13] For example, consider the Honkasuo neighborhood project (HEL, 2012), where the master plan was approved in 2011, but the project remains unfinished.

> 2) The individuals or groups who would approve or disapprove of the respondent engaging in behavior.
>
> 3) The factors that would hinder or enable engaging in the behavior.

When applying the theory to study a population (rather than an individual), *modal* salient beliefs are elicited. These are collected by interviewing various representatives of the target population to determining which beliefs are most frequently held. A content analysis of interviews is recommended as the best way to establish modal salient beliefs. (Fishbein and Ajzen, 2010: pg. 102-103). This dissertation research followed the recommendation and conducted semi-structured interviews to elicit modal salient beliefs. An interview guide was developed for collecting the data. Because the interview guide formed part of a broader master's thesis research project (Franzini, 2018), the guide referenced questions recommended by Fishbein and Ajzen's (2010) template questionnaire alongside non-theoretical questions. A total of eight questions were included in the interview guide (see: Supplementary Info 1). Questions 2 and 4 closely follow Fishbein and Ajzen's (2010) suggestions for eliciting outcome beliefs and normative referents. The guide states:

> *2) What do you as an individual see as the advantages and disadvantages of using wood materials in wooden multistory construction?"*
>
> *4) What actors weigh in on the decisions for or against using wood as a material in wooden multistory construction?"*

The interview guide omitted a direct question for ascertaining control factors. Nevertheless, determining which resources limit and enable the implementation of wooden multistory buildings was possible due to the additional interview questions. On the other hand, the inclusion of the additional questions can result in the inadvertent collection of non-salient beliefs. This presents only a minor issue, as operationalizing non-salient belief items on a survey only affects whether the measure will hold a significant correlation to the direct measurement item (e.g., belief outcome measurement correlation to attitude measurement). When belief measures do not correlate with their corresponding direct measurement, they are simply excluded from further analysis.

3.3.1.4 Population sample

The elicitation study targeted 11 municipal civil servants from mainland Finland. These key informants were representatives from six municipalities. The professional roles included a variety of high-level duties associated with land use planning and decision making. Each interview lasted approximately 60 minutes. Interview details are provided in Table 1. Details about the municipalities are provided in Table 2.

Table 1 – Interviewees by their professional role and interview length.

Interview	Interview length	Role in municipality
1	69	Project manager, Architect
2	51	City development, Director
3	55	Master designer, Architect
4	50	Mayor
5	20	Senior architect
6	52	Regional architect
7	64	City planning, Director
8	66	Senior architect
9	59	Land use and development expert
10	51	City development, Director
11	63	City planning, Director

Table 2 – Municipalities represented by interviewees.

Municipality	2017 Population	% of total population
Espoo	279,044	5.06%
Helsinki	643,272	11.67%
Rauma	39,620	0.72%
Seinäjoki	62,676	1.14%
Turku	189,669	3.44%
Uusikaupunki	15,752	0.29%

3.3.1.5 Constructing modal salient beliefs

The elicitation study applied Schreier's (2012) method for qualitative content analysis to construct the modal salient beliefs. Schreier's qualitative content analysis is a method of content analysis that subsumes data into categories through the development of a coding frame. The coding frame is then applied systematically across all the data to quantify the number of frequencies each category within the coding frame comes up. This approach was applied to reveal the most frequently mentioned (i.e., modal) outcome beliefs, normative referents, and control factors across the 11 interviews (see: Supplementary Info 2).

3.3.2 Survey study

The main study sets out to design, test, and deploy the theory of planned behavior questionnaire. The purpose of the questionnaire is to measure each of the seven constructs of the theory (behavioral beliefs, normative beliefs, control beliefs, attitude, subjective norms, perceived behavioral control, and intention). Recall that while all constructs were measured in the survey, the dissertation research only analyzes data from behavioral beliefs and attitudes.

3.3.2.1 Preparing the questionnaire

According to Fishbein and Ajzen (2010), the first step in preparing the questionnaire was designing the measurement scales for attitude, subjective norm, perceived behavioral control, and intention. The recommendation is using a minimum of three items to measure each

construct. Attitudes is recommended to be measured with 7-point semantic differential scales[14] (Chapter 3), and subjective norm and perceived behavioral control with a 7-point Likert[15] scale (Chapter 4, 5). The use of unipolar versus bipolar scoring is contested, wherein some measurement includes strict recommendations for scoring and others are more flexible (see: Ajzen, 1991).

This research used 5-point bipolar semantic differential scales to measure attitude. Subjective norms and perceived behavioral control were measured using a 5-point bipolar Likert scale. For these measures, the neutral option was omitted and a "don't know" choice was presented at the end of the scale to reduce central tendency bias[16]. Exceptionally, intention was measured as a binary "yes/no" question rather than through a Likert scale. It appeared confusing to apply a 5-point probabilistic scale for measuring behavioral intention of an organization (e.g., "*my municipality intends to implement wooden multistory buildings*" strongly agree/agree/don't know/disagree/strongly disagree). Instead, a binary option was presented (i.e., "*my municipality is planning to build wooden multistory buildings in the next five years*" yes/no/don't know).

Belief-based measures are weighted scales designed by using the modal salient beliefs collected from the elicitation study. As per the theory, each modal salient belief is operationalized as a composite between two separate measurement items (usually a "strength" measure of how strongly the respondents hold the belief and an "evaluative" measure). The "strength" measures deployed 5-point bipolar scales. The evaluations measures deployed 4-point unipolar scales. The responses to these two measures are combined through multiplication to form the salient belief composite (see: Ajzen, 1991). To facilitate reader ease in the following section, the belief constructs, the salient beliefs, and the composite measurements are referred to alongside a shorthand acronym.

Behavioral beliefs (b_ie_i) were developed according to the salient behavioral outcomes (i) derived from the elicitation study. For each behavioral outcome (i), there was one item measuring the strength of the behavioral belief outcome (b_i), coupled with one item for measuring the evaluation of said outcome (e_i). In line with the theory, the responses to these measurement pairs are combined in a multiplicative fashion to form the behavioral belief (b_ie_i) for each salient behavioral outcome. In this study, 16 behavioral outcomes ($i_{n=1\text{-}16}$) were derived from the elicitation study. The items measuring the strength of the behavioral belief outcome (b_i) asked participants to rate various outcomes (i) of implementing wooden multistory buildings relative to implementing concrete multistory buildings in their municipality (individual belief). The question assessing the outcome evaluations (e_i) asked the respondent how influential these outcomes (i) were for the municipality's implementation of multistory buildings of any kind (organizational evaluation). In this way, the composite weights the individual belief about the outcomes of these buildings against the organization's evaluation of the outcome.

Normative beliefs (n_jm_j) were developed according to the normative referents (j) derived from the elicitation study. For each normative referent (j), there is one item measuring the belief of the referent's approval of the behavior (n_j), coupled with one item for measuring the individual's motivation to comply with the referent (m_j). The product of the two measurements forms the normative belief measure (n_jm_j) for each salient normative referent.

---

[14] For more information on semantic differential scales, see Osgood et al. (1957).
[15] For more information on Likert scales, see Lavrakas (2008: pg. 428-429).
[16] For more information about neutral response options in measurement scales, see Bishop (1987).

12 normative referents ($j_{n=1-12}$) were derived from the elicitation study. The question measuring referents' approval of the behavior (n_j) asked the respondent what they believe referents (j) think about implementing wooden multistory buildings in the municipality (individual belief). The questions assessing motivation to comply (m) measure the degree of influence the referent (j) has over the municipality's decision to implement wooden multistory buildings (organizational evaluation). In this way, the composite weights the individual's belief about the normative referent's opinion of these buildings against the organization's evaluation of the referents.

As with the process for the other two belief constructs, control beliefs (c_kp_k) were developed according to the control factors (k) derived from the elicitation study. 13 control factors were derived from the elicitation study ($k_{n=1-12}$). For each control factor (k), there was one item measuring the belief that the control factor (k) will be present (c_k), coupled with one item measuring the power of the control factor (k) to facilitate the behavior (p_k). The product of the two measurements forms the control belief measure (c_kp_k). In this way, the composite weights the individual belief about control factors being present, against the organization's evaluation of the control factors.

The last step in the survey design was to draft additional questions. Ordinarily, this includes exogenous factors, like demographical data or other background questions deemed suitable for the study. Table 3 provides a breakdown of the total number of measurement items used for each construct and the total number of background questions in the survey. The entire questionnaire is provided in the Supplementary Information (S4).

Table 3 – Overview of measurement items for survey constructs.

Constructs	Scale	Scoring	Polarity	Items
Attitude (ATT)	Semantic differential	5- point	bipolar	7
Subjective norm (SN)	Likert	5-point	bipolar	2
Perceived behavioral control (PBC)	Likert	5-point	bipolar	2
Intention (INT)	Binary	2-point	binary	1
Behavioral belief strength (b_i)	Likert	5-point	bipolar	16
Outcome evaluation (e_i)	Ordered-category rating	4-point	unipolar	16
Normative belief strength (n_j)	Ordered-category rating	5-point	bipolar	12
Motivation to comply (m_j)	Ordered-category rating	4-point	unipolar	12
Control belief strength (c_k)	Likert	5-point	bipolar	12
Power of control (p_k)	Ordered-category rating	5-point	bipolar	12
Additional questions	--	--	--	19
			Total	111

3.3.2.2 Evaluating, translating, and finalizing the questionnaire

Preliminary survey questions were evaluated by pilot testing. The first set of pilot tests occurred after the belief measures were developed. The paper questionnaire was evaluated in English by three municipal civil servants representing municipalities with a population size of less than 5,000 residents as the elicitation study only included interviews with informants working for larger municipalities. Therefore, it was important to confirm that the modal salient beliefs were representative of employees of smaller municipalities. After the evaluations, the survey was translated from English into Finnish. The translation was done by a native Finnish-English expert in the field of architecture. Translations were corroborated by native Finnish speaking colleagues at the University. A second set of evaluations occurred after the survey was translated into Finnish to ensure pilot testers understood the survey questions and key terminology similarly. The questionnaire was evaluated on paper in Finnish by three municipal civil servants, although discussions were held in English. The survey was then uploaded to the University of Helsinki's online survey platform (*E-lomake*). A final quality check was arranged with two municipal civil servants to ensure respondents could easily navigate the online survey platform and that the survey length was not overly cumbersome (i.e., less than 20 minutes).

3.3.2.3 Deploying the questionnaire

Determining suitable candidates for survey participation required manually collecting records of public municipal employees because Finland does not possess a free, publicly accessible register of civil servants employed by municipalities. Candidate information was collected from the online webpages of each municipality (296 municipalities in 2019). Candidates were selected through personal discretion. If the employee's job title could fulfill a task related to land use planning or decision making, then the employee was added to the e-mailing list. This included tasks associated with high level strategic management (e.g., mayors, development officers), zoning (e.g., architects, planners, zoning officers, environmental planners), property management (e.g., real estate managers, city housing managers), and construction supervision (e.g., building inspection). Ultimately, the reconnaissance of the 296 municipal webpages resulted in a mailing list of 3,537 individuals. At least one representative from each municipality in mainland Finland was included in the mailing list. The survey was distributed via e-mailed on November 25, 2019, along with a letter of intention outlining the purpose of the survey (see: Supplementary Information 3). One additional reminder e-mail was sent on December 12, 2019. The survey was available until December 17, 2019.

3.3.2.4 Population Sample

A total of 283 surveys were collected. Duplicate surveys, blank surveys, and surveys missing more than 15% of multiple-choice responses were omitted from analysis. Afterwards, 273 usable surveys remained, constituting an 8% response rate. 136 municipalities were represented in the sample, constituting 46% of all municipalities targeted in mainland Finland (n=296). A demographic breakdown of the respondents is provided in Table 4. Regional distribution is provided in Table 5. Note that to preserve respondent anonymity, information on individual municipalities is not provided and is instead coarsened by region.

Table 4 – Respondent demographics (n=273). Percentages rounded to the nearest whole.

Gender	n	%	Age	n	%	Profession in municipality	n	%
Female	98	*36%*	18-29	11	*4%*	Tasks related to planning	98	*36%*
Male	165	*60%*	30-39	45	*16%*	Tasks related to property management	28	*10%*
Missing	10	*4%*	40-49	53	*19%*	Tasks related to building supervision	48	*18%*
			50-59	88	*32%*	Strategic tasks of senior management	41	*15%*
			60-69	50	*18%*	Other	42	*15%*
			Missing			Did not respond	16	*6%*

Table 5 – Outreach by regional distribution.

Region in Finland	*n* emailed[a]	% emailed[b]	*n* responses[c]	% responded[d]
Etelä-Karjala	70	2.1%	2	0.7%
Etelä-Pohjanmaa	167	5.1%	12	4.4%
Etelä-Savo	107	3.3%	6	2.2%
Kainuu	59	1.8%	6	2.2%
Kanta-Häme	132	4.0%	6	2.2%
Keski-Pohjanmaa	107	3.3%	5	1.8%
Keski-Suomi	218	6.7%	14	5.1%
Kymenlaakso	99	3.0%	8	2.9%
Lappi	141	4.3%	5	1.8%
Päijät-Häme	134	4.1%	12	4.4%
Pirkanmaa	279	8.5%	27	9.9%
Pohjanmaa	158	4.8%	2	0.7%
Pohjois-Karjala	131	4.0%	11	4.0%
Pohjois-Pohjanmaa	312	9.5%	27	9.9%
Pohjois-Savo	150	4.6%	6	2.2%
Satakunta	170	5.2%	6	2.2%
Uusimaa	594	18.2%	67	24.5%
Varsinais-Suomi	240	7.3%	25	9.2%
Missing	*NA*	*NA*	*26*	*10%*
Total	**3268**		**273**	

[a] denotes total number of individuals e-mailed in region.
[b] denotes individuals e-mailed per region over the total number of individuals e-mailed.
[c] denotes responses per region.
[d] denotes responses per region over the total number of responses collected.

3.3.2.5 Limitations and suggested improvements to the measurement tool

Given the research context for applying the theory, limitations were discovered with the development and deployment of the survey. To improve response rates and reduce respondent burden, the length of the survey was kept under 20 minutes (see: Lavrakas, 2008: pg. 659-670). As a tradeoff, survey length was decreased by deploying fewer than three items to measure subjective norms (n=2), perceived behavioral control (n=2), and intention (n=1). It is challenging to validate whether these measures are appropriate indicators of the underlying constructs (see: construct validity, Cronbach and Meehl, 1955). The omission of

a pilot survey during the elicitation study further restricted the possibility to assess whether these direct measures were reliable. Furthermore, because belief measures are verified according to their correlation with their respective formative construct, belief measures may show inconsistent correlations to their respective direct measurement construct if the direct measure is an inappropriate indicator of the underlying construct. I would recommend deploying *at least* four items to measure each dimension of the theory (attitude, subjective norm, perceived behavioral control and intention), ideally more, if a pilot survey is not used in the elicitation study.

In a similar vein, the principles of compatibility were at times more loosely followed than the exemplary survey questions provided by Fishbein and Ajzen (2010), where the same target, context, action, and time is applied using consistent word order for each question. In this survey, word order required modifications. This was partially a result of applying the theory to an organizational level behavior, and thereby needing to create questions that captured both individual level items and organizational level items. The translation of the survey into Finnish also resulted in challenges towards maintaining compatibility and strict word order. In surveys that require translations, I would recommend a pilot test of the survey with at least 25 respondents to allow pseudo-testing of the constructs (e.g., to ensure successful creation of belief composites and successful testing of the formative and reflective measures).

While survey evaluations were conducted to ensure that the target group held a similar understanding of the questions, the evaluations did not test whether the measurement scales were optimal. The choice to employ 5-point scales versus 7-point scales was based on reducing survey annoyance. On the other hand, research suggests that the use of 5- to 7- point scales is adequate for ordinal measures (Lavrakas, 2008: pg. 428-429). I would recommend following Fishbein and Ajzen's (2010) measures of 7-point scales. Furthermore, I provide two additional points of caution. First, use either a 5- or 7-point scale, but not both. This ensures the belief composites are all the same range after being weighted together. Second, ensure that all reflective and formative items are *at least* 5 points in scale, as binary items otherwise present a challenge for structural equation modeling.

When considering sampling error, a few points should be considered. First, assembling a target population e-mail list of participants from public web pages may introduce sampling error if contact information was not up to date or representatives were missing. Second, using personal discretion to collect the target population introduces sampling bias if representatives were inadvertently excluded or included and the e-mail list does not represent the target group. This limitation was lessened by the survey statement explaining the research aims and describing the intended target group (see: Supplementary Info 3: pg. 1). Third, the sampling technique constitutes convenience sampling. The intention was to deploy the survey to the entire target population of municipal civil servants responsible for land use planning and decision making, but survey participation was voluntary, and representativeness of the sample cannot be guaranteed or verified. This limitation is exacerbated by the lack of database information on active municipal employees. Nevertheless, respondents from certain regions are overrepresented and others are underrepresented (Table 5). In the same vein, representatives from larger municipalities are overrepresented. Lastly, the availability of a survey only in Finnish may have resulted in the unintentional exclusion of representatives from majority Swedish speaking municipalities within mainland Finland. This bias is potentially lessened by the consideration that by law all civil servants in Finland must have working knowledge of both Finnish and Swedish. To tackle issues of sampling bias, I would

encourage researchers to opt for reaching out to participants on an individual basis via phone call and request they participate in the survey, rather than opting for convenience sampling.

3.4 Ethical deliberations

Several ethical considerations were deliberated during this research. First was the anonymity and confidentiality of the interview and survey informants, given their role as civil servants. In Finland, civil servants are expected to function under a code of conduct (VM, 2021) that promotes impartiality (pg. 7). Previously, legal recourse was taken against zoning plans forcing wooden multistory construction on the grounds that this constituted material preferentialism and thereby contradicted EU import law (Päätokset, 2011). In short, concerns arose around whether zoning regulations constituted a breach of impartiality and "material neutrality" (i.e., not exhibiting preferentialism for construction materials). While the Supreme Court of Finland has ruled that such zoning regulations are legally acceptable (Päätokset, 2015), the topic of "material neutrality" is cited as a tension (e.g., see: Franzini, 2018: pg. 58-59; Riala and Ilola, 2014: pg. 371). The survey data was coarsened (see: Lavrakas, 2008: pg. 202-203) to remove respondent details that might serve as personal identifiers. For example, professional occupation and municipalities are never discussed simultaneously, ages are only disclosed in groups, municipal demographics are disclosed in groups, and municipalities are not compared at the individual level. All responses were anonymous, and no contact information or consent forms were collected. The survey's cover letter disclosed the purpose of the research and processing of coarsened data (see: Supplementary Info S3; S4: page 1). No sensitive personal information was requested in the survey. Regarding the storage of information, only the primary researcher had access to the raw data collected through *E-lomake*[17].

As a final point, 49% of municipalities in Finland are bilingual or Swedish speaking (Kuntaliitto, 2021). Finland officially recognizes both Finnish and Swedish as national languages, but the survey was only available in Finnish. This presents an ethical dilemma surrounding the status of Swedish as an official minority language in Finland. As all municipal administrative processes provide equal access to Finnish and Swedish, given the target group are municipal civil servants, it should hold that the survey be made available both in Swedish and Finnish.

[17] The guidelines and policies for *e-lomake* data storage are available online (HY, 2021).

4 SUMMARY OF THE ARTICLES

The following chapter summarizes the three original articles forming the dissertation research according to their materials, methods, and main findings. While all the studies are underpinned by the theory of planned behavior, each article analyzes a distinct set of theoretical constructs. Figure 5 illustrates the constructs applied to each article. Table 6 provides an overview of the articles.

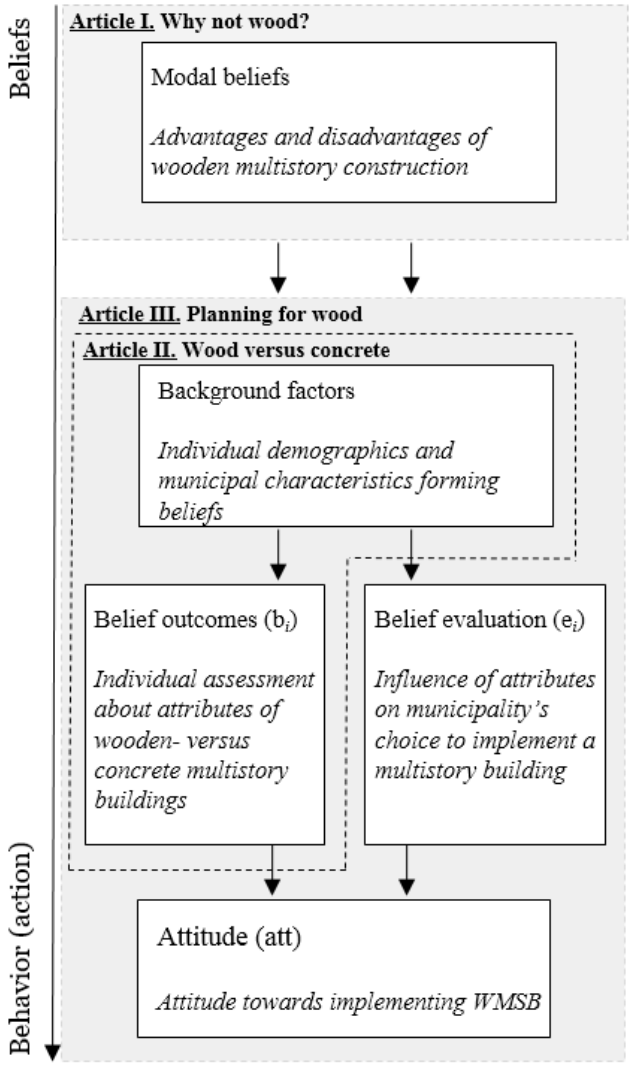

Figure 5 – Overview of the theoretical constructs analyzed across Articles I-III

Table 6 – Overview of the articles forming the dissertation research.

	Dissertation research question	Article research questions		Data collected	TPB construct analyzed	Data analysis method	Findings
Article I.	RQ1. What do municipal civil servants perceive as the barriers and drivers to wooden multistory construction?	1.1. What perceptions do municipal civil servants hold about wooden multistory construction?		11 interview transcriptions	Modal behavioral beliefs	Qualitative content analysis	WMC is seen to provide multiple benefits to society, the environment, and local economies. Yet, a challenging operating environment and resource shortages persist as barriers.
Article II.	RQ2. How do municipal civil servants compare wooden multistory buildings and concrete multistory buildings?	2.1. How do municipal civil servants compare attributes of wooden multistory buildings relative to concrete multistory buildings?	2.2. Do different backgrounds or experiences correlate to how attributes are perceived by the municipal civil servants?	273 survey responses	Behavioral belief outcomes	ANOVA	WMSBs are believed to possess larger environmental benefits and economic development opportunities, however, CMSBs are deemed more fire safe and cost effective. Profession was the largest exogenous factor shaping differences in beliefs.
Article III.	RQ3. Which ideologies influencing land use planning underpin acceptance for implementing wooden multistory buildings among municipal civil servants?	3.1. (H1) The behavioral beliefs civil servants hold about implementing WMSBs explain their attitudes towards implementing WMSBs.	3.2. (H2) Attitudes of municipal “planners” versus “non-planners” towards implementing WMSBs are formed by different beliefs.	273 survey responses	Behavioral beliefs (belief outcome x belief evaluation) and attitudes	Factor analysis; Structural equation modeling;	Behavioral beliefs about implementing WMSBs shaped attitudes about implementing WMSBs. Planner and non-planner attitudes were formed by different behavioral beliefs.

4.1 Article I: Why not wood?

Article I is a qualitative analysis of the data collected during the formative research associated with applying the theory of planned behavior (Chapter 3.3.1). To recap, the dataset consisted of 11 semi-structured interviews held with municipal civil servants employed to carry out various land use planning and decision-making tasks. Professionally, the key informants fulfilled high-level responsibilities, either technical (e.g., architects and planners) or managerial (e.g., mayors and development directors). Article I analyzes the behavioral beliefs held by the key informants, specifically, the perceived advantages and disadvantages of wooden multistory construction. Schreier's (2011) qualitative content analysis was used to identify and categorize recurring themes of discussion (i.e., behavioral beliefs) across the interview. Ultimately, advantages and disadvantages were understood as "benefits" and "barriers".

The benefits discussed across the interviews are heuristically described in Figure 6. Note the diagram subsumes all benefits discussed across interviews; thus, not all interviewees discussed every opinion presented in the diagram. Benefits were grouped according to four topics (i.e., "*economy*", "*lifestyle*", "*technology*", and "*environmental sustainability*"). These topics help to describe thematic content and discern the beneficiaries. The figure also conceptualizes interlinkages between benefits; a reminder that the outcomes of wooden multistory construction produce direct and indirect effects across society. To briefly recapitulate the four topics, the "*economy*" grouping typifies economic benefits that societal actors (particularly businesses and industries) gain through the implementation of wooden multistory construction projects. The "*lifestyle*" grouping represents the quality-of-life benefits that a citizen (e.g., residents and end-users) gains from living within, or nearby to, a wooden multistory building. The "*technology*" grouping exemplifies the benefits that builders and developers accrue from using wooden multistory construction building solutions in lieu of the business-as-usual concrete multistory building solutions. Finally, the "*environmental sustainability*" grouping captures the climatic and environmental benefits society gains from wooden multistory construction.

The barriers discussed across the interview are illustrated in Figure 7. The figure presents how barriers coalesce to result in the implementation of business-as-usual multistory projects (i.e., concrete frames). Essentially, interviewees maintained there was a perceptually poor operating environment for wooden multistory construction. The wooden multistory construction sector was seen to have developed slowly, in large part due to the strength of the concrete industries standardized building technologies, well-established position in the construction sector, and strong capacity to lobby. This proprietary market position was believed to hinder wooden multistory construction firms from entering the market and thus, in turn, limited the firms from expanding and gaining experience and resources to provide necessary services. In other words, the perceived shortage of skilled professionals and access to wood construction value chain actors (i.e., builders, developers, material suppliers) was described as challenging.

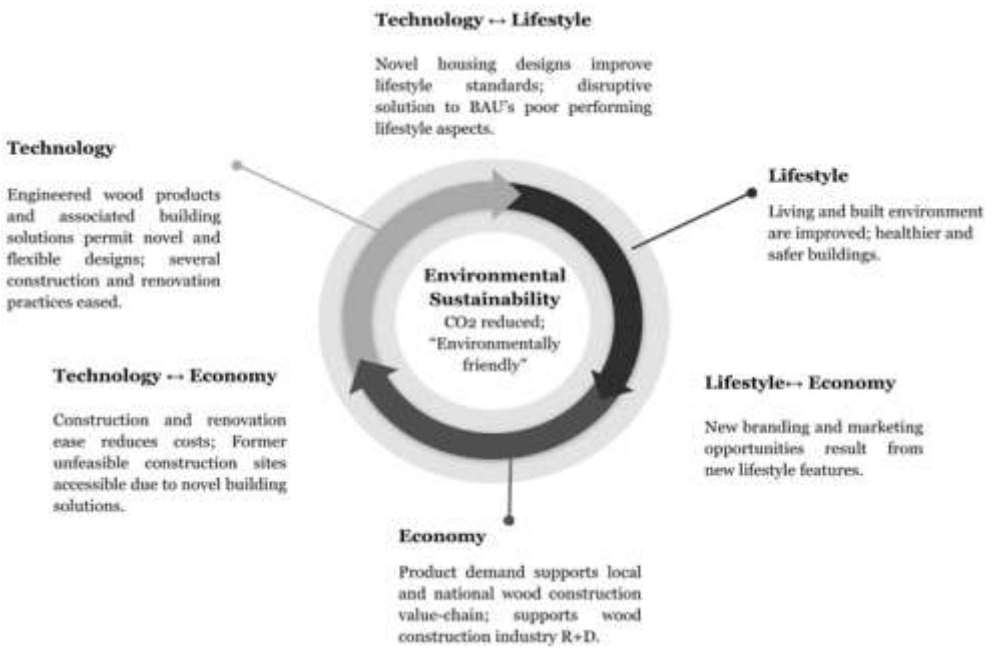

Figure 6 – The figure summarizes the perceived benefits of wooden multistory construction shared across interviews.

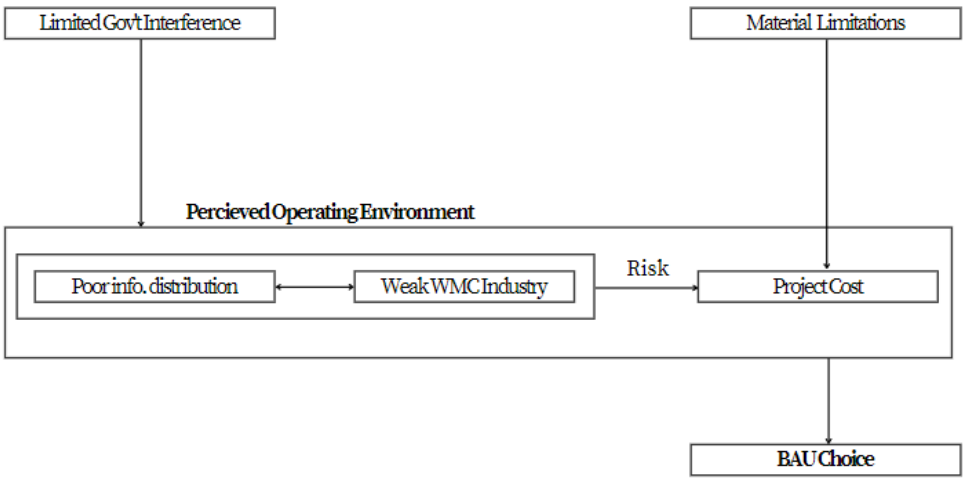

Figure 7 – Depiction of relationships between perceived barriers discussed by key respondents.

In addition, some respondents shared that they lacked knowledge about wooden multistory construction and almost all the interviewees described challenges with accessing information. This lack of knowledge occasionally led to uncertainties about how the technical aspects of wooden multistory buildings would perform in the future. To this end, the general concerns surrounding the perceived operating environment for wooden multistory construction translated as risky and cost culminated as a central gripe, especially the perceived uncertainty about cost. Thus, divesting from business-as-usual construction practices (i.e., concrete multistory buildings) appears especially perilous.

Apart from the uncertain operating environment, two especially critical factors exacerbated the situation. First, there were limitations associated with the wooden elements, such as design challenges and strict fire code regulations that translated into high(er) costs. Secondly, some interviewees disclosed limited support from the government towards dismantling barriers within the operating environment. At the local level, municipal political will was occasionally described to lack support for the development of wooden multistory construction. For example, it was cited that local political directives could more effectively push for wooden multistory construction, that municipal development strategies could aim to include wooden multistory construction, and that zoning plans could more frequently be used to enforce wooden multistory construction. Concomitantly, the national government was criticized for being only a weak supporter, especially because fire building code legislation was deemed too demanding (i.e., expensive) to favor realizing projects.

4.2 Article II: Wood versus concrete

Article II is a quantitative analysis of data collected during the main research associated with applying the theory of planned behavior (Chapter 3.3.2). To recap, the dataset consisted of 273 survey responses. Professionally, the respondents were employed to fulfilled various tasks related to planning, building inspection, real estate management, environmental inspection, and senior management roles. Article II explores the behavioral belief outcomes held by respondents, specifically, survey items asking respondents to compare various attributes of wooden multistory buildings relative to concrete multistory buildings. This narrowed the data analysis to 16 survey items measuring behavioral belief outcomes (b_i) and 9 background questions. Descriptive statistics was used to appraise statement responses. One-way analysis of variance (ANOVA), Levene's test, and Tukey's test were applied to test the relationships between the behavioral belief outcomes and background questions.

Descriptive statistics of the responses to the 16 attribute statements are presented in Table 7. Altogether the statements present various economic, social, environmental, and technical quality outcomes associated with implementing multistory buildings. The table shows all the environmental outcomes (i.e., "*More environmentally friendly*", "*Lower carbon dioxide* (CO_2) *emissions*", "*Easier to recycle*") were more highly regarded in wooden multistory buildings. The same is true for the economic development outcomes (i.e., "*Better for my municipality's brand*", "*A greater value-added product for domestic industries*", "*Contribute more to the economic value of the area*", "*Improve my municipality's economy*"). Both wooden- and concrete- multistory buildings were regarded as equally safe financial investments.

Table 7 – Attribute statements for the belief outcomes preceding the statements was the primer, "*What views do you have on the following statements? Compared to concrete apartment buildings, wooden apartment buildings are/have…*". Statements were evaluated on a 5-point Likert scale from -2 to 2.

Belief outcome (b_i) / attribute statement	Mean	Std. Dev.	t-score
More expensive to build[B]	-0.47	0.85	8.83
Less susceptible to fire	-0.40	0.78	-8.38
More expensive to maintain[B]	-0.22	0.79	4.42
Less susceptible to mold	-0.10	0.91	1.69[A]
Longer life cycle	0.01	0.81	0.23[A]
A financially safer investment	0.09	0.69	2.17
Easier to implement within reasonable schedule	0.29	0.90	5.20
Better for my municipality's economy	0.36	0.68	8.34
Less susceptible to poor indoor air	0.60	0.90	10.98
Contribute more to the economic value of the area	0.81	0.72	18.19
More beautiful	0.91	0.87	17.20
A greater value-added product for domestic industries	1.17	0.70	27.46
Easier to recycle	1.20	0.81	24.51
Better for my municipality's brand	1.26	0.66	31.39
Lower carbon dioxide emissions	1.28	0.72	29.03
More environmentally friendly	1.34	0.64	34.47

[A] Mean value does not show a large enough difference from a neutral value of zero.
[B] Measurement scales for statements were reverse coded to facilitate interpretation.

On the other hand, concrete multistory buildings are associated with lower project costs (i.e., "*less expensive to build*", "*less expensive to maintain*"). Statements about the technical qualities received mixed results. Some qualities were regarded more highly in wooden multistory buildings (i.e., "*Less susceptible to poor indoor air*", "*Easier to implement within reasonable schedule*"), and others more so in concrete multistory buildings (i.e., "*Less susceptible to fire*"). Both are perceived to be equally susceptible to mold and to possess equal life cycles. Lastly, the aesthetics of buildings (considered a social dimension in this research) are perceived as "*more beautiful*" in wooden multistory buildings.

The relationships between the attribute statements and background factors are presented in Table 8. Each background factor holds a significant relationship to at least one attribute, thereby showing that the different information collected through these background incidences do contribute differently to the formation of beliefs about wooden- and concrete-multistory buildings. Furthermore, background factors can be categorized into three groups: previous experiences (with multistory buildings), social environment, and demographics, each of which also play a role in the formation of beliefs. Note, 6 attribute statements did not have a statistically significant relationship to the background factors tested in this study.

While Article II details each significant relationship on a case-by-case basis, for the purpose of this dissertation, only one relationship per background factor group is reported. Looking at demographics, profession held a significant relationship to all the environmental outcome beliefs. Figure 8 depicts the emergent trend where the planner's group holds the highest mean values while the real estate manager's group and building inspector's group hold the lowest mean values. Nevertheless, all the mean values are positive across the professional groups. Looking at previous experiences, respondents who had previously worked on a wooden multistory construction project regarded the beauty and economic contribution of wooden multistory buildings less strongly than their peers. Figure 9 depicts

the group with previous working experience holding lower mean values. Note, however, the mean values were still positive between both groups. Lastly, looking at the social environment (i.e., organizational environment), respondents employed by the smallest municipalities (in terms of total population) were the group that, on average, most strongly believe that wooden multistory buildings are more beautiful and contribute more to the economic value of the area. The opposite is true of respondents from the largest municipalities. Figure 10 depicts the differences in mean values between the groups.

Table 8 – Adapted from Article II. ANOVA between attribute statements and exogenous factors. Black squares represent statistically significant ANOVA results that passed the Levene's test for homoscedasticity. White squares represent a non-significant ANOVA *or* lack of homoscedasticity.

Attribute statement (bi)	Previous WMSB work	Residential occupancy	Current tenure length	Municipal density	Municipal population	Profession	Educational degree	Gender	Age
Less susceptible to fire	□	□	■	□	□	□	■	□	■
Less susceptible to poor indoor air	□	□	□	□	□	■	■	□	□
Longer occupational lifecycle	□	□	□	□	□	■	■	■	□
Lower carbon dioxide emissions	□	□	□	□	□	■	□	□	□
Easier to recycle	■	□	□	□	□	■	□	□	□
More environmentally friendly	□	□	□	□	□	■	□	□	□
More beautiful	■	■	□	■	■	□	□	□	□
More expensive to maintain	□	□	■	□	□	□	□	□	□
Contribute more to economic value of area	■	□	□	■	■	□	□	□	□
Better for my municipalities brand	□	■	□	□	□	□	□	■	□

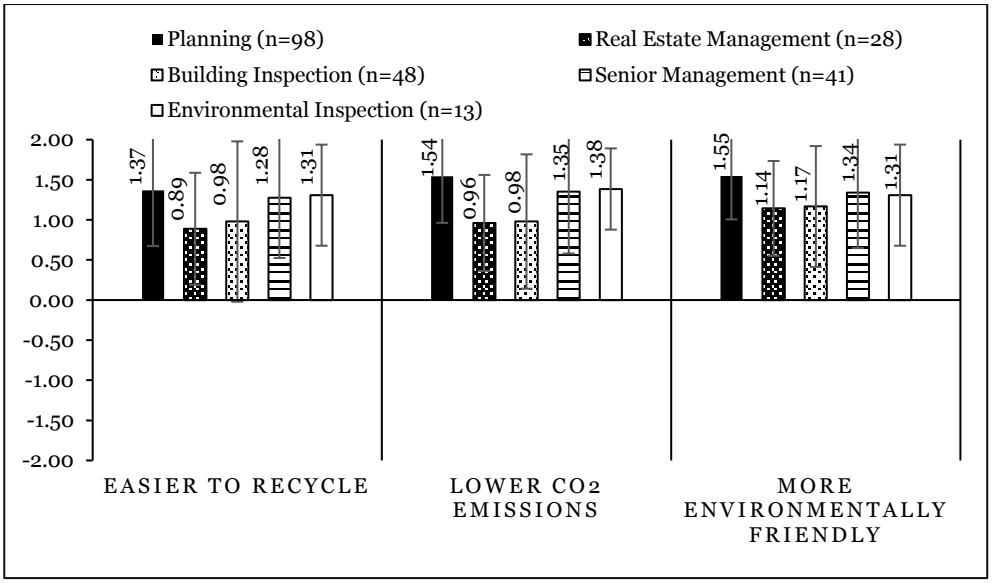

Figure 8 – Between-group comparison of mean values for three of the five attribute statements significantly associated with the background factor “profession”. Response scale was from −2 to 2 (strongly disagree / disagree / the same / agree / strongly agree).

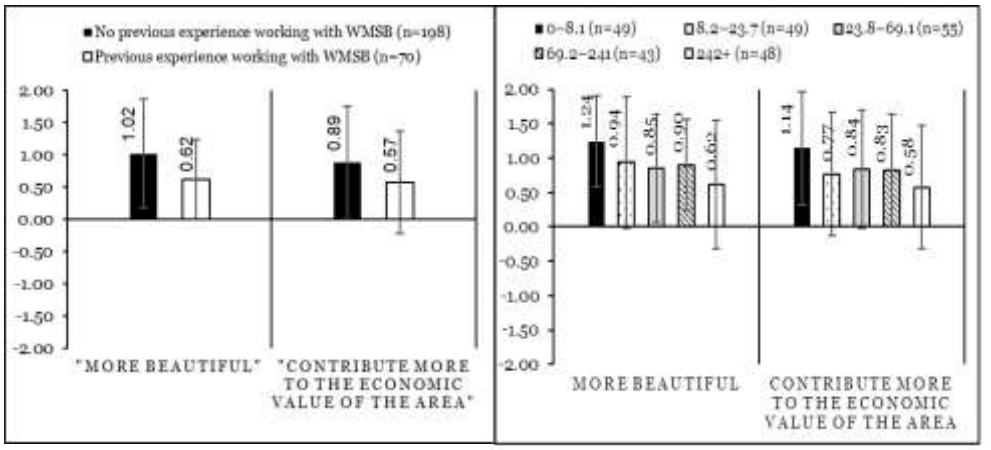

Figure 9 (left) – Between-group comparison of mean values for two of the three attribute statements significantly associated with the background factor “experience working with wood”. Response scale was from −2 to 2 (strongly disagree / disagree / the same / agree / strongly agree).

Figure 10 (right)– Between-group comparison of mean values for three of the five attribute statements significantly associated with the background factor “municipal population”. Response scale was from −2 to 2 (strongly disagree / disagree / the same / agree / strongly agree).

4.3 Article III: Planning for wood

Article III is a quantitative analysis of data collected during the main research associated with applying the theory of planned behavior (Chapter 3.3.2). To recap, the dataset consisted of 273 survey responses. For the purpose of this study, respondents were parsed into two professional categories (i.e., "planners" and "non-planners") based on their self-identified professional role in the municipality (i.e., planners, real estate management, building inspection, strategic tasks of senior management, or other). The 98 respondents who self-identified as being responsible primarily for planning tasks were categorized as "planners". All remaining 175 respondents were categorized as "non-planners". Those who did not disclose a professional group were also categorized as "non-planners". It was not possible to parse non-planners into smaller homogenous groups due to the nature of statistical test employed. On the other hand, this was not an issue as the major hypothesis in this paper was that planners hold different land use planning values than their peers.

Article III analyzes the attitudes and behavioral beliefs held by respondents. There are two research hypotheses. The first hypothesis is that the beliefs municipal civil servants hold about the outcomes of implementing wooden multistory buildings explain their attitudes towards wooden multistory buildings being implemented in their municipality. The second hypothesis is that the attitudes of planners and non-planners will be formed based on a different set of beliefs. To test the first hypothesis, structural equation modeling was applied to confirm that behavioral beliefs form attitudes across the whole population group. To test the second hypothesis, a belief-attitude model was applied to the two professional subgroups, "planners" and "non-planners". This testing required analyzing the 7 semantic differential statement items measuring attitudes (A_i) and the 16 behavioral belief composites (b_ie_i). To recap, creating the behavioral belief composites (b_ie_i) entails multiplying the behavioral belief outcomes item (b_i) to the corresponding belief evaluations item (e_i) (see: Chapter 3.3.2).

A two-step procedure was used to build the structural equation model. In the first step, the behavioral belief composites were subject to exploratory factor analysis to assess the underlying structure of the beliefs and reduce the large number of composites into belief typologies (i.e., factors, see e.g., Andow et al., 2017). The exploratory factor analysis utilized maximum likelihood and varimax rotation; composites with high cross-loadings on multiple factors were omitted from the analysis (Dawson, 2017). The final factor scores were saved for use in building the structural equation model. In the second step, the relationship between behavioral beliefs and attitudes was tested using a multiple indices multiple causes (MIMIC, see: Jöreskog and Goldberger, 1975) structural equation model. MIMIC models deploy formative and reflective indicators onto a latent construct and permit the assessment of construct validity (Posey et al., 2015). When applying the theory of planned behavior to structural equation modeling, belief measures are treated as the formative indicators, and direct measures are treated as the reflective indicators (Ajzen, 2020). In this case, the latent variable was attitude, the four factors from the exploratory factor analysis were the formative variables, and the semantic differential items were the reflective indicators. The model's goodness-of-fit was evaluated using root mean square of approximation (RMSEA, <.08), comparative fit index (CFI, >.90), and Tucker-Lewis index (TLI, >.90) (Brown, 2015). A multigroup comparison was applied to the whole sample and the two professional subgroups.

Responses to semantic differential statements measuring attitudes are presented in Table 9. Note that one items (A6) was omitted because it held low internal consistency (see: Supplementary Info 4: Page 2, Question 6). The mean scores indicate the entire group of

respondents, on average, were extremely receptive to the idea of wooden multistory buildings being implemented in their municipality. The final rotated factor matrix solution from the exploratory factor analysis is presented in Table 10. The 13 behavioral belief composites were typified into four factors dubbed, environmental beliefs, economic development beliefs, technical quality beliefs, and cost-related beliefs. These belief typologies form attitudes about implementing wooden multistory buildings. As these typologies are composed from sets of beliefs, they are discussed as ideologies (i.e., sets of beliefs). Table 11 presents the modeling results. The goodness of fit indices confirm that the models are acceptable.

Figures 11-13 illustrate the belief-attitude model. Following, they are explained in detail. Recall the standardized estimates convey how strongly a measurement relates to the latent variable (Attitude). The reflective indicators (attitude measures) are a proxy for measuring the latent variable. In figures 13-15, the reflective indicators are found on the right-hand side of the model and their relationship to the latent variable is depicted by the arrows pointing *away* from the latent variable. The standardized estimates of the reflective indicator are displayed above the arrow. These inform the reader how strongly interrelated the reflective indicators are. The formative indicator (ideology measures) are the underlying beliefs forming the latent variable. They are found on the left-hand side of the model and their relationship to the latent variable is depicted by arrows pointing *towards* the latent variable. The standardized estimate is displayed above the arrow. These inform the reader how strongly the formative measures form the latent variable. The higher the standardized estimate, the stronger the ideology's role in forming attitude.

The whole population model (Fig. 11) shows that attitudes are primarily formed by economic development beliefs (e.g., if the buildings increase land value, improve the municipalities economy, etc., see: Table 10). Then, the technical qualities, environmental performance, and cost related outcomes of the buildings (respectively). In the planner sub-model (Fig. 12), planner attitudes are primarily formed by the building's technical qualities, and then equally by environmental and economic development outcomes, respectively. Cost-related beliefs did not play a role in forming attitudes, as they were not statistically significant. In the non-planner model (Fig. 13), attitudes were formed predominantly by economic development outcomes, then by technical qualities, and almost insignificantly by cost-related outcomes and environmental outcomes, respectively. This comparison between the professional subgroup model confirmed the hypothesis that the attitudes of planners and non-planners are formed by different ideologies.

Table 9 – Statements were rated from -2 to 2. The primer questions, asked, "If wooden multistory buildings were implemented in my municipality, I would think that it is…"

Item	Symantec Differential	Mean	S.Dev.	n	Cronbach's Alpha
A1	Bad - Good	1.57	0.64	293	0.875
A2	Unreasonable - Reasonable	1.23	0.83	293	
A3	Negative - Positive	1.5	0.61	293	
A4	Dangerous - Safe	0.75	0.76	293	
A5	Foolish - Sensible	1.09	0.72	293	
A7	Worthless - Worthwhile	0.99	0.72	293	

Table 10 – Rotated factor matrix presenting the four-factor solution and factor scores for 13 behavioral belief items; extracted using maximum likelihood with varimax rotation.

Behavioral belief item	Factor 1	Factor 2	Factor 3	Factor 4
Environmental Beliefs				
Environmentally friendly	**0.823**	0.169	0.179	0.141
CO_2 Emissions	**0.786**	0.131	0.122	0.041
Recyclability	**0.612**	0.215	0.081	0.175
Economic Development Beliefs				
Land value	0.200	**0.693**	0.177	-0.052
Municipality's economy	0.203	**0.637**	0.025	0.110
Investment safety	0.071	**0.614**	0.215	0.156
Value-added (bioeconomy) product	0.463	**0.511**	0.003	0.133
Technical Quality Beliefs				
Susceptibility to mold	0.063	0.063	**0.673**	0.122
Indoor air quality	0.287	0.219	**0.585**	0.097
Building's lifecycle	0.027	0.362	**0.427**	0.298
Cost Related Beliefs				
Cost to build	0.068	0.058	0.070	**0.651**
Project time schedule	0.298	0.165	0.137	**0.426**
Cost to maintain	0.097	0.042	0.334	**0.417**
Cronbach's Alpha	.818	.754	.650	.554

Table 11 – Standardized estimates (S.E.), goodness of fit indices, squared multiple correlation of whole population model and subpopulation models. ** indicates statistical significance (p<.01). * indicates statistical significance (p<.05).

	Whole group	Planners	Non-planners
S.E. Ideology measures			
Environmental Performance	0.22**	.22*	.17*
Economic development	0.39**	.20*	.48**
Technical qualities	0.31**	.30*	.29**
Cost-related	0.18**	*0.14*	.19*
S.E. Attitude measures			
Bad - Good	0.82**	.86**	.80**
Unreasonable - Reasonable	0.61**	.62**	.59**
Negative - Positive	0.82**	.78**	.83**
Dangerous - Safe	0.69**	.62**	.71**
Foolish - Sensible	0.71**	.64**	.73**
Worthless - Worthwhile	0.63**	.60**	.62**
Goodness-of-fit Indices			
CFI	0.945	0.982	0.935
RMSEA	0.070	0.034	0.079
TLI	0.093	0.977	0.918
n (population)	273	98	175
Squared multiple correlation			
Attitude	.326	.195	.426

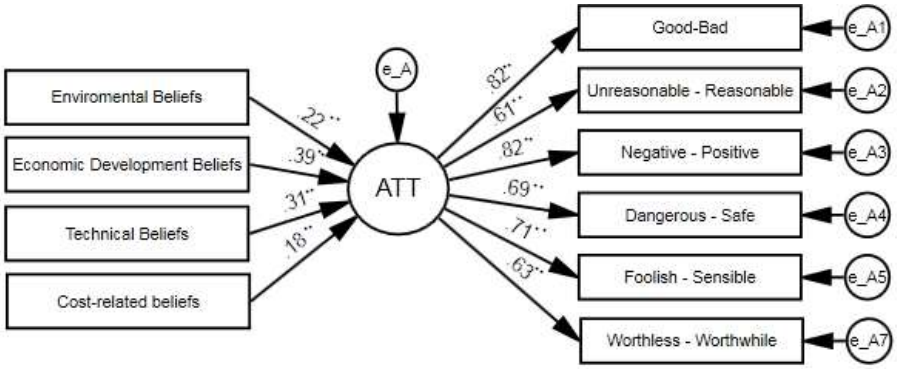

Figure 11 – Belief-attitude model for the full dataset (n=273). ** Denotes statistical significance (p<.01). * Denotes statistical significance (p<.05).

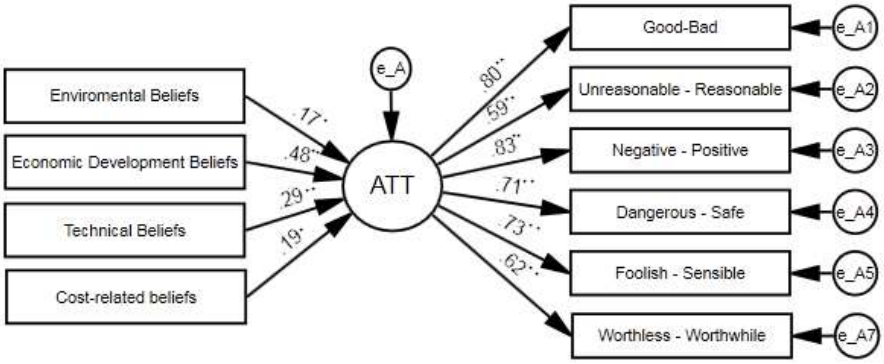

Figure 12 – Belief-attitude submodel for *non-planner* dataset (n=175). ** Denotes statistical significance (p<.01). * Denotes statistical significance (p<.05).

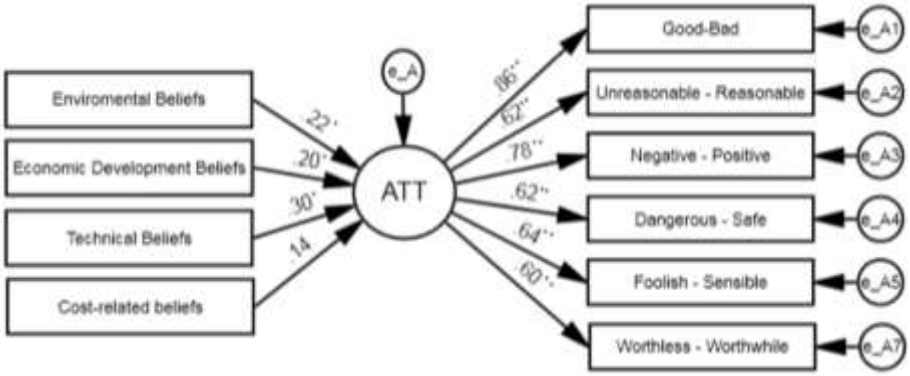

Figure 13 – Belief-attitude model for *planner* dataset (n=98). ** Denotes statistical significance (p<.01). * Denotes statistical significance (p<.05).

5 DISCUSSION

This chapter discusses three facets related to the state wooden multistory construction: the barriers and drivers to wooden multistory construction (RQ1), how attributes of wooden- and concrete- multistory buildings are compared (RQ2), and which ideologies (i.e., sets of beliefs) influencing land use planning priorities underpin attitudes towards implementing wooden multistory building (RQ3). In conjunction, I link the findings to broader aspects of technology innovation and the diffusion of wooden multistory construction, including lock-ins, tensions, legitimacy, and resistance. The chapter concludes with remarks about the limitations to the study.

5.1 Contributions and implications

5.1.1 Substudy 1

Article I contributes to the literature by providing the first account of how local public administrations responsible for land use planning view the advantages and disadvantages of wooden multistory construction. It answers the question **what do municipal civil servants perceive as the barriers and benefits to wooden multistory construction?** Prior to 2018, the literature on wooden multistory construction primarily relied on building industry professional as key informants (see: Gosselin et al., 2017). In Finland, these views were chiefly taken from architects and engineers (e.g., Riala and Ilola, 2014; Ruuska and Häkkinen, 2016; Toppinen et al., 2018a). It is only more recently that the literature has broadened to include perceptions also from wood construction firms (e.g., Toppinen et al., 2019a, 2020; Viholainen et al., 2021b), public sector policymakers (e.g., Vihemäki et al., 2019; Toivonen et al., 2021b) and end-users (e.g., Lähtinen et al., 2019b; Kylkilahti et al., 2020; Viholainen et al., 2020, 2021a; Karjalainen and Ilgin, 2021). Even views from municipal civil servants are now reaching the literature (e.g., Lähtinen et al., 2019a; Salmi et al., 2022). In this dissertation research, I argue that comparing the "advantages" and "disadvantages" levied against wooden multistory construction reveals that municipal civil servants consider serving the public interest as a responsibility of land use planning (Figure 7). On the other hand, the stated barriers reveal that fulfilling such objectives is constrained by shared rules and network interdependencies that bind municipalities and the broader sociotechnical regime into repeatedly selecting the incumbent construction practice, concrete multistory construction (Fig. 8).

When discussing the disadvantages of wooden multistory construction, the respondents narrated an aversion to engage with the projects due to risk and uncertainty. They regarded the regulatory environment (e.g., limited financing mechanisms, fire regulations) and operating environment (e.g., limited wood construction actor network, limited access to designers and builders) as barriers. A small fraction of the interviewees also found limitations with the technical qualities of the buildings (e.g., uncertainty about a buildings occupancy life, how facades will age, and the frame materials susceptible to moisture). The major bottleneck rested with how these barriers resulted in heftier project cost. In turn, the risk of higher cost led to (re)selection of incumbent multistory construction technologies (i.e., concrete multistory construction). Several studies have corroborated and commented

extensively on similar sets of barriers discussed by the key informants (see e.g., Aaltonen et al., 2021; Ruuska and Häkkinen, 2016; Hurmekoski et al., 2015, 2018; Lazarevic et al., 2020; Toppinen et al., 2018a, 2018b, 2019a, 2019b; Toivonen et al., 2021a; Vihemaki et al., 2019). Because this dissertation research is concerned with municipalities, I will not comment on these aforementioned barriers further. Instead, I would like to draw attention to the role of cost and network interdependencies in leading to strong lock-in mechanisms for the reproduction of incumbent construction practices.

Recall from Chapter 2.2.3 that land use planning in Finland is governed under new public management. This governance regime borrows from business management theory and emphasizes cost efficiency as a guiding principle (Pollitt and Bouckaert 2000). In Finland, this plays out as the need for efficient and expedient planning outcomes that restrain expenditures (e.g., Juntunen and Leinonen, 2007). Because the informants emphasized cost as a bottleneck constraining the implementation of wooden multistory construction, this reveals that cost is a constraining rule leading to lock in. Additionally, cost is perceived as a constraint by several other construction industry actors, for example developers, contractors, and wood building experts (e.g., Hemström et al., 2017; Toppinen et al., 2018a; Aaltonen et al., 2021). In other words, cost is a *sociotechnical regime rule* (Geels, 2002, 2004) that stabilizes the whole regime and causes resistance towards the uptake of novel technologies. In practice, this means both public and private developers will identify financial riskiness and costliness as undesirable, and thus neither party readily opts for wooden multistory construction. This aversion results in a feedback loop, where interviewees disclosed their aversion to wood construction due to high cost while acknowledging that the limited number of wooden multistory projects reduced opportunities to train a skilled workforce that could later drive down the cost of the projects.

In addition to rules that constrain behaviors, there are network interdependency between municipalities and developers compounding the lock-in. In a functional sense, municipalities rely on developers to deliver projects that will stimulate growth in the municipality. Meanwhile, developers rely on the municipalities to issue them building permits (Chapter 2.2.3). Interviewees presented two complex scenarios stemming from these interdependencies. First, when a smaller municipality hosts a design competition to procure a wooden multistory building, the incumbent construction sector will not place bids on the project because they can search for a bid in another municipality. In such circumstances, it appears as if the interdependency between municipalities and developers is more one-sided. Second, it was discussed that developers actively lobbied for building with concrete in scenarios where municipalities took initiatives to procure wooden multistory building projects (see also: Lähtinen et al., 2019). This lobbying is arguably a form of resistance where a incumbent actors attempts to suppress a novel innovation (see: Geels, 2004). Furthermore, it hints that the incumbent construction regime holds some degree of privileged relationship with municipalities that allows them to exercise this capacity so readily. As public-private partnerships are cited as one context under where such lobbying can occur (e.g., Mäntysalo and Saglie, 2011), perhaps this is a source of privilege. Ultimately, the (potentially) one-sided interdependency and resistance from developers exposes a complex flow of power between municipalities and developers.

When discussing the advantages of wooden multistory construction, the key informants were uniquely holistic. Advantages really came to denote “benefits”, where the beneficiaries included a broader set of actors than was typically discussed in the literature at the time (e.g., see: Gosselin et al., 2017). Residents, end-users, and even the municipalities themselves were perceived as beneficiaries of wooden multistory construction. This holistic view is

understandable if these key informants are guided by the National Building and Land Use Act (132/1999) objective to "*create preconditions for a favorable living environment and promote ecologically, economically, socially and culturally sustainable development*" (Section 1). Thus, the interviewees shared their views on how wooden multistory construction fulfills these aims. These holistic benefits expose a tension between municipalities and the construction industries. Where municipalities saw wooden multistory construction as a means improve the lifestyle of citizens beyond current market standards (see: Figure 4, lifestyle and technology grouping), the construction industry is typically described as having limited interest to incorporating end-users into their value-chains (Riala and Ilolla, 2014; Toppinen et al., 2019a; Viholainen et al., 2020b). If tensions represent windows of opportunity where wider technological diffusion is achievable (Geels, 2002: pg. 1262), then the holistic views of these municipal civil servants could serve as are a reminder to (wood) construction businesses that wooden multistory construction has values outside traditional key strategic aspect (e.g., maintaining cost-competitiveness). There is an opportunity to improve the lifestyle of end-users through wooden multistory construction. Harnessing these benefits may require re-conceptualizing wooden construction businesses models to better incorporate end-users (see: Brege et al., 2014; Toppinen et al., 2018b; Viholainen, 2020b). Considering that a strong wood construction actor-network has yet to develop in Finland (Lazarevic et al., 2020), such reconceptualization should be possible because the structuration of activities is less developed among these actors (Geels, 2004).

5.1.2 Substudy 2

Article II answers the question **how do municipal civil servants compare implementing wooden multistory buildings against concrete multistory buildings?** In doing so, it provides the first quantitative empirical study on perceptions comparing wooden– and concrete– multistory buildings in Finland. While there are a growing number of studies providing perceptions about wood as a construction material (e.g., Bysheim and Nyrud, 2009; Roos et al., 2010; Høibø et al., 2015; Gosselin et al., 2017; Viļuma and Bratuškins, 2017; Conroy et al., 2019; Markström et al., 2019), only a handful actively compare between wooden– and concrete– multistory buildings (e.g., Hemström et al., 2011; Larasatie et al., 2018). In addition, Article II contributes as a benchmark study measuring perceptions among municipal civil servants in Finland. In this dissertation research, I argue these stated preferences partially reveal how legitimately municipal civil servants view wooden multistory construction. Legitimacy stems partially from how desirably a technology is viewed (Geels and Verhees, 2011) and this legitimacy functions as an important source for enabling wooden multistory construction diffusion (see: Lazarevic et al., 2020).

Article II corroborated several perceptions about wooden multistory construction found across the literature. For example, in line with previous research, the respondents believed wooden multistory buildings have more positive environmental impacts, are faster to construct, and are more beautiful (e.g., Bysheim and Nyrud, 2009; Hemström et al., 2011; Gosselin et al., 2017; Markström et al., 2019; Larasatie et al., 2018). Meanwhile concrete multistory buildings were, on average, seen to be more fire safe than wooden multistory buildings (also, Hemström et al., 2011). Opposite to some previous findings, respondents, on average, believed that the lifecycle between concrete- and wooden multistory buildings were mostly the same (Wang et al., 2014). The respondents also saw both concrete– and wooden– multistory buildings to be equally susceptibility to mold. This is in contrast with literature

from Sweden suggesting mold is a concern during the selection process of engineered wood products used in construction (Markström et al., 2019).

Unique to the context of Finland, Article II clarified views on several barriers and benefits cited by key informants in Article I. Where key informants discussed apprehension towards mold, Article II revealed that, on average, civil servants see both buildings to be equally susceptible to mold. On the other hand, the findings show that wooden multistory buildings are seen as more expensive to build, more expensive to maintain, and more susceptible to fire. This confirms several apprehensions and barriers discussed during Article I. Lastly, when considering benefits, the findings evidence overwhelming agreement about the environmentally friendly and low-CO_2 aspects of wooden multistory buildings. This was vital information given the limited number of discussions regarding environmental sustainability during Article I. Furthermore, the survey responses revealed large agreement over wooden multistory buildings being a greater value-added product for domestic industries, a larger contributor to the economic value of the area, and being better for a municipality's brand. These statements communicate that these buildings are linked to improving economic development within a municipality. Hynynen (2016) was first to suggest wooden multistory construction would be considered an attractive proposition for municipalities seeking to find a new source of revenue investments. The survey findings suggest respondents may agree *if* municipalities are attempting to attract investments by improving their municipality's brand through wood.

Apart from measuring how wooden– and concrete– multistory buildings are compared, Article II also found exogenous factors linked to differences in responses between respondent groups. According to theory of planned behavior, exogenous factors identify experiences leading to the formation of divergent beliefs (Fishbein and Ajzen, 2010: Chapter 7). I would especially like to draw attention to the civil servant's professional role because this factor was linked to 5 of the 16 beliefs statements. For example, real estate managers and building inspectors were, on average, far less strongly convinced that wooden multistory buildings outperformed concrete multistory buildings regarding environmental attributes and technical attributes. Meanwhile, planners appeared more convinced than their peers about the superiority of the environmental attributes. These divergent perceptions among occupational groups indicates they assess the qualities of multistory buildings differently**.** With regards to how this impacts the diffusion of wooden multistory construction, it is possible that certain occupational groups are predisposed to view qualities of wooden multistory construction with more legitimacy. Yet, I also argue that for municipal civil servants, the legitimacy of wooden multistory construction rests not only with their being a general set of positively perceived attributes, but also with whether those attributes fulfil the civil servant's land use planning priorities. This is because legitimacy is not bounded only by desirability, but also by appropriateness to a socially constructed system of values (see: Geels, 2011). For municipal civil servants, wooden multistory construction must also be deemed appropriate to fulfilling land use planning priorities (i.e., the system of values for land use planning in Finland). While Article II cannot outright address what these land use planning priorities might be, Article III is in a better position to do so.

5.1.3 Substudy 3

Article III answered the question, which ideologies (i.e., sets of beliefs) influencing land use planning priorities underpin a municipal civil servant's attitudes towards implementing wooden multistory buildings? In answering this question, Article III links research on the

uptake of wooden multistory construction to research on land use planning practices in Finland. No literature fully develops this relationship, although the relationship is recognized in the literature (e.g., Hynynen, 2016; Lähtinen et al., 2019b, Salmi et al., 2022). Where research on wooden multistory construction has identified drivers behind why government institutions enable wooden multistory construction (e.g., Vihemäki et al., 2019; Lazarevic et al., 2020; Toivonen et al., 2021b), this remains separate from literature researching how the state's transformation and rescaling drives Finnish land use planning practices (e.g., Mäntysalo et al., 2011; Hytönen, 2016; Hytönen and Ahlqvist, 2019). This article combines these various research streams to showcase how attitudes towards implementing wooden multistory building projects form according to different land use planning priorities. Thus, the article creates new understanding about how the governance rules guiding actions in the municipality impacts attitudes towards implementing wooden multistory buildings. In this dissertation research, I argue wooden multistory construction aggravates land use planning tensions and that this might be a source of laggard adoption.

The article tested and confirmed a belief-attitude model postulating that ideologies (i.e., sets of beliefs) about the outcomes of implementing wooden multistory buildings form attitudes towards implementing these buildings. To recapitulate, the ideologies were linked to 1) *economic development* (i.e., improves municipal economies, supports local bioeconomy and wood industry, safe financial investment, improves land area); 2) *technical qualities* (i.e., indoor air quality, susceptibility to mold, lifecycle of building); 3) *environmental performance* (i.e., environmentally friendly, CO_2 emissions, recyclability); and 4) *cost-related aspects* (i.e., cost construct, cost to maintain, speed of construction). The model measures to what degree each of these ideologies form an individual's attitude towards implementing wooden multistory buildings in their municipality. The model showed not all ideologies impact the formation of attitudes equally. Furthermore, occupational sub-models displayed variability between two professional subgroups (i.e., planners and non-planners.) In the context of sociotechnical regimes, I argue these differences represent a tension because they illustrate mismatched land use planning values among governance regime actors.

Zooming in on the sub-models, it is critical to ask why such differences are found between planners and non-planners. Here, the literature on urban planning is a useful explanatory device (Chapter 2.2.3). For planners, attitudes about implementing wooden multistory buildings are predominantly formed by the technical qualities of the building. After this, attitudes are formed in equal parts by the economic development and environmental performance of the buildings. The importance of economic development coincides with historical planning agendas in Finland to promote growth-stimulation (Hytönen and Ahlqvist, 2019). I also argue the equal importance of environmental performance to economic development reflects *inclusivity* and because environmental outcomes affect society at large (e.g., due to climate change). Note cost-related aspects *do not* play a role in forming planner attitudes. In other words, the sub-model shows planners are societally conscious in a *holistic* manner that encompasses "the public interest" (see also: Kangasoja and Mattila, pg. 185), because attitudes are driven equally by environmental ideologies and economic development ideologies. What this means in practice is that planners regard the environmental performance, socioeconomic outcomes, and technical qualities of wooden multistory buildings in equal parts when forming an attitude towards whether these buildings should be developed in their municipality. If the project possesses all these qualities, they will be viewed favorably by the planner. If it does not, then the project is viewed unfavorably.

In comparison, the non-planner sub-model shows that attitudes form predominantly according to economic development outcomes, followed by the technical quality of the

buildings. Meanwhile environmental performance is a marginal contributor towards forming attitudes. Note that cost-related ideologies *do* play a role in forming non-planner attitudes. The large emphasis on economic development in tandem to the role of cost-related attributes suggests these municipal civil servants hold an *economizing managerial* outlook (see: Ahlqvist, 2013). That is, they emphasize planning outcomes that restrain expenditures in conjunction to land use planning priorities that improve local development. This is especially evidenced by the fact that attitudes form according to cost-related attributes. Furthermore, I argue that the large prioritization of economic development outcomes relative to the low prioritization of environmental performance strongly reflects the current-day values of new public management. As discussed in Chapter 2.2.3, increases to local discretionary powers (e.g., relegation of central government powers to municipal authorities) in conjunction to Finland's neoliberal state transformation and state rescaling have left municipalities responsible for both provisioning local services *and* obtaining the capital to deliver these services (Hytönen, 2019; Hytönen and Ahlqvist, 2019; Moisio and Rossi 2020). The need to acquire capital (e.g., via new taxpayers or private investments) is ultimately driven by the priority to improve local development and employment opportunities in the municipality. It is argued that the acquisition of capital comes at the expense of long-term goal seeking and environmental agendas (e.g., see: Hytönen, 2019). The non-planner sub-model would appear to corroborate such arguments because economic development eclipses environmental performance as the underlying ideology forming attitude. Thus, I argue the two contrasting sub-models represent two different sets of land use planning priorities (i.e., holistic versus economizing managerial).

The differing priorities between planners and non-planners expose a tension–a possible mismatch in value systems. Ultimately, the question is whether this tension can enable greater diffusion of wooden multistory construction. On the one hand, the sub-models suggest there are flexible opportunity to support wooden multistory construction under the pretext of either environment performance *or* economic development. This can be concluded by how almost all respondents held extremely positive attitudes towards wooden multistory construction (Table 9). In other words, even though there are different (mismatched) reasons for prioritizing wooden multistory construction, all respondents hold positive attitudes towards wooden multistory buildings. On the other hand, lack of common vision among wood construction policy narratives was suggested to hinder market diffusion due to the disparate goals and support measures (Toivonen et al., 2021b). To put this in the context of local municipal administrations, imagine how planners and non-planners might deliberate over the implementation of these projects if the associated outcomes included good technical qualities, good environmental performance, mediocre economic development outcomes. Would planners challenge the incumbent (governance) regime's limited prioritization of environmental performance and seek to promote strong measures in favor of wood? Since the model cannot elucidate on this, I turn to research by Puustinen et al. (2017) suggesting that under the rules of new public management, municipal planners have increasingly limited control over influencing land use planning goals. Instead, planning agendas are led by municipal managers found to support land use planning objectives that increase the attractiveness of their city (ibid). If this is indeed the case, then the environmental performance of wooden multistory buildings may be largely unable to motivate these key civil servants towards implementing these projects. Since environmental attributes are among the most well-regarded attributes of wooden multistory construction (Article II), this severely narrows the window of opportunity to leverage environmental attributes as a justifier for project implementation.

5.2 Research limitations

One novelty of this dissertation research is the application of the theory of planned behavior as a framework to collect and explore the perceptions municipal civil servants have about wooden multistory construction. Employing the theory resulted in a robust mix of both qualitative and quantitative information about a variety of theoretical dimensions (i.e., modal beliefs, attitudes, belief outcomes, and behavioral beliefs). Furthermore, the successful application of the belief-attitude model (Article III) suggests that the theory of planned behavior is a *valid* conceptual framework for this research application. Nevertheless, the dissertation research was unable to test the full predictive model (i.e., attitudes, norms, perceived behavioral control, and intention) due to inadequacies with constructing the measurement scales. While the theory of planned behavior serves as a useful heuristic, there are challenges to operationalizing the theory's measurement tool. From a broader research point of view, the theory is limited in that it primarily addresses why individuals engage in actions based on unidimensional constructs. The theory acknowledges there are interconnectivities between constructs, and it also attempts to measure the relationship between these. Alone, the theory does little to contextualize the interconnectivity between these constructs.

In terms of *reliability*, while the dissertation research reported both qualitative and quantitative findings, caution must be taken to not overextend the generalizability of the findings. For the survey study, an 8% response rate is rather low for suggesting a representative sample. The results should be understood as an exploration of perceptions rather than the "average" perceptions held by municipal civil servants across Finland. Furthermore, the representativeness of the informant's professional role or other personal demographics cannot be verified due to the lack of publicly available registers on currently employed municipal civil servants. What is apparent, however, is that there is an overrepresentation of respondents from large municipalities and an underrepresentation of smaller municipalities. In particular, the Uusimaa region is over-represented and the Pohjanmaa region is underrepresented (Table 6). Representativeness can especially affect responses to questions about how wooden multistory construction is perceived to impact a municipality. This can be seen in Article II, where municipal demographics held a statistically significant link to responses relating to the economic impact of wooden multistory buildings on the municipality. Such responses should be interpreted with caution as they might change with a larger representative sample. Article III is also vulnerable to the effect of low representation. Because of the low number of respondents, a heterogenous group of "non-planners" was constructed. Perhaps the model would look different if the group was split up according to homogenous groups.

It is apparent that the views of the informants across the elicitation and survey study are views from individuals that approve of wooden multistory construction. Thus, this dissertation research should be understood as reporting perceptions from an "approving" cohort and should not be extended to suggest all municipal civil servants perceive wooden multistory construction in the same fashion. This means that findings in Article II may yield different results if the informant is not accepting of wood construction. Findings in Article III should remain the same regardless of whether the cohort is positive or negative. This is because the theory suggests that negative attitudes stem from a low appraisal of the behavior. For example, if the civil servant thinks wood is very beautiful, and beauty is a significant factor in forming attitudes, then they will have positive attitudes towards wood. The opposite is also true, meaning that if they think wood is ugly then they will have a negative attitude

towards wood. Changes in attitudes do not mean that a different set of beliefs would be prioritized by the respondent. Article III is instead more vulnerable to sample size and representativeness. From the *reliability* point of view, that the respondents are an approving cohort may result in the omission of relevant modal salient beliefs during the elicitation phase, thus leading to inadvertent exclusion of relevant measurement items during the survey design. Put simply, important topics may have been overlooked.

Finally, it is important to recall that interviews were conducted between 2017-2018 and the survey reflects views from 2019. Today, perceptions may have already changed. For example, the Ministry of Environment has increased support for wooden multistory construction through national targets for public wood construction, thus providing strong directive for municipalities to build with wood (YM, 2020). In addition, regulatory barriers associated with fire building codes (e.g., limits to the height of wooden multistory construction) were reformulated at the beginning of 2018 (848/2017). Nevertheless, wooden multistory buildings over two stories necessitate sprinkler systems, an obligation not mandated for concrete multistory buildings. Perhaps for this reason, recent research on municipalities continues to cite regulatory barriers to wooden construction (Salmi et al., 2022).

6 CONCLUSIONS

The objective of this dissertation was to gleam into the perceptions that Finnish municipal civil servants hold about wooden multistory construction. The overarching motivation to study the perception of municipal civil servants stems from shortcomings in the literature neglecting to address how local public administrations responsible for governing land use planning view wooden multistory construction. Finland was chosen as a case study due to its high degree of national level support and low rates of diffusion. Because Finland's municipal civil servants can be described as gatekeepers of construction, they are an especially valuable and interesting target group. To collect these perceptions, the dissertation research applied the theory of planned behavior (Ajzen, 1991) as a conceptual framework. The theory postulates that actions are guided by attitudes, subjective norms, and perceived behavioral control, all of which are formed by beliefs. In this dissertation research, behavioral beliefs and attitudes form the key unit of analysis transmitting perceptions. To this end, the theory was a useful elicitation tool, although it was challenging to operationalize the measurement tool. Thus, several dimensions of the theory remain unexplored (i.e., subjective norms, norm beliefs, perceived behavioral control, control beliefs).

In short, the dissertation contributes to the ever-growing field of research on wooden multistory construction. The articles reveal that Finnish municipal civil servants perceive wooden multistory construction as a viable, and often superior, multistory construction alternative because of the multiple benefits it provides to various societal actors. The prospect of lowering carbon emissions, supporting local wood products industries, improving the local economy, safeguarding good indoor air quality; these are among the several attributes that create positive attitudes towards wooden multistory construction. But land use planning is a multi-actor affair, and it appears municipal civil servants see project implementation largely hampered by barriers relating to the wood construction sector's poor operating environment (e.g., limited regulatory support, limited access to wooden construction information and skilled workforce, lack of leadership, project risk aversion). Despite the perceived barriers,

municipal civil servants appear open and receptive to the idea of wooden multistory construction projects being implemented in their municipalities. This receptiveness is interlinked with the municipal civil servant professional role and the ideologies (i.e., sets of beliefs) prioritized during land use planning. For some professionals, attitudes are shaped primarily by whether a wooden multistory construction project will provide outcomes that economically improve local development in their municipality (e.g., supporting local wood industries, improving land value, improving the municipality's economy). Thus, if a wooden multistory project is not perceived to hold these attributes, then it will not be viewed favorably. Surprisingly, it is also the case that for certain professional groups, the environmental performance of a wooden multistory construction project has little impact on their attitudes towards these buildings. Thus, even though these buildings are believed to hold superior environmental qualities (e.g., low CO_2 emissions), these qualities do little to impact whether the building will be viewed with a positive attitude.

Future research should work to analyze the mechanisms through which the beliefs of municipal civil servant translate into actions that can enable (or hinder) wooden multistory construction diffusion. To this end, I would propose exploring the relationship between local land use planning priorities and land use policy tools for promoting wooden multistory construction. Toivonen et al., (2021b) has shown that various policy narratives in support of wooden construction stem from divergent goals that favor disparate policy tools. A similar outcome might be found among municipal civil servants. Given that bottom-up and top-down policies instruments can impact the rate of wooden multistory construction diffusion differently (Hurmekoski et al., 2018), there is precedence for such a study. Such research necessitates identifying different advocacy coalitions with shared policy belief systems (Sabatier, 1988) and contrasting these to policy instrument preferences. This comparison could be operationalized through discourse network analysis (Leifield, 2017). With Finland striving to achieve carbon neutrality by 2035, land use planning practices and policy measures will surely react to such forces. The 2020 national targets for public wood construction (YM, 2020) are one exemplary reaction, although others may emerge as well. How these policies are apprehended by the gatekeepers of construction may provide insights into whether or not they are deployed. Furthermore, there is an upcoming renewal to Finland's Land Use and Building Act in 2022, and this may result in major ramifications to land use governance structures and thus the number of wooden multistory construction projects finalized across the country.

SUPPLEMENTARY INFORMATION

S1. Semi-structured interview guide. Adapted from Franzini (2018).

**WMC = Wooden multistory construction, meaning 2 or more floors, with either wooden frames or hybrid wooden elements and materials.*

Frame 1. Municipal attitudes towards urban residential WMC* projects.

1. What is the vision and strategy of the city in terms of development and housing? Is there a formal strategy? What is the role of urban residential WMC in this vision?
2. What do you as an individual see as the advantages and disadvantage of using wood materials in WMC? Have you ever worked with a WMC project, and if so how?
3. Does the municipality have formal criteria related to the living environments in homes? If so, do they assess the homes criteria post-construction?

Frame 2. Actors involved in urban residential WMC.

4. What actors weigh in on the decisions for or against using wood as a material in WMC? What channels of communication exist between the municipalities and these actors?
5. Do end-user wants and needs affect WMC in the city? How does the city communicate with the end-user about their wants and needs?
6. How does communication take place between the municipality and builders throughout the WMC project and after the WMC project is completed?

Frame 3. Contextual influences impacting urban residential WMC adoption.

7. What processes exist for gathering new information on design and building technology about WMC? How is this information communicated throughout the municipality?
8. Are there any other issues which you find to be important that have not been discussed?

S2. QCA coding framework revealing modal behavioral beliefs. Adapted from Franzini (2018).

Enables WMC Projects (advantages)	
• Supports sustainable development • Climate and environment • Provides new business opportunities • Supports local industries • Construction/renovation ease • Novel and flexible designs • Improves building quality standards • Price competitive material	• Branding and marketing opportunity • New construction opportunities • Safety • Increased building lifecycle • Improves built environment • Improves living environment • Encourages National Forestry Sector
Hinders WMC projects (disadvantages)	
• Financial uncertainties • Limited designers/planners • Limited builders • Limited Interest • Formal regulations • Accessing WMC info difficult • Limited branding and marketing • Lack of WMC Knowledge • Cost	• Technical limitations • Building lifecycle uncertainties • Safety concerns • Poor project-builder communication • End-user knowledge limited • End-User apathy • Limited city-level support • Design/planning limitations • Slow industry development
Actors	
• Participant (interviewee) • City planning department • City housing management • City housing procurement • State-level administration • Local elected politicians	• City leaders • Residents • WMC end-users • Private developers and builders • WMC actors • Concrete industry

S3. Survey Questionnaire Cover Letter

Prospects for wood construction in Finnish municipalities | Answer the survey by 17.12

Dear recipient,

In Finland, municipal officials play a significant role in decision making concerning the built environment. They are primarily responsible for organizing land use planning and decision making. However, we have only a limited understanding of how building material choices are assessed as part of land use planning and decision making. In addition, we know little about the views of officials on wooden multistory construction.

As part of my dissertation research at the University of Helsinki, I turn to you to understand your views on the following topics: differences among building materials, the impact of different actors on building material decisions in your municipality, and the factors limiting the wider use of wood construction in your municipality.

If you are a civil servant in your municipality, you belong to the target group of the survey. Answering the questionnaire does not require technical expertise, as the answers are based on each respondent's own perceptions. All responses will be treated as anonymous.

It takes about 15 minutes to complete the survey. The last possible answer date is 17.12.2019.

The results of the study are intended to support provincial and master planning. At the end of the project, we will only publish results based on averages and generalizations.

The answers you provide will help us to understand the views of municipal officials on different aspects of land use planning and decision-making. This will help to develop a consensus between officials and other actors regarding apartment building projects both within and between municipalities.

If you would like to know more about the study, you can read about it in the following **blog** or you contact me directly via email.

Kindly,

Florencia Franzini

Doctoral Researcher | Sustainable Use of Renewable Natural Resources
Room 525 | Forest Science Building | Latokartanonkaari 7
University of Helsinki | Florencia.Franzini@helsinki.fi

S4. Survey questionnaire.

Note: original survey was presented digitally in Finnish. The format herein does not reflect the digital format. A copy of the Finnish online survey is accessible through the University of Helsinki's *e-lomake* server: https://elomake.helsinki.fi/lomakkeet/112784/lomake.html.

Page 1

Subject Line: A study on perceptions about wooden multistory buildings and their zoning

This survey is especially for civil servants whose duties are related to land use planning in municipalities, however, all those working in municipalities, cities, or state administration may also answer the survey.

In this study, we research the views of municipal and city employees regarding wooden construction.

The subjects of this survey questions include:

- Differences in construction materials
- The influence of external factors on the municipality's land use decision making process
- Obstacles to the construction of wooden multistory buildings (at least 3 stories, whose load frame materials are made from wood)

At the end of the research project, we will publish reports based on the average results and an overview of the findings.

How to answer: Answer based on your immediate first impression. Some questions may not reflect the situation in your own municipality as clearly as other questions, but please still attempt to answer all questions.

It takes about 15 minutes to complete the survey. The final response date is 17.12.2019.

Page 2

If there were wooden multistory buildings in my municipality, I would think that it is…

1.	Really bad	Bad	Neither	Good	Really good	Choose not to say
2.	Very meaningful	Meaningful	Neither	Unreasonable	Very unreasonable	Choose not to say
3.	Very negative	Negative	Neither	Positive	Very positive	Choose not to say
4.	Really safe	Safe	Neither	Dangerous	Really dangerous	Choose not to say
5.	Really sensible	Sensible	Neither	Insensible	Really insensible	Choose not to say
6.	Really cheap	Cheap	Neither	Expensive	Really expensive	Choose not to say
7.	Really worthless	Worthless	Neither	Valuable	Really valuable	Choose not to say

Page 3

What views do you have on the following statements? Compared to concrete multistory buildings, wooden multistory buildings are/have…

	Completely disagree	Disagree	No different	Agree	Completely agree	Choose not to say
1. Less susceptible to fire						
2. Less susceptible to mold						
3. Less susceptible to poor indoor air						
4. Longer occupational life cycle						
5. Less CO_2 emissions						
6. Easier to recycle						
7. Easier to implement within a reasonable schedule						
8. More environmentally friendly						
9. More beautiful						

What views do you have on the following statements? Compared to concrete apartment buildings, wooden apartment buildings are…

	Completely disagree	Disagree	No different	Agree	Completely agree	Choose not to say
1. More expensive to build						
2. More expensive to maintain						
3. Contribution more to the economic value of the area						
4. A higher value-added product for domestic industries						
5. A financially safer investment						
6. Improve my municipality's economy						
7. Improve my municipality's image						
8. More difficult projects to implement in my municipality						

Page 4

How much do you think the following factors will influence your municipality's decision to implement any kind of apartment building projects?

	Does not affect	Affects a little	Affects a lot	Affects completely	Don't know	Choose not to say
1. Fire safety of buildings						
2. "Moldlessness" of building						
3. Indoor air quality in building						
4. Appearance of the building						
5. Life cycle of the building						
6. Construction GHG emissions						
7. Construction project duration						
8. Environmental friendliness						

How much do you think the following factors will influence your municipality's decision to implement any kind of apartment building projects?

	Does not affect	Affects a little	Affects a lot	Affects completely	Don't know	Choose not to say
1. Construction project cost						
2. Building's maintenance costs						
3. Land value development						
4. Impact on the local economy						
5. Attractiveness as an investment						
6. Impact on municipality's brand						
7. Supporting Finnish bioeconomy						
8. Municipal circular economy goals						

Page 5

In what way do you believe the following actors will be concerned with the implementation of wooden multistory building?

	Don't want any	Mostly don't want	They don't care	Mostly want	Only want	Don't know	Choose not to say
1. Ministry of Environment							
2. Government authorities							
3. My municipal council							
4. Regional Council							
5. Construction companies							
6. (Sub)contractors							
7. Municipal consultants							
8. Business associations							
9. Municipal residents							
10. Local businesses							
11. Local forest owners							
12. My colleagues							

Think about the opinions of all the people you care about. Do they think you should plan wooden multistory buildings?

I certainly should	*Maybe I should*	*They don't care*	*Maybe I shouldn't*	*I certainly shouldn't*	*Can't say*	*Choose not to say*

Page 6

How much do you think the following actors influence your municipality's decision to implement wooden multistory building projects?

	Don't affect at all	Affect a little	Affect	Affect a lot	Don't know	Don't want to answer
1. Ministry of the Environment						
2. Government authorities						
3. My municipal council						
4. Regional council						
5. Construction companies						
6. (Sub)contractors						
7. Municipal consultants						
8. Business associations / organizations						
9. Municipal residents						
10. Local businesses						
11. Local forest owners						
12. My colleagues						

Page 7

What do you think about the following statements: For wooden multistory building projects it is... / there are ...

	Totally disagree	Disagree	Agree	Totally agree	Don't know	Don't want to answer
1. Difficult to find designers						
2. Difficult to find builders						
3. Too expensive to hire designers						
4. Too expensive to hire builders						
5. Insufficient funding available						
6. Sufficient gov't funding available						
7. Sufficient national targets set						
8. Easy to obtain building materials						

What do you think about the following statements?

	Totally disagree	Disagree	Agree	Totally agree	Don't know	Don't want to answer
1. It is difficult to get bids for WMSB tenders						
2. Wood building material prices are high						
3. Finnish legislation supports WMSBs						
4. WMSB developers are reliable						
5. I don't have time to find information about WMSBs						
6. Most experts like myself in other municipalities are planning WMSBs						
7. I believe it's ultimately the responsibility of municipalities to decide on the frame materials for multistory buildings						
8. It's completely up to me whether I work on WMSB projects						

Page 8

What are your views: how do the following factors affect opportunities to implement and plan wooden multistory building projects in your municipality?

	Degrades opportunities a lot	Degrades opportunities some	No effect	Improves opportunities some	Improves opportunities a lot	Don't know	Don't want to answer
1. Labor availability							
2. Availability of funding							
3. National legislation							
4. Lack of time							
5. The high cost of available professionals							
6. The high cost of wooden building materials							
7. Availability of wooden building materials							
8. Availability of trusted implementers							
9. National land use planning programs and strategies							
10. Availability of designers							
11. Availability of builders							
12. Miscellaneous subsidies for WMSB construction							

Page 9

	No	Yes	Don't know	Don't want to answer
1. Have you ever worked on a wood apartment project?				
2. My municipality is planning to build a wooden multistory building over the next five years				
3. Are you aware if there are official strategies in place in your municipality that support the construction of wooden apartment blocks?				
4. Do you know if there is a formal climate strategy in your municipality?				
5. Should municipalities force wood as a frame material through zoning regulations?				

What are the different benefits of forcing the frame material to be wooden? What disadvantages could it have?: (Fill in)

Page 10

1. In what municipality do you work?: (*Fill in*)

2. Do you live in the same municipality where you work? *(Yes/No/ Don't want to answer)*

3. Which of the following best describes your role in the municipality? (Select one)

Planning	*Real estate management*	*Building Inspection*	*Strategic senior management tasks*	*Other: (Fill in)*	*I don't want to answer*

4. Including yourself, (approximately) how many civil servants from your municipality work in tasks related to the planning, design, or construction of housing?

1-5	*6-15*	*16-25*	*26-50*	*51+*	*Can't say*	*I don't want to answer*

5. In the last 5 years, what percentage of the municipal planning work has your municipality commissioned to external consultants?

0%	*1%-20%*	*21%-40%*	*41%-60%*	*61%-80%*	*81%-99%*	*100%*	I don't want to answer

6. In which year did you start working in your current municipality? *(Fill in)*

7. How many years have you been an official? *(Fill in)*

8. Your year of birth? *(Fill in)*

9. Gender? *(Male/Female/Other)*

10. Level of education / number of years of study (Select one)

Primary school (up to 10 years)	*Secondary education (primary school + 3 years)*	*Bachelor's Degree (Secondary Education + 3-4 years)*	*Master's degree (secondary education + 5-6 years)*	*Doctorate (Master + 3-4 years)*

10. In what subject did you obtain your highest degree? (Fill in)

12. I have lived most of my life in…

A single detached house	*Semi-detached house*	*Townhouse*	*Multistory building (1-2 floors)*	*Multistorey building (3+ floors)*	*In another apartment*	*I don't want to answer*

S5. List of finalized wooden multistory projects in Finland from December 1995 to May 2021 (Karjalainen, 2021). This list is re-printed with permission from Markku Karjalainen.

	Project Name (Year finalized)	Number of buildings	Number of dwellings
1	Kiintesitö Oy Ylöjärven Vuokratalot (1996)	3	19
2	Kiintesitö Oy Viikinmansio (1997)	7	65
3	Kiintesistö Oy Puukotka (1997)	3	33
4	Tuusulan Hyrylän Puukerrostalot (1997)	2	46
5	Raison asuntomessujen Puukerrostalot (1997)	3	42
6	Asunto Oy Porvoon Fredrika (1998)	1	19
7	Asunto Oy Porvoon Aleksanterinkatu 29 (1999)	1	24
8	Naantalin Puukerrostalot (2000)	3	51
9	Oulun Puu-Linnanmaan Puukerrostalo (2000)	1	14
10	Lahden Puu-Paavolan Puukerrostalot(1998-2003)	4	74
11	Vuosaaren Kiinteistöt Oy Omenamäki (2006)	3	131
12	Asunto Oy Heinolan Puumera (2011)	1	27
13	Viikin Latokartanon Puukerrostalokortteli (2012)	5	104
14	Seinäjoen Lintuviita (2013)	1	50
15	Kiinteistö Oy Turun Palvelukoti (2014)	1	54
16	Jyväskylän Puukuokka 1 (2014)	1	58
17	Saarijärven Omatoimi - Ikääntyvien Yhteisötalo (2015)	1	24
18	Haso & Heka, Pukinmäen Puukerrostalot (2015)	4	91
19	Iin Kirjalan Puukerrostalo (2015)	1	15
20	Puumera (2015)	1	186
21	Seinäjoen Mäihä (2016)	1	28
22	Imatra Tyyppikerrostalo (2016)	1	13
23	Kajaanin Rajavartioston Puukerrostalot (2016)	1	15
24	Naava Chalet, Puukerrostalo Hirrestä (2016)	1	16
25	Helsingin Honkasuon Puukerrostalokortteli (2016-2017)	4	116
26	Tampereen Vuoreksen Koukkurannankatu (2017)	2	53
27	Joensuun Pihapetäjä (2017)	1	40
28	Helsingin Honkasuon Siklan Puukerrostalot (2017)	4	43
29	Jyväskylän Puukuokka 2 (2017)	1	70
30	Helsingin Kuninkaantammen Taidemaalarinkadun Puukerostalot (2018)	2	58
31	Jyväskylän Puukuokka 3 (2018)	1	58
32	Pori, Tuomarinkulma (2018)	1	23
33	Järvenpää, Puusinfonia (2018)	1	27
	**List continues on next page		

	Project Name (Year finalized)	Number of buildings	Number of dwellings
34	As.Oy Turun Puulinna (2018)	2	94
35	As. Oy Turun Amiraali (2018)	2	30
36	Seinäjoen Tuohi (2018)	1	44
37	Jyväskylän Seminaarinmäki (2018)	2	103
38	AS.Oy Turun Amiraali 1 (2019)	2	37
39	Helsingin Jätkäsaaren Wood City (2019)	2	98
40	Turun Pernoon Puukerrostalot (Koy Goliathin Salmi) (2019)	2	31
41	Fleminginkatu 4 (Yh Priimus) (2019)	1	83
42	AS. Oy Turun Marinum (2019)	3	82
43	Rovaniemen Riihipellonpuiston puukerrostalo (2019)	1	103
43	Rovaniemen Riihipellonpuiston puukerrostalo (2019)	1	103
44	Joensuun Ellin puukerrostalo [Lighthouse Joensu] (2019)	1	117
45	Nurmijärven Toimelan Puukerrostalo (2019)	1	53
46	AS. Oy Tampereen Tuohi (2019)	1	36
47	As. Oy Turun Linnanfälttin Lyhdynkantaja (2019)	1	57
48	As. Oy hämeenlinnan Visa 1 (2019)	1	31
49	Espoon tuuliniityn puukerrostalokortteli, osa1 (2020)	1	42
50	AS. Oy Vantaan Voltti (2020)	1	34
51	Jyväskylän Mannisenrinteen puukerrostalot Puumanni (2020)	2	48
52	As Oy Kirkkonummen Tinankartano (2020)	2	52
53	Nurmeksen Yhteisöpihan puukerrostalo (2020)	1	19
54	Asunto Oy Tampereen Tohtori (2020)	1	64
55	KOY Päivänsäde 3-4, Linnanfältti (2020, 2021)	4	128
56	Kirkkonummen Kartanonrannan Konsulintorni (2020)	1	19
57	As. Oy Puupyygeli (2020)	2	70
58	Asunto Oy Vaasan Viherlehto (2021)	1	32
59	As. Oy Keravan Kuusikulma (2021)	1	48
60	Sipoon Söderkullanrannan puukerrostalot (2021)	2	72
61	Espoon tuuliniityn puukerrostalokortteli, osa 2 (2021)	1	165
62	Kuopion Lehtoniemen puukerostalot (2021)	2	48
63	Tampereen vuoreksen Kuusikko (1/6 rakennuksesta valmiina 6/2021)	1	42
64	Tampereen Kaupin puukerrostalo (2021)	1	70
65	Asunto Oy Tampereen Härmälänsydän (2021)	1	23
66	Asunto Oy Jyväskylän Vuorihelmi (2021)	1	17

REFERENCES

132/1999. Land Use and Building Act (Amendment 222/2003 included).

848/2017. Decree of the Ministry of the Environment on Fire safety of Buildings.

Aaltonen A, Hurmekoski E, Korhonen J (2021) What About Wood?—"Nonwood" Construction Experts' Perceptions of Environmental Regulation, Business Environment, and Future Trends in Residential Multistory Building in Finland. Forest Prod J 71: 342–351. https://doi.org/10.13073/FPJ-D-21-00033.

Ahlqvist, T (2013) Potential Governmentality and the State Transformation in Finland. Geopolitics 18: 328–342. https://doi.org/10.1080/14650045.2012.723286.

Ahlqvist T, Moisio S (2014) Neoliberalisation in a Nordic State: From Cartel Polity towards a Corporate Polity in Finland. New Polit Econ 19: 21–55. https://doi.org/10.1080/13563467.2013.768608.

Ahlqvist, T, Sirviö H (2019) Contradictions of Spatial Governance: Bioeconomy and the Management of State Space in Finland. Antipode 51: 395–418. https://doi.org/10.1111/anti.12498.

Ajzen I, Fishbein M (1980) Understanding attitudes and predicting social behavior. Prentice-Hall Inc, Englewoods Cliffs, New Jersey, USA. ISBN 0139364439.

Ajzen I (1991) The theory of planned behavior. Organ Behav Hum 50: 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Ajzen I (2005) Attitudes, Personality and Behaviour. McGraw-Hill Education New York, New York, USA: ISBN 0335217036.

Ajzen I (2011) The theory of planned behaviour: Reactions and reflections. Psychol Health 26: 1113–1127. https://doi.org/10.1080/08870446.2011.613995.

Ajzen I (2019) "Constructing a theory of planned behavior questionnaire." https://people.umass.edu/aizen/pdf/tpb.measurement.pdf. Accessed September 2021.

Ajzen I (2020) The theory of planned behavior: Frequently asked questions. Human behavior and emerging technologies, 2:314–324. https://doi.org/10.1002/hbe2.195.

Ali MM, Al-Kodmnay K (2012) Tall Buildings and Urban Habitat of the 21st Century: A Global Perspective. Buildings 2: 348-423. https://doi.org/10.3390/buildings2040384.

Baker M (2014) Land use Planning. In: Michalos AC (eds) Encyclopedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_1600.

Bishop GF (1987) Experiments with a middle response alternative in survey questions. Public Opin Quart, 51: 220–232. https://www.jstor.org/stable/2748994.

Bosnjak M, Ajzen I, Schmidt P (2020) The Theory of Planned Behavior: Selected Recent Advances and Applications. Europe's Journal of Psychology 16: 352–356. https://doi.org/10.5964/ejop.v16i3.3107.

Brege S, Stehn L, Nord T (2014) Business models in industrialized building of multi-storey houses. Construction Management and Economics 32: 208–226. http://dx.doi.org/10.1080/01446193.2013.840734.

Brown TB (2015) Confirmatory Factor Analysis for Applied Research Second Edition. The Guilford Press, New York, New York, USA: ISBN 9781462515363.

Bruland K (1995) Patterns of resistance to new technologies in Scandinavia: an historical perspective. In Bauer M (eds) Resistance to New Technology Nuclear Power, Information Technology and Biotechnology. Cambridge University Press, London, England, pp 125–146. https://doi.org/10.1017/CBO9780511563706

Bysheim K, Nyrud AQ (2009) Using a predictive model to analyze architects' intentions of using wood in urban construction. Forest Prod J 59: 65–74.

C40 Cities (2019) Defining carbon neutrality for cities and managing residual emissions. https://c40-production-images.s3.amazonaws.com/researches/images/76_Carbon_neutrality_guidance_for_cities_20190422.original.pdf?1555946416. Accessed February 2022.

Carbon Neutral Cities Alliance (CNCA) (2020) City Policy Framework for Dramatically Reducing Embodied Carbon. https://www.embodiedcarbonpolicies.com/. Accessed February 2022.

Christensen C (1997) The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press, Boston, Massachusetts, USA: ISBN 0875845851.

Churkina G, Organschi A, Reyer CPO, Ruff A, Vinke K, Liu Z, Reck BK, Graedel TE, Schellnhuber HJ (2020) Buildings as a global carbon sink. Nature Sustainability 3: 269–276. https://doi.org/10.1038/s41893-019-0462-4.

Conroy K, Riggio M, Knowles C (2018) Familiarity, Use, and Perceptions of Wood Building Products: A Survey Among Architects on the United States West Coast. BioProducts Business 3: 118–135. https://doi.org/10.22382/bpb-2018-010.

Cronbach LJ, Meehl PE (1955) Construct validity in psychological tests. Psychological Bulletin 52: 281–302. https://doi.org/10.1037/h0040957

Dangel U (2016) Turning Point in Timber Construction: A New Economy. Birkhäuser Verlag, Basel, Switzerland. https://doi.org/10.1515/9783035608632.

Dodoo A, Gustavsson L, Sathre R (2014) Lifecycle carbon implications of conventional and low-energy multi-storey timber building systems. Energ Buildings 82: 194–210. https://doi.org/10.1016/j.enbuild.2014.06.034.

Fishbein M, Ajzen I (2010) Predicting and Changing Behavior: The Reasoned Action Approach. Psychology Press, New York, New York, USA. https://doi.org/10.4324/9780203838020.

Franzini F (2018) Wooden multistory construction in Finland: perceptions of municipality civil servants. Master's thesis. University of Helsinki, Helsinki, Finland. http://urn.fi/URN:NBN:fi:hulib-201806122465.

Geels FW (2002) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res policy 31: 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8.

Geels FW (2004) From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Res policy 33: 897–920. https://doi.org/10.1016/j.respol.2004.01.015.

Geels FW (2014) Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. Theor cult soc 3: 21–40. https://doi.org/10.1177/0263276414531627.

Geels FW and Verhees B (2011) Cultural legitimacy and framing struggles in innovation journeys: A cultural-performative perspective and a case study of Dutch nuclear energy (1945–1986). Technol Forecast Soc 78: 910–930. https://doi.org/10.1016/j.techfore.2010.12.004.

Global Alliance for Buildings and Construction, International Energy Agency, and the United Nations Environment Programme (GlobalABC) (2020) GlobalABC Roadmap for Buildings and Construction: Towards a zero-emission, efficient and resilient buildings and construction sector 2020-2050. International Energy Association, Paris, France.

GlobalABC/IEA/UNEP (2019) 2019 Global Status Report for Buildings and Construction. https://webstore.iea.org/download/direct/2930?fileName=2019_Global_Status_Report_for_Buildings_and_Construction.pdf. Accessed February 2022.

Gosselin A, Blanchet P, Lehoux N, Cimon Y (2017) Main motivations and barriers for using wood in multi- story and non-residential construction projects. Bioresources 12: 546–570.

Granqvist K, Sarjamo S, Mäntysalo R (2019) Polycentricity as spatial imaginary: the case of Helsinki City Plan. Eur Plan Stud 27: 739–758. https://doi.org/10.1080/09654313.2019.1569596.

Gustavsson L, Sathre R (2006) Variability in energy and carbon dioxide balances of wood and concrete building materials. Build Enviro 41: 940–951. https://doi.org/10.1016/j.buildenv.2005.04.008.

Gustavsson L, Sathre R (2011) Energy and CO_2 analysis of wood substitution in construction. Climate Change 105: 129–153. https://doi.org/10.1007/s10584-010-9876-8.

Gustavsson L, Pingoud K, Sathre R (2006) Carbon dioxide balance of wood substitution: comparing concrete- and wood-framed buildings. Mitig Adapt Strat Gl 11: 667–691. https://doi.org/10.1007/s11027-006-7207-1.

Healey P (2003) Collaborative planning in perspective. Plan theor 2: 101–123. https://doi.org/10.1177/14730952030022002.

City of Helsinki (HEL) (2012) Honkasuo: 33. Kaupingosa Maminkartano Asemakaava. City of Helsinki urban planning department report 11870, Helsinki, Finland. https://kartta.hel.fi/helshares/kaavaselostus/ak11870_selostus.pdf. Accessed February 2022.

Hemström K, Mahapatra K, Gustavsson L (2011) Perceptions, attitudes and interest of Swedish architects towards the use of wood frames in multistorey buildings. Resour Conserv Recy 55: 1013–1021. https://doi.org/10.1016/j.resconrec.2011.05.012.

Hemström K, Gustavsson L, Mahapatra K (2017a) The sociotechnical regime and Swedish contractor perceptions of structural frames. Construction Management and Economics 35: 184–195. https://doi.org/10.1080/01446193.2016.1245428.

Hemström K, Mahapatra K, Gustavsson L (2017b) Architects' perception of the innovativeness of the Swedish construction industry. Construction Innovation 17: 244-260. https://doi.org/10.1108/CI-06-2015-0038.

Heravi G, Nafisi T, Mousavi R (2016) Evaluation of energy consumption during production and construction of concrete and steel frames of residential building. Energ Buildings 130: 244–252. https://doi.org/10.1016/j.enbuild.2016.08.067.

Hildebrandt J, Hagemann N, Thran D (2017) The contribution of wood-based construction materials for leveraging a low carbon building sector in Europe. Sustain cities soc 34: 405–418. https://doi.org/10.1016/j.scs.2017.06.013.

Hirvonen-Kantola S, Mäntysalo R (2014) The recent development of the Finnish Planning system: The city of Vantaa as an executor, fighter and independent actor. In: Reimer M, Getimis P, Blotevogel HH (eds) Spatial planning systems and practices in Europe: A comparative perspective on continuity and changes. Routledge, pp 42–60.

Hughes TP (1987) The evolution of large technological systems. In: Bijker WE, Hughes TP, Pinch T (eds) The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology. The MIT Press, Cambridge, Massachusetts, USA, 51–82.

Hurmekoski E, Jonsson R, Nord T (2015) Context, drivers, and future potential for wood-frame multi-story construction in Europe. Technol Forecast Soc 99: 181–196. http://dx.doi.org/10.1016/j.techfore.2015.07.002.

Hurmekoski E, Pykäläinen J, Hetemäki L (2018) Long-term targets for green building: Explorative Delphi backcasting study on wood-frame multi-story construction in Finland. J Clean Prod 172: 3644–3654. http://dx.doi.org/10.1016/j.jclepro.2017.08.031.

University of Helsinki (HY) (2021.) "Mitä minun tulee huomioida henkilötietojen käsittelyssä?" [What should I consider when processing personal information?]. https://wiki.helsinki.fi/pages/viewpage.action?pageId=252121442. Accessed October 2021.

Hynynen A (2016) Future in Wood? Timber Construction in Boosting Local Developments. European Spatial Research and Policy 23: 127–139. https://doi.org/10.1515/esrp-2016-0007.

Hytönen J (2016) The problematic relationship of communicative planning theory and the Finnish legal culture. Plan Theor 15: 223–238. https://doi.org/10.1177/1473095214549618.

Hytönen J (2019) Limits of localism: Institutional perspectives on communicativeness, neoliberalization and sustainability in Finnish spatial planning. Nordia Geographical Publication 4.

Hytönen J, Mäntysalo R, Peltonen L, Kanninen V, Niemi P, Simanainen M (2016) Defensive routines in land use policy steering in Finnish urban regions. Eur Urban and Reg Stud 23: 40–55. https://doi.org/10.1177/0969776413490424.

Hytönen J, Ahlqvist T (2019) Emerging vacuums of strategic planning: an exploration of reforms in Finnish spatial planning. Eur Plan Stud 27: 1350–1368. https://doi.org/10.1080/09654313.2019.1580248.

Ibn-Mohammed T, Greenough R, Taylor S, Ozawa-Meida L, Acquaye A (2013) Operational vs. embodied emissions in buildings—A review of current trends. Energ Buildings 66: 232–245. http://dx.doi.org/10.1016/j.enbuild.2013.07.026.

Ilgın HE, Karjalainen M, Pelsmakers S (2021) Finnish architects' attitudes towards multi-storey timber-residential buildings. International Journal of Building Pathology and Adaptation. [Accepted for publication] https://doi.org/10.1108/IJBPA-04-2021-0059.

IPCC, 2019: Annex I: Glossary. In: Shukla PR, Skea J, Calvo Buendia E, et al. (eds) Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/11_Annex-I-Glossary.pdf. Accessed January 2022.

City of Joensuu (Joensuu) (2017) Joensuun kaupunki, rakennus- ja ympäristölautakunta. [Granting of a building permit to Penttilänkulma 2] 21.06.2017. §66 Rakennusluvan myöntäminen osoitteeseen Penttilänkulma 2. 1091/10.03.00/2017.

Julin J, Säilä P, Talonpoika L, Aho M, Kaarakka V, Kyyrönen K (2010) The International Promotion of Wood Construction as a Part of Climate Policy. Working Group Report. Commissioned by Ministry of Foreign Affairs of Finland, Helsinki.

Juntunen P, Leinonen J (2007) Exploring Finnish Local and Regional Administration – Some Current Perspectives. University of Lapland, Faculty of Social Science: Rovaniemi.

Jussila J, Nagy E, Lähtinen K, Hurmekoski E, Häyrinen L, Mark-Herbert C, Roos A, Toivonen R, Toppinen A (2022) Wooden multi-storey construction market development – systematic literature review within a global scope with insights on the Nordic region. Silva Fennica 56, article ID 10609. https://doi.org/10.14214/sf.10609.

Jöreskog KG, Goldberger AS (1975) Estimation of a model with multiple indicators and multiple causes of a single latent variable. Journal of the American Statistics Association 70: 631–639. https://doi.org/10.2307/2285946.

Kangasoja J and Mattila H (2018) Facing up to Finnish Planning Pathologies: A Contextual Interpretation of Planner Capabilities and a Call for Change. In: Taşan-Kok T and Oranje M (eds) From Student to Urban Planner: Young Practitioners' Reflections on Contemporary Ethical Challenges. Routledge, New York, New York, USA. https://doi.org/10.4324/9781315726854.

Karhunmaa K (2019) Attaining carbon neutrality in Finnish parliamentary and city council debates. Futures 109:170–180. https://doi.org/10.1016/j.futures.2018.10.009.

Karjalainen M (2002) Suomalainen puukerrostalo puurakentamisen kehittämisen etulinjassa [Finnish wooden multistory building at the forefront wooden construction development]. Doctoral dissertation, University of Oulu, Faculty of Technology, Department of Architecture. http://urn.fi/urn:isbn:9514266188.

Karjalainen M, Ilgın HE (2021) The Change over Time in Finnish Residents' Attitudes towards Multi-Story Timber Apartment Buildings. Sustainability-Basel 13, article ID 5501. https://doi.org/10.3390/su13105501.

Karjalainen M, Ilgın HE, Tulonen L (2021) Main Design Considerations and Prospects of Contemporary Tall Timber Apartment Buildings: Views of Key Professionals from Finland. Sustainability-Basel 13, article ID 6593. https://doi.org/10.3390/su13126593.

Karjalainen M (2021) Personal Correspondence, Excel Document.

Kitek-Kuzman M, Klarić S, Barčić AP, Vlosky RP, Janakieska MM, Grošelj P (2018) Architect perceptions of engineered wood products: An exploratory study of selected countries in Central and Southeast Europe. Constr Build Mater 179: 360-370. https://doi.org/10.1016/j.conbuildmat.2018.05.164.

Knowles C, Theodoropoulos C, Griffin C, Allen J (2011) Oregon design professionals views on structural building products in green buildings: implications for wood. Can J Forest Res 41: 390–400. https://doi.org/10.1139/X10-209.

Korhonen J, Miettinen J, Kylkilahti E, Tuppura A, Autio M, Lähtinen K, Pätäri S, Pekkanen T-L, Luhas J, Mikkilä M, Linnanen L, Ollikainen M, Toppinen A (2021) Development of a

forest-based bioeconomy in Finland: Insights on three value networks through expert views. J Clea Prod 299, article ID 126867. https://doi.org/10.1016/j.jclepro.2021.126867.

Korkein hallinto-oikeus (KHO) (2015) KHO:2015:56. https://www.kho.fi/fi/index/paatokset/vuosikirjapaatokset/1428403349476.html, Accessed September 2021.

Kukkonen A, Ylä-Anttila T (2020) The Science–Policy Interface as a Discourse Network: Finland's Climate Change Policy 2002–2015. Politics and governance 8: 200–214. https://doi.org/10.17645/pag.v8i2.2603.

Kuntaliitto (2021) Finnish municipalities and regions. https://www.localfinland.fi/finnish-municipalities-and-regions. Accessed October 2021.

Kuntaliitto (2022a) Kuntien tontinluovutus ja valtiontukisäädösten huomioonottaminen [Municipal land transfer and compliance with state aid regulations] https://www.kuntaliitto.fi/tilastot-ja-julkaisut/verkko-oppaat/maapolitiikan-opas/maapolitiikan-keinot/tonttien-luovuttaminen/kuntien-tontinluovutus-ja-valtiontukisaadosten-huomioonottaminen. Accessed February 2022.

Kuntaliitto (2022b) "Luovutusmenettely" [Surrender Procedure]. https://www.kuntaliitto.fi/tilastot-ja-julkaisut/verkko-oppaat/maapolitiikan-opas/maapolitiikan-keinot/tonttien-luovuttaminen/luovutusmenettely. Accessed February 2022.

Kylkilahti E, Berghäll S, Autio M, Nurminen J, Toivonen R, Lähtinen K, Vihemäki H, **Franzini F**, Toppinen A (2020) A consumer-driven bioeconomy in housing? Combining consumption style with students' perceptions of the use of wood in multi-storey buildings. Ambio 49: 1943–1957. https://doi.org/10.1007/s13280-020-01397-7.

Laguardo-Mallo MF, Espinoza O (2015) Awareness, perceptions and willingness to adopt Cross-Laminated Timber by the architecture community in the United States. J Clean Prod 94: 198–210. http://dx.doi.org/10.1016/j.jclepro.2015.01.090

Larasatie P, Guerrero JE, Conroy K, Hall TE, Hansen E, Needham MD (2018) What does the public believe about tall wood buildings? An exploratory study in the US Pacific Northwest. J Forest 116: 429–436. http://dx.doi.org/10.1093/jofore/fvy025/

Lavrakas PJ (2008) Encyclopedia of survey research methods (Vols. 1-0) Sage Publications, Inc, Thousand Oaks, California, USA:. https://dx.doi.org/10.4135/9781412963947.

Lazarevic D, Kautto P, Antikainen R (2020) Finland's wood-frame multi-storey construction innovation system: Analysing motors of creative destruction. Forest policy econ 110, article ID 101861. https://doi.org/10.1016/j.forpol.2019.01.006.

Leifeld P (2017) Discourse network analysis: policy debates as dynamic networks. In: Victor JN, Montgomery AH, Lubell M (eds) The Oxford Handbook of Political Networks. Oxford University Press, Oxford, England, pp 1–26. https://doi.org/10.1093/oxfordhb/9780190228217.013.25

Lindgren J, Emmitt S (2017) Diffusion of a systemic innovation: A longitudinal case study of a Swedish multi-storey timber housebuilding system. Construction Innovation 17: 25–44. http://dx.doi.org/10.1108/CI-11-2015-0061.

Lützkendorf T, Foliente G, Balouktsi M, Wiberg AH (2015) Net-zero buildings: incorporating embodied impacts. Build res inf 43: 62-81. https://doi.org/10.1080/09613218.2014.935575.

Lähtinen K, Harju C, Toppinen A (2019a) Consumers' perceptions on the properties of wood affecting their willingness to live in and prejudices against houses made of timber. Wood material science & engineering 14: 325–331. https://doi.org/10.1080/17480272.2019.1615548

Lähtinen K, Toppinen A, Malm N (2019b) Effects of Lobbying Among Urban Planners in Finland – Views on Multi-Storey Wooden Building. BioProducts Business 4: 77–92. https://doi.org/10.22382/bpb-2019-007.

Mahapatra K, Gustavsson L (2008) Multi-storey timber buildings: breaking industry path dependency. Build Res Inf 36: 638–648. https://doi.org/10.1080/09613210802386123.

Mahapatra K, Gustavsson L, Hemström K (2012) Multi-storey wood-frame buildings in Germany, Sweden and the UK. Construction Innovation 12: 62–85. http://dx.doi.org/10.1108/14714171211197508.

Marfella G, Winson-Geideman K (2022) Timber and Multi-Storey Buildings: Industry Perceptions of Adoption in Australia. Buildings 11, article ID 653. https://doi.org/10.3390/buildings11120653.

Markström E, Kuzman MK, Bystedt A, Sandberg D (2019) Use of wood products in multi-storey residential buildings: views of Swedish actors and suggested measures for an increased use. Wood Material Science & Engineering 14: 404-419. https://doi.org/10.1080/17480272.2019.1600164.

Moisio S (2018) Urbanizing the nation-state? Notes on the geopolitical growth of cities and city-regions. Urban geogr 39: 1421–1425. https://doi.org/10.1080/02723638.2018.1454685.

Moisio S, Leppänen L (2007) Towards a Nordic competition state? Politico-economic transformation of statehood in Finland, 1965–2005. Fennia 185: 63–87. https://doi.org/10.1080/02723638.2018.1454685.

Moisio S, Rossi U (2020) The Start-up State: Governing urbanised capitalism. Environ Plann A 52: 532–552. https://doi.org/10.1177/0308518X19879168.

Mäntysalo R, Saglie IL (2010) Private Influence Preceding Public Involvement: Strategies for Legitimizing Preliminary Partnership Arrangements in Urban Housing Planning in Norway and Finland. Planning Theory & Practice 11:317–338. https://doi.org/10.1080/14649357.2010.500123.

Mäntysalo R, Saglie IL, Goran C (2011) Between Input Legitimacy and Output Efficiency: Defensive Routines and Agonistic Reflectivity in Nordic Land use Planning. Eur Plan Stud 19: 2109–2126. https://doi.org/10.1080/09654313.2011.632906.

Mäntysalo R, Jarenko K, Nilsson KL, Saglie IL (2015) Legitimacy of Informal Strategic Urban Planning—Observations from Finland, Sweden and Norway. Eur Plan Stud 23: 349–366. https://doi.org/10.1080/09654313.2013.861808.

Osgood CE, Suci GJ, Tannenbaum PH (1957) The measurement of meaning. University of Illinois Press, Urbana, Illinois, USA: ISBN 0252745396.

Ottaway RN, Cooper CL (1978) Moving Toward a Taxonomy of Change Agents. International Studies of Management & Organization 8: 7–21. https://doi.org/10.1080/00208825.1978.11656242.

Ottelin J, Amiri A, Steubing B, Junnila J (2021) Comparative carbon footprint analysis of residents of wooden and non-wooden houses in Finland. Environ res lett 16, article ID 074006. https://doi.org/10.1088/1748-9326/ac06f9.

Pollitt C, Bouckaert G (2011) Public Management Reform: A Comparative Analysis. New Public Management, Governance and the Neo-Weberian State. Oxford University Press, Oxford, ISBN 0199595097.

Posey C, Roberts TL, Lowry PB, Bennett RJ (2015) Multiple Indicators and Multiple Causes (MIMIC) Models as a Mixed-Modeling Technique: A Tutorial and an Annotated Example. Communications of the Association for Information Systems 36: 179–2014. https://doi.org/10.17705/1CAIS.03611.

Prime Minister's Office (PMO) (2019a) Inclusive and competent Finland – A socially, economically and ecologically sustainable society. Finnish Government Publication 2019:25, Programme of Prime Minister Antti Rinne's Government, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-287-760-4.

Prime Minister's Office (PMO) (2019b) Inclusive and competent Finland – A socially, economically and ecologically sustainable society. Finnish Government Publication 2019:33, Programme of Prime Minister Sanna Marin's Government, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-287-811-3

Purkarthofer E, Humer A, Mattila H (2021) Subnational and Dynamic Conceptualisations of Planning Culture: The Culture of Regional Planning and Regional Planning Cultures in Finland, Planning Theory & Practice 22: 244–265. https://doi.org/10.1080/14649357.2021.1896772.

Puustinen S, Mäntysalo R, Hytönen J, Jarenko K (2017) The "deliberative bureaucrat": deliberative democracy and institutional trust in the jurisdiction of the Finnish planner. Planning Theory & Practice 18: 71–88. https://doi.org/10.1080/14649357.2016.1245437.

Päätokset (2011) Kaarelan Kortteleiden Nro 33350-33376 Ym. Alueiden (Honkasuo) Asemakaavan Määrääminen Osittain Voimaan Ennen Lainvoimaisuutta (Nro 11870) [Partial entry into force of the town plan of Kaarela Blocks No. 33350 - 33376 and other areas (Honkasuo) before final validity (No. 11870)]. Diary number HEL 2011-001369. https://dev.hel.fi/paatokset/asia/hel-2011-001369/khs-2012-44/. Accessed February 2022.

Päätokset (2015) Kaupunginvaltuuston päätös 29.8.2012, Helsingin hallinto-oikeudenpäätös 18.6.2013 ja korkeimman hallinto-oikeuden päätös 10.4.2015 asemakaava-asiassa (piirustus nro 11870, Kaarela, Honkasuo) [Helsinki Administrative Court decision of 18 June 2013 and Supreme Administrative Court decision of 10 April 2015 in the town plan case (case number 11870, Kaareloa, Honkasuo)]. Diary number HEL 2011-001369. https://dev.hel.fi/paatokset/asia/hel-2011-001369/100es1-2015-12/. Accessed February 2022.

Ramage MH, Burridge H, Busse-Wiche H, Fereday G, Reynolds T, Shah DU, Wu G, Yuc L, Fleming P, Densley-Tingley D, Allwood J, Dupree P, Linden PF, Scherman O (2017) The wood from the trees: The use of timber in construction. Renewable and Sustainable Energy Reviews 68: 333–359. https://doi.org/10.1016/j.rser.2016.09.107.

Ravetz J, Neuvonen A, Mäntysalo R (2021) The new normative: synergistic scenario planning for carbon-neutral cities and regions. Reg Stud 55: 150–163. https://doi.org/10.1080/00343404.2020.1813881.

Riala, M, Ilola L (2014) Multi-storey timber construction and bioeconomy – barriers and opportunities. Scand J Forest Res 29: 367–377. https://doi.org/10.1080/02827581.2014.926980.

Rip A, Kemp R (1998) Technological change. In: Rayner S, Malone E.L (Eds) Human Choice and Climate Change, Vol. 2. Battelle Press, Columbus, Ohio, USA pp 327–399.

Rogers EM (1962) Diffusion of Innovations. Free Press of Glencoe, New York, New York, USA: ISBN 0598411046.

Roos A, Woxblom L, McClusky D (2010) The influence of architects and structural engineers on timber in construction—perceptions and roles. Silva Fenn 44: 871–884. https://doi.org/10.14214/sf.126.

Ruuska A, Häkkinen T (2016) Efficiency in the Delivery of Multi-story Timber Buildings. Energy Proced 96: 190–201. https://doi.org/10.1016/j.egypro.2016.09.

Sabatier PA (1988) An advocacy coalition framework of poliicy change and the role of policy-oriented learning therein. Policy Sciences 21: 129–168. doi:10.1007/BF00136406. https://www.jstor.org/stable/4532139.

Sager T (2009) Planners' Role: Torn between Dialogical Ideals and Neo-liberal Realities. Eur Plan Stud 17: 65–84. https://doi.org/10.1080/09654310802513948.

Salmi A, Jussila J, Hämäläinen M (2022) The role of municipalities in transformation towards more sustainable construction: The case of wood construction in Finland. Construction Management and Economics. https://doi.org/10.1080/01446193.2022.2037145.

Sanni-Anibire MO, Zin RM, Olatunji SO (2020) Causes of delay in the global construction industry: a meta analytical review. International Journal of Construction Management. https://doi.org/10.1080/15623599.2020.1716132.

Schreier M (2012) Qualitative Content Analysis in Practice. Sage Publication Ltd, Los Angeles, California, USA. ISBN: 1446258750.

Stjernberg M (2019) Concrete Suburbia: Suburban housing estates and socio-spatial differentiation in Finland. Doctoral dissertation, University of Helsinki, Department of Geosciences and Geography. http://urn.fi/URN:ISBN:978-951-51-4920-6.

Takano A, Pittau A, Hafner A, Ott S, Hughes M, De Angelis E (2014) Greenhouse gas emission from construction stage of wooden buildings. International Wood Products Journal 5: 217-223. https://doi.org/10.1179/2042645314Y.0000000077.

TEKES (2000) Puurakentaminen 1995-1998: Loppu- ja arviointiraportti [Wood construction 1995-1998: Evaluation- and final report]. Report 12/2000, Tekes, Helsinki, Finland: ISSN 1239-1336.

Ministry of Employment and the Economy (TEM) (2012) Metsäalan strateginen ohjelma 2011–2015 [The Strategic Program for the Forestry Sector 2011-2015]. Report 43/2012, Ministry of Employment and the Economy, Helsinki, Finland: ISSN 1797-3562.

Ministry of Employment and the Economy (TEM) (2014) Sustainable growth from bioeconomy: The Finnish Bioeconomy Strategy. Report, Biotalous, Helsinki, Finland. https://biotalous.fi/wpcontent/uploads/2014/08/The_Finnish_Bioeconomy_Strategy_110620141.pdf. Accessed February 2022.

Ministry of Employment and the Economy (TEM) (2015) From forest to pioneering bioeconomy: Final report on the Strategic Program for the Forest Sector (MSO) Report 15/2015, Ministry of Employment and the Economy, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-327-030-5.

Ministry of Economic Affairs and Employment (TEM) (2017) Wood-Based Bioeconomy Solving Global Challenges. Report 2/2017, Ministry of Economic Affairs and Employment, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-327-214-9.

Toivonen R, Lilja A, Vihemäki H, Toppinen A (2021a) Future export markets of industrial wood construction – A qualitative backcasting study. Forest policy econ 128, article ID 102480. https://doi.org/10.1016/j.forpol.2021.102480.

Toivonen R, Vihemäki H, Toppinen A (2021b) Policy narratives on wooden multi-storey construction and implications for technology innovation system governance. Forest policy econ 125, article ID 102409. https://doi.org/10.1016/j.forpol.2021.102409.

Tollefson J (2017) The wooden skyscrapers that could help to cool the planet. Nature 545: 280-282. https://doi.org/10.1038/545280a.

Toppinen A, Röhr A, Pätäri S, Lähtinen K, Toivonen R (2018a) The future of wooden multistory construction in the forest bioeconomy – A Delphi study from Finland and Sweden. J Forest Econ 31: 3–10. https://doi.org/10.1016/j.jfe.2017.05.001.

Toppinen A, Autio M, Sauru M, Berghall S (2018b) Sustainability-Driven New Business Models in Wood Construction Towards 2030. In: Filho L (eds) Towards a Sustainable Bioeconomy: Principles, Challenges and Perspectives. Springer International Publishing, pp 499–516. https://doi.org/10.1007/978-3-319-73028-8_25.

Toppinen A, Miilumäki N, Vihemäki H, Toivonen R, Lähtinen K (2019a) Collaboration and shared logic for creating value-added in three Finnish wooden multi-storey building projects. Wood Material Science & Engineering 14: 269–279. https://doi.org/10.1080/17480272.2019.1653365.

Toppinen A, Sauru M, Pätäri S, Lähtinen K, Tuppura T (2019b) Internal and external factors of competitiveness shaping the future of wooden multistory construction in Finland and Sweden. Construction Management and Economics 37: 201–216. http://dx.doi.org/10.1080/01446193.2018.1513162.

Tykkä S, McCluskey D, Nord T, Ollonqvist P, Hugosson M, Roos A, Ukrainski K, Nyrud AQ, Bajric F (2010) Development of timber framed firms in the construction sector — Is EU policy one source of their innovation? Forest Policy Econ 12:199–206. https://doi.org/10.1016/j.forpol.2009.10.003.

United Nations Environment Programme (UNEP) (2021) 2021 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi.

Ministry of Foreign Affairs (UM) (2010) "Finland's climate asset in the future: wood construction". https://um.fi/current-affairs/-/asset_publisher/gc654PySnjTX/content/puurakentamisesta-suomen-ilmastovaltti. Accessed January 2022.

Vihemäki H, Ludvig A, Toivonen R, Toppinen A, Weiss G (2019) Institutional and policy frameworks shaping the wooden multi-storey construction markets: a comparative case study on Austria and Finland. Wood Material Science & Engineering 14: 312–324. https://doi.org/10.1080/17480272.2019.1641741.

Vihemäki H, Toppinen A, Toivonen R (2020) Intermediaries to accelerate the diffusion of wooden multi-storey construction in Finland. Environmental Innovation and Societal Transitions 36: 433–448. https://doi.org/10.1016/j.eist.2020.04.002

Viholainen N, Kylkilahti E, Autio M, Toppinen A (2020a) A home made of wood: Consumer experiences of wooden building materials. Int J Consum Studies 44: 542–551. https://doi.org/10.1111/ijcs.12586.

Viholainen N, Kylkilahti E, Autio M, Pöyhönen J, Toppinen A (2020b) Bringing ecosystem thinking to sustainability-driven wooden construction business. J Clean Prod 292, article ID 126029. https://doi.org/10.1016/j.jclepro.2021.126029

Viholainen N, **Franzini F**, Lähtinen K, Nyrud AQ, Widmark C, Hoen HF, Toppinen A (2021) Citizen views on wood as a construction material: results from seven European countries. Can J Forest Res 51: 647–659. https://doi.org/10.1139/cjfr-2020-0274.

Viļuma A, Bratuškins U (2017) Barriers for use of wood in architecture: The Latvian case. Architecture & Urban Planning 13: 43-47. https://doi.org/10.1515/aup-2017-0006.

Ministry of Finance (VM) (2021) Virkamieseettinen toimintaohje [Code of conduct for officials]. Report Valtiovarainministeriö 07/2021, Ministry of Finance, Helsinki, Finland. http://urn.fi/URN:ISBN:978-952-367-505-6.

Wang L, Toppinen A, Juslin H (2014) Use of wood in green building: a study of expert perspectives from the UK. J Clean Prod 65: 350–361. http://dx.doi.org/10.1016/j.jclepro.2013.08.023.

Xia B, O'Neill T, Zuo J, Skitmore M, Chen Q (2014) Perceived obstacles to multistorey timber-frame construction: An Australian study. Architectural Science Review 57: 169–176. https://doi.org/10.1080/00038628.2014.912198.

Ministry of Environment (YM) (2002) Finland's National Land Use Guidelines. Report 83, Ministry of the Environment, Helsinki, Finland, pp 38. https://helda.helsinki.fi/bitstream/handle/10138/135808/Ymp%C3%A4rist%C3%B6opas_93en.pdf?sequence=1 Accessed 17 September 2021.

Ministry of Environment (YM) (2017) Government decision on Finland's National Land Use Guidelines. Accessed 17 September 2021.

Ministry of Environment (YM) (2019) Puurakentamisen ohjelman kehittävä väliarviointi 2019 [Mid-term evaluation of the wood construction program 2019]. Report, Witmill Oy for Ympäriministeriö, Finland, May, pp 44.

Ministry of Environment (YM) (2020) National Targets for Public Wood Building. Report 09/2020, Ympäriministeriö, Helsinki, Finland, September.