Market development for multi-story wood construction

- Views of architects and structural engineers

Marknadsutveckling för träbygge i flervåningshus
Arkitekter och byggnadsingenjörers perspektiv

Isac Färnström

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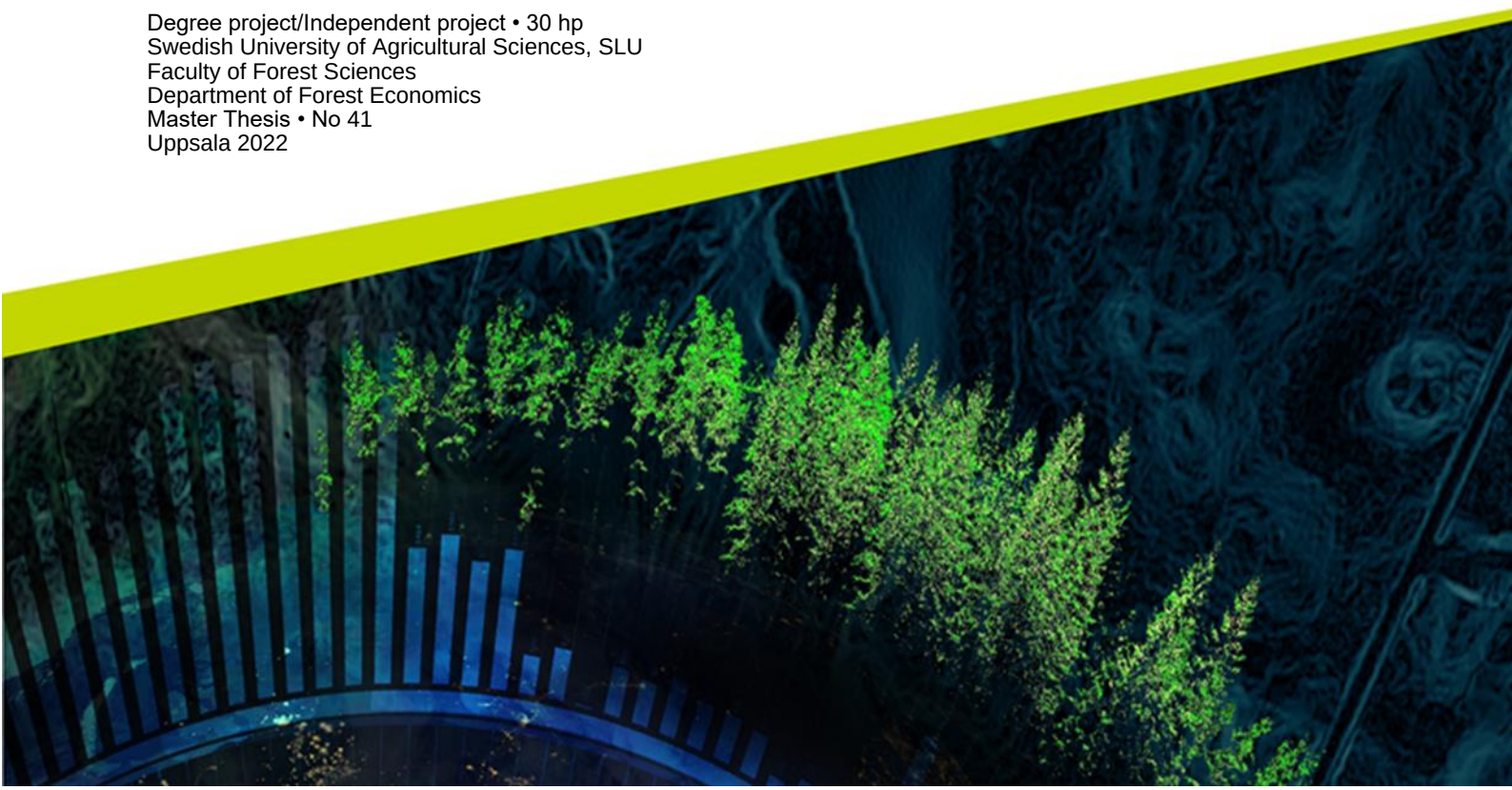

Market development for multi-story wood construction - Views of architects and structural engineers

Isac Färnström

Supervisor: Anders Roos, Swedish University of Agricultural Sciences, Department of Forest Economics

Examinator: Cecilia Mark-Herbert, Swedish University of Agricultural Sciences, Department of Forest Economics

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Swedish University of Agricultural Sciences
Faculty of Forest Sciences
Department of Forest Economics

Summary

The multi-story wood construction industry has been on the rise in the past decades because of new regulations making it legal in Sweden and Finland. Politicians have been suggesting more wood materials in buildings because of the positive environmental impact when wood stores carbon dioxide. Concrete is still the most used material in buildings and many developers have a poor perception of wood. The aim of this project was to analyze the wood construction industry in Sweden and Finland. More specifically to identify enabling and limiting factors and suggest measures for increased usage of wood. The method used was a qualitative and quantitative web survey directed to architects and structural engineers experienced in wood construction. The target group was reached by using connections from the project “Knock on wood” and reaching out to interest organizations. This project found that knowledge gaps among developers and contractors, high costs, and lack of standardized processes were limiting the industry. To overcome these issues and increase the usage of wood, the conclusion was: Industry actors need more education about wood construction, carbon taxes should be implemented on materials, and more prefabricated wood products should be made by the manufacturers.

Keywords: architects, back casting, enabling factors, gap-analysis, limiting factors, multi-story wood construction, structural engineer.

Sammanfattning

Flervåningsbyggandet med trä har ökat i Sverige och Finland de senaste decennierna efter ändringar i reglerna kring träbyggnad. Politiker föreslår att vi borde använde mer trä inom byggandet för den positiva miljöpåverkan trä ger när det lagrar koldioxid. Cement är fortfarande det materialet som används mest inom flervåningsbyggandet och många byggherrar har en dålig uppfattning av trä. Syftet med den här studien var att analysera träbyggnadsindustrin i Sverige och Finland. Mer specifik, så vill studien identifiera drivkrafter och begränsande faktorer, och sen föreslå åtgärder för att öka användandet av trä. Metoden som användes var en webbenkät för arkitekter och byggnadsingenjörer som har erfarenhet av att jobba med trä. Målgruppen nåddes genom att använda kontakter inom projektet ”Knock on Wood” and kontakta intresseorganisationer. Studien fann att brist på kunskap, höga kostnader, och bristen på standardiserade processer var begränsande för träbyggnadsindustrin. För att hantera de begränsande faktorerna och öka användningen av trä var slutsatsen att: Industrins aktörer behöver mer utbildning om träkonstruktion, koldioxidskatter bör införas på material och fler prefabricerade träprodukter bör tillverkas av tillverkarna.

Nyckelord: arkitekter, backcasting, begränsande faktorer, byggnadsingenjörer, drivkrafter, flervåningshus med trä, gap-analys

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Abbreviations

Abbreviation	Meaning	Introduced on page
CLT	Cross-laminated timber	30
Glulam	Glued-laminated timber	30
LVL	Laminated veneer lumber	30
LCA	Life cycle assessment	25
MWC	Multi-story wood construction	1

1 Introduction

This chapter provides a background to multi-story wood construction and its role in Sweden and Finland. The introduction addresses many parts of the industry and puts architects and structural engineers in the focus. Then the aim and research questions are presented.

1.1 Problem background

Wood construction has a long history in Sweden, especially for small houses where it accounts for 80-90% of the new construction (Government Offices of Sweden 2018). In 1874 Sweden decided to ban the construction of wooden houses with more than two floors after several major city fires. In 1994 the legislation was changed, and multi-story wood buildings became legal. The new law came in connection with new fire safety requirements, such as buildings being equipped with sprinklers and fireproof solutions (Coulson 2014). Wood can be used in different parts of the construction, most commonly as frame, insulation, cladding, or surface. In Sweden, the number of multi-story buildings constructed with a wood frame has increased from 9% of new construction in 2015, to 20% in 2019 (TMF n.d). Wood construction is also increasing in Finland. In 2010, only 1% of all apartment buildings could be defined as Multi-story Wood Construction (**MWC**). This figure had increased to 10% in 2015 (Toppinen 2015). The increase can also be explained by the changes in the Finnish building legislation 2011, where wood construction with up to eight stories was allowed. In this thesis non-residential buildings like schools, malls, or libraries will also count as multi-story buildings even if they are one story. The focus of this thesis is to promote wood construction and analyze the future market development for wood construction**.**

Building houses with wood is more climate-friendly compared to other materials, like steel or concrete since it stores carbon dioxide for the life span of the building (Churkina *et al*. 2020). The carbon emissions and energy used is also less from wood compared to concrete during construction (Gustavsson & Joelsson 2010). Wood construction also has other benefits, for example by simplifying the construction process and shortening construction times (Švajlenka *et al*. 2017). By harvesting and using wood in buildings, carbon dioxide is stored, and the climate impact is reduced. The growth in Swedish forests exceeds the harvest volumes that are used for buildings (Sveriges träbyggnadskansli n.d). Furthermore, Jim Coulson (2014), explains how the wood in buildings could be recycled at the end of its first use cycle. The wood could be either reprocessed into another wood-based material or used as biomass. When it comes to economic comparisons some argue it's more profitable and some not (Konttinen 2019). It seems to depend on other factors such as suppliers, planning, and experience. Hence, studies have shown that the advantages of timber construction are that it's climate-friendly, cheap, flexible, and low weight. Problems that have been identified are customers' perception of fire risks, decay risks, instability, and poor sound insulation (Roos *et al.* 2010).

The demand on politicians to meet the environmental goals from the European Commission is increasing and one of the key targets is to cut greenhouse gas

emissions by 40% by 2030, from the 1990 levels (European Commission, u.å). Wood construction can also be closely connected to four of the 17 UN sustainable development goals. The goals are “Industry, innovation, and infrastructure”, “Sustainable cities and communities'‘, “Responsible consumption and production” and “Climate action”. In 2017 the prime minister of Sweden pledged that more houses will be built with wood because it reduces the climate impact and creates jobs (Statement of Government Policy 2017). The Swedish government has made it clear that MWC is part of its strategy for reaching environmental goals and upholding its promises of acting for the environment. In Sweden, the law of climate declaration came into force in 2022 (Swedish National Board of Housing, Building and Planning 2021). The new law means the developer needs to declare all the climate impact from the building from a life cycle perspective. The purpose of the law is to reduce climate impact and to inspire the developers to learn more about the climate aspects of construction. The environmental goals, the political strategy and the new laws will lead to an increased focus at wood construction. If governments, companies, and individuals invest their time into increasing wood construction it is important to know how they can utilize their time and focus.

Important stakeholders in wood construction are developers, contractors, policymakers, consumers, and wood manufacturers. Architects and construction engineers both have a focus on the technical part of the construction. Architects have a bigger role in the design and shape, while construction engineers are experts in the construction process. These groups have specific backgrounds and education for dealing with different materials. However, representatives of the profession have declared that their education lacks training in wood construction techniques (Roos *et al.* 2009).

Previous studies show that architects have a more positive attitude toward using timber in all parts of the building, relative to developers and main contractors (Markström *et al*. 2019). Engineers and architects considered wood the most environmental-friendly material in both design and construction (Li & Xie 2013). However, construction engineers and, in Sweden, especially architects, often experience that they do not influence the choice of material, compared to the developer and entrepreneur (Roos *et al.* 2009). Construction engineers and architects can, to some extent, influence the choice of building material by promoting and arguing for wood. But it’s also the lack of experience and education on timber construction that is stopping architects and engineers from promoting it more (Roos *et al.* 2010). This study will be based on the views and experiences on wood construction of architects and engineers.

1.2 Problem

Wood is a renewable resource that can contribute to more climate-friendly building processes and can also store carbon dioxide. More climate-friendly construction fits both the Swedish and Finnish political strategies more than concrete buildings. Even though the percentage of wood-constructed apartments is increasing, 80% of all constructed apartment buildings in Sweden, in 2020, were built with a concrete frame, relative to only 19% in wood (TMF u.å). MWC has increased in the last

decades in Finland and Sweden and it has grown from being a small industry to now being promoted by politicians and interest organizations. The usage of wood has increased, but there are many challenges in the wood construction industry and many developers still prefer concrete. The New European Bauhaus is a political initiative from the European Union that connects the green deal to our living spaces. The values to work towards in the initiative is sustainability, aesthetics, and inclusion in our living spaces. If constructing with wood can contribute to those values, it would connect our construction closer to the green deal.

The rapid development has created a new industry and opinions on wood have been collected from consumers, scientists, entrepreneurs, architects, and municipalities. Studies suggest that lack of knowledge (Markström *et al.* 2019) and low productivity standardization (Aaltonen *et al.* 2021) are limiting the industry. One study (Edvard & Röhr 2016) investigated the future of MWC, and suggested knowledge transfer, technological aspects, and co-operating are crucial for the future success of this industry. Another study suggests a shift towards the strategy of service-dominant logic, which means exchanging competencies among groups to benefit all (Edward & Röhr 2016). Many different studies have been made on how to increase usage and improve the wood construction industry. The results differ in the studies, and it is unclear how these measures could be implemented and how different stakeholders can influence wood construction.

Now that wood construction has been allowed for almost three decades, more experiences have been collected and more wood projects have been implemented. Architects and engineers have much knowledge about production processes, cooperation, education, regulation, and policies. In particular, the respondents chosen have experiences in the wood construction industry and can help this study explain enabling and limiting factors in a competent manner. They also work closely with other stakeholders and have insights into the power dynamics and their stakeholder roles. Skillful architects and structural engineers are key to the future success of multi-story wood construction (Toppinen *et al.* 2019). These experiences and views can be used to examine the wood construction industry and investigate what improvements can be made. Actors in the wood construction industry can benefit from a bigger understanding of the enabling and limiting factors because it will help them develop the wood construction market. The result will improve the understanding of wood construction, which will help important stakeholders support wood construction and increase usage. In that sense, it becomes appealing to investigate the industry specifiers and their current perception regarding wood construction and future market development.

1.3 Aim and research questions

The aim is to examine how architects and structural engineers experience and view the multi-story wood construction industry. Their views and experiences will be used to identify the enabling factors that can help wood construction to increase and limiting factors that can lead to a decrease in wood construction. The overall objective is to give more insight into which decision-makers have the biggest

potential in solving the issues and which measures can be taken to increase wood construction.

- Which enabling and limiting factors are there in the multi-story wood construction industry?
- Which measures can be taken to improve the future outcome of the industry?
- How can the wood construction industry to contribute to Bauhaus values? (Sustainability, aesthetics, inclusion)

1.4 Structure

The structure of the thesis starts by introducing the readers with an introduction that covers the background and history of wood construction. Then the readers are introduced to the problem and the aim of the study. The theoretical framework that helps answer the research questions are then be presented. After that the methodological approach are explained. Then the results are presented and after that analyzed and discussed. After that the thesis is closed with conclusions.

2 Literature review

The literature review starts by presenting previous studies with results relating different advantages and weaknesses of wood construction. After that the review presents previous studies with results regarding measures for the future of wood construction.

2.1 Advantages and weaknesses of wood construction

The attitudes from different stakeholder are described as a big challenge for wood construction. Developers and contractors often have a more negative attitude towards wood compared to architects and structural engineers (Roos *et al.* 2010). Which limits wood since architects and structural engineers also saw their influence on wood construction as limited compared to contractors and developers. Architects and structural engineers found wood to be an appropriate construction material but with negative aspects in terms of sound insulation, instability, and decay. The positive aspects were the strengths, climate-friendliness, simple handling, and appropriateness for conjunctions. Swedish architects (Hemström *et al.* 2011) found in a study comparing concrete, wood, and steel that concrete was most suitable as a frame for a 3-8 story building. The reason for preferring concrete is the fire risk and instability in wood construction. The architects had a positive attitude towards wood construction, but it wasn't as adequately proven as concrete or steel.

Construction experts that do not work with wood were not opposed to Wood construction, but lack of standardization and low productivity benefits made the switch in practice not worth the risk. Nonwood construction experts, unlike Wood construction experts, also saw the impact of consumer preferences on material as relatively small (Aaltonen *et al.* 2021). The Consumer's view on MWC was that it had clear benefits from both the social and economic perspective, but also that it could risk deforestation and biodiversity loss (Nagy *et al*. 2021). Citizens had higher approval for wood construction in Sweden and Finland, compared to some other European countries, but the general approval for wood construction was high (Viholainen *et al.* 2020). In a study with contractors, architects, and developers involved in MWC the biggest reasons for choosing wood were the aesthetic appeal and low climate impact, while the biggest reason for not choosing wood was the lack of knowledge and information (Markström *et al.* 2019).

One study discusses multiple reasons for there being fewer wood buildings compared to other materials (Žegarac *et al.* 2021). The reasons are the complexity in the design for the selection of a suitable structural system and the fact that the energy efficiency depends heavily on factors such as location, climate, wind exposure, and risk for earthquakes. The study suggests that architects and structural engineers need to discuss some features in construction to adjust buildings to their local geographical and time context. Features in terms of design, structural systems, and materials. A study that examined buildings with timber frames and masonry surfaces found that those materials together have a good earthquake resistance (Dutu *et al.* 2012). The study compared how that type of building was constructed differently in different countries and how it fulfilled its different purposes.

2.2 Future of wood construction

One previous study was a questionnaire sent out to architects, developers, and contractors with the purpose of finding measures for increased usage of wood (Markström *et al.* 2019). The study identified some measures that they found would facilitate increased use of wood products in buildings. The measures discussed were incentives to select materials with a low climate impact, training and information, product development, and economic incentives. The study also identified obstacles for wood products in buildings which were: Mismatch in influence and material preferences, conflict of interest, and bad experiences with wood. They also concluded that demonstration projects weren't as effective as expected. One study in Sweden and Finland, evaluated which internal and external factors will shape the future of MWC (Toppinen *et al.* 2019). The result showed that skilled architects and builders are key for future success together with standardized building systems. The development of technical infrastructure and business network projects are key for influencing future competitiveness in the industry. Additional changes in regulation and law are on the other hand something that is perceived as less important for the future.

Finnish architects perceived that the biggest advantages with wood are that its lightweight, local and ecological (Emre Ilgın, Karjalainen & Pelsmakers 2021). They also perceived that wood construction needed more complex engineering which could risk turning expensive. Finish architects favored wood in low residential buildings instead of taller buildings. Slovakian architects favored wood in small architecture and residential buildings (Kaputa & Paluš 2014). Their attitude was more negative against using wood in technical constructions, industrial buildings, and civil buildings. This Slovakian study also showed a significant difference in attitude towards wood between younger and older architects, with younger architects being more positive. The authors found that to increase the wood among structural engineers and architects, the industry needs to solve the knowledge gaps and increase the support in the industry (Roos *et al.* 2010).

An American and Canadian study with engineers and architects analyzed the usage of wood in the non-residential construction market (Kozak & Cohen 1999). The results showed that specifiers perceived wood construction as functional, cheap, and considered environmentally friendly. They also perceived wood as bad for buildings with an occupancy of big amounts of people, because of fire restrictions. The authors provided strategies with the purpose of increasing wood in non-residential buildings. The strategies suggested focused campaigns based on market research with long-term goals and monitoring processes.

3 Theoretical framework

Chapter three starts with a theoretical approach and then presents the theories in the order sustainability transitions and innovations theory, theory of planned behavior, and stakeholder theory. The chapter ends with a conceptual framework describing how the theories support the analysis of the empirical material.

3.1 Theoretical approach

The theories were chosen to help answer our research questions about enabling and limiting factors, future actions, and the New European Bauhaus goals. Sustainability transitions explain more specifically the transition towards more sustainability and sustainability innovations can help describe the innovations involved in the transitions. This helps us understand what actions can have a positive impact on the transition. Theory of planned behavior and stakeholder theory were chosen to look more at the actors and individuals to analyze their roles in wood construction. Both what their roles are and how their behaviors can be influenced.

3.2 Sustainability transitions and innovations

Sustainability transition theory is a framework for understanding the transformation in society towards being more environmentally friendly. The wood construction industry wants to transition the construction industry into being more sustainable. Sustainability innovations will also help in mapping out which areas in the industry that could benefit from innovations.

Politics, policy, and policy processes are major components in the transition towards sustainability (Edmondson, Kern & Rogge 2019). One policy to push the transition can for example be to increase the internal cost of environmental damage, with carbon pricing or cap and trade schemes. Policies can stimulate transition with subsidies, grants, and incentives. Edmondson, Kern and Rogge (2019) have created a framework for analyzing how both policy and socio-technical systems affect each other on the journey towards sustainability transitions. Socio-technical systems are the work design of how people and technology work together in the workplace, towards sustainable change.

Policy mix affects socio-technological change with the policy instruments resource effects, interpretive effects, and institutional effects (Edmondson, Kern & Rogge 2019). Resource effects mean when a policy provides resources so it can influence the actors with activities and strategies to change the socio-technological system. This means politicians supporting wood construction financially in society. The interpretive effects involve policies providing information and support to change visions and meanings for the actors. This can for example be projects or support in campaigns. The institutional effects mean laws, regulations, and rules that clearly regulate the socio-technical systems to be more sustainable. These three keywords will be used to understand what types of measures the specifiers think will work the best for wood construction. In those three ways policy affects socio-technical

change but on the other hand socio-technological change affects policy with feedback mechanisms.

The socio-technological change affects policy mix with political feedback, administrative feedback, and fiscal feedback. Political feedback is whether actors or the public support the change in policy. Fiscal feedback is if the new policy creates a budgetary strain that makes actors question the fiscal value of the new policy. Administrative feedback is when the administrative bodies that are responsible for policy design and implementation act in a way that changes the internal morale, external reputation, and political support. These forms of feedback will be used in the thesis to understand how actors in wood construction affect politicians. Exogenous circumstances can also have an impact on both policy mix and socio-technological change, meaning that economic trends, demographic changes, and innovation have an impact (Edmondson, Kern & Rogge 2019).

One way for researching sustainability is through Boons and Lüdeke-Freunds (2013) business model for sustainable innovations. The authors found three streams that were most important for a sustainable business model. The first was technological innovation, which is the innovation in production processes, services, and products. The key to technological innovation is how well the business can commercialize and market the new technologies. The second is organizational innovation, which is transitions in routines, structures, and cultures, toward a more sustainable business model. The third is social innovation and that involves how well the business can create social value and maximize social profit. Developing the market with a social purpose gives the business the ability to be a market device for other innovations. This business model will be used to look at how the wood construction industry can innovate to increase the market share for wood.

3.3 Theory of planned behavior

Theory of planned behavior helps to explain how behaviors and attitudes change and the theory helps to examine the motivations for shifting from conventional construction to wood construction. It is used to analyze stakeholders and organizations in MWC and what their incentives are for switching to more wood construction. The theory of planned behavior explains the psychological parts of behaviors and the intentions behind them. Attitudes toward behavior, subjective norms, and perceived behavioral control can help predict the intentions to perform certain behaviors (Ajzen 1991).

An individual attitude toward a behavior is determined by their current beliefs about behavior (Ajzen & Fishbein 1975). Beliefs are created by individuals' subjective views of the probability that a behavior will produce a specific outcome. The evaluation of every outcome affects the individuals' attitudes towards the behaviors. It's the sum of all knowledge, experiences, and prejudices that are connected to a behavior (Ajzen 1991). For the stakeholders in wood construction, this could help explain how previous experiences and views influence the decisions on the material.

Perceived behavioral control is how much of our behavior we believe we can control (Ajzen 1991). Investigations show that behaviors are influenced by the confidence a person has in their own ability to perform the behavior. Perceived behavioral control together with intention, can be used to predict behavioral achievement. If we believe we have a high level of control, we will try harder to succeed (Ajzen 1991). This means that if wood promoters believe they can affect the decision on material, there is a bigger chance that they'll promote it more. In his thesis, this could also help explain why opinions and actions in decision-making don't always fit.

Subjective norms are the perception of reactions to different behaviors that friends, family, and society will have (Ajzen 1991). A common method for measuring subjective norms is to ask respondents if others would accept or reject certain behaviors. In our case, this could be how decision-makers in MWC think society and stakeholders will react to their choice of material. Since trends in society influence corporations to be more sustainable, subjective norms could have an impact on MWC. In wood construction, the different stakeholders such as engineers, architects, developers, and contractors have to adapt to each other's behaviors.

3.4 Stakeholder theory

Stakeholder theory is used to explain how organizations and processes are influenced by different groups with specific interests (Freeman *et al.* 2010*).* In our case, this will help us analyze how different stakeholders (e.g., Developers, constructors, politicians, architects etc.) affect the wood construction industry.

The stakeholder theory is created to help us understand business in a world where development depends on relationships between actors and how they depend on each other (Freeman *et al.* 2010*)*. The development of a business depends therefore on the stakeholders which can be groups and individuals. The stakeholders may have conflicting expectations and organizations must balance these opinions. They also hold different amounts of power over the organization and the stakeholders can be external and internal. The first fundamental in the theory is that the purpose of a business is to create value for various stakeholders. The second is that the focus of the theory is on the management of the business and its core. The third is that the theory does not separate ethical issues from business issues since it's all connected. Stakeholders that affect the wood construction industry can for example be politicians, media, contractors, developers, suppliers, etc. The stakeholders that is the aim of the study is architects and engineers. But their views and experiences from other stakeholders are also important.

3.5 Conceptual framework

The three streams of innovations in sustainability innovations theory will be used to analyze the empirical results. Technological innovation, organizational innovation, and social innovation will be keywords for analyzing what type of

innovation, the wood construction industry needs. The research will also analyze how politicians should use the policies, with the keywords resource effects, interpretive effects, and institutional effects. Analyzing the stakeholders involved will also be key to understanding our research questions. The stakeholders and their relationships will be analyzed in relation to industry of wood construction to understand it on a deeper level. From the theory of planned behavior, the keywords attitudes, subjective norms, and perceived behavioral control will be used to discover what influences wood construction actors and their behaviors. In the transition towards wood construction, these keywords will help us explain what affects the behavior of important stakeholders.

4 Method

This chapter provides a presentation of the approach and research design. The chapter starts with a presentation the methodological approach and the research design. After that the choices for data collection and then data analysis is explained. The chapter ends by presenting the search for reliability and validity, and ethics.

4.1 Methodological approach

This study used an abductive approach, which is a combination between the deductive and inductive approach (Bryman & Bell 2018). A deductive approach starts with a hypothesis about phenomenon and tests if its valid or not through observations. An inductive approach starts with the observations and tries to create a new theory from the data. This study combined the approaches by using empirical results and a conceptual framework to draw conclusions about the phenomena. The abductive approach matched our aim because the study needed to explain views and put them in relation to a theory.

4.2 Research design

This study has applied a flexible research design to a web survey for architects and structural engineers. Our aim was to examine the market development and since there are a lot of factors involved, we needed flexibility with both open-ended questions and answers-options (Bryman & Bell 2018). Open questions give the respondents the possibility to discuss outside the researcher's view and answer options help the researcher collect and analyze the data (Persson 2019). Using a flexible design can help the researcher both present their theoretical propositions and the basics of the results (Östlund *et al.* 2011). It will also help give a better understanding of the links between theory, empirical findings, theoretical assumptions, and new theories.

In this study, the unit of analysis was the wood construction industry in Sweden and Finland, and its role in the construction industry. The aim is to understand the wood industry better and focus on the future and growth. The items that were observed, measured, and collected, are views and opinions of architects and structural engineers that are experienced in wood construction.

4.3 Data collection

4.3.1 Web survey

Dillmans' (2014) book emphasizes that you must tailor the survey after the problem you are studying. This study wanted to research a wide array of viewpoints on wood construction and therefore we had to use multiple types of questions. The research questions asked the respondents to rank, prefer, predict, and explain factors in wood construction to give us an understanding of the wood business. A web survey was chosen because it has low costs, speed, and are easy to distribute and collect (Dillman *et al.* 2014). Web surveys also have the advantage that they can contribute

to good data accuracy because the researcher doesn't have to code the data as much as interviews and can therefore avoid errors (Bryman & Bell 2018).

The questions were worded and shaped based on Dillman *et al.*'s (2014) guidelines for ordinal closed-ended, nominal closed-ended, and open questions. The guidelines to provide a good survey were that the questions needed to be technically accurate, apply to the respondent, organized for respondents to comprehend, have simple language for understanding, and have concrete language for specifying (Dillman *et al.* 2014). The concrete words and concepts that were chosen were all common words for architects and structural engineers. Dillman *et al*. (2014) have multiple guidelines for making people answer the survey. First, you must understand how many pages to distribute the questions on. The web survey contained 29 questions spread out on five pages divided by categories. The survey also must have an informative welcome text and be interesting to answer. To make the survey interesting to answer, different kinds of questions are used. The argument for a variety of question types is to avoid giving the respondent an understanding of a "right answer".

The questions in the survey are presented in Appendix 1. The questions and approaches were shaped to align with the aim and theories. Our aim to understand the market for wood construction meant some open questions that could include very different answers. That's why multiple theories can be connected to each section of the survey. The structure of the survey can be found in Table 1, where the related theory and aim are connected to each section.

Table 1: Structure of the interview guide

Theme	Related theory or approach	Related aim
Introduction	No specific theory	Understand the respondents, and their general opinions
Limiting factors	Sustainability transitions and innovations, gap analysis	Identify limiting and enabling factors
Stakeholder roles	Stakeholder theory Theory of planned behavior	Measures to improve the future outcome of the industry
Future market development	Backcasting, Sustainability transition	Measures to improve the future outcome of the industry
The New European Bauhaus values	Sustainability transitions	Wood construction and its contribution to the European Bauhaus

Table 1 shows how the survey was structured into five sections and what the purpose of each section was. The first section of the survey asked for more general questions about them and about how wood compared to concrete in different categories. The second was about the challenges and gaps, both ranking the three biggest and discussing how to overcome the challenges. Page three is mostly about stakeholders and discovering their roles in wood construction, which is mainly connected to stakeholder theory. Page four is mainly backcasting and is structured so it first gives the respondents a future scenario and situation, for them to go on and answer a bunch of different questions about future actions. The last page is mainly about The New European Bauhaus Values and how wood construction can support that political initiative.

4.3.2 Gap analysis

In the second section on the web survey in Table 1, a gap analysis was used in the survey by asking the respondents about challenges and how to overcome them. The gap analysis was used in this survey for finding limiting factors, challenges, and problems for the industry to overcome. It contributed with a method for discovering gaps in businesses and seeing which parts of the business can be improved. Gap analysis involves a comparison between the current performance of an actor and the potential ideal performance or situation (Kim & Ji 2018). The analysis involves identifying when an organization, or in this case an industry, is not fulfilling its potential because of maladaptation in processes, practices, technologies, or strategies. The result will consequently help businesses to allocate their resources to obtain a more optimal level. The gap analysis helped this study to discover areas of weaknesses and shortcomings, find differences between reality and perception, finds the best places to deploy resources, and provide information to decision-makers.

4.3.3 Backcasting

This study used a backcasting approach to shape the questions and help the study obtain useful information from the architects and engineers. Backcasting was used in the fourth section of the interview, as Table 1 shows. Backcasting is especially useful when the problem is complex, there's a need for a major change, dominant trends are part of the problem, externalities are part of the problem, and the problem is long-term (Dreborg 1996). Backcasting is an approach where the researcher defines a desirable future and then analyzes how actors, organizations, or society can be coordinated to get there (Holmberg & Robèrt 2000). The key to backcasting is the concept called *the product*, which is an image of the future that society wants to attain (Dreborg 1996). In this thesis, the respondents were presented with a future state, and then asked for their ideas and opinions on how to achieve that state. In this survey, *the product* was described as a future situation where wood is a more mainstream material by 2030. Then they had the chance to answers different question on how the industry can improve. Backcasting originally came from analyzing sustainability problems and trying to figure out ideas for solutions. The method is applied to complex long-term issues in society, where innovation and new strategies can make a change.

4.3.4 Selection of respondent

The data was collected from Swedish and Finnish architects and structural engineers, also called specifiers, who are experienced in wood construction. The reason for that is their expertise in wood construction combined with knowledge of innovations and processes which are key parts of analyzing the future. It is important to make an assessment based on how well the sampling frame covers the target population (Dillman *et al.* 2014). The aim was to have knowledgeable respondents with much experience. The sample was reached both from connections and networks inside the project "Knock on wood" and for reaching out to interest organizations. To increase the number of respondents, the survey and interactions needed to show authenticity, use a professional design, build on past relationships, and show appreciation (Dillman *et al.* 2014). The survey was also distributed with a snowball method meaning the respondents were asked for recommendations on other good respondents.

4.3.5 Distributing the survey

The online survey was distributed by email to the sampling group where they were directed to Netigate for the survey. The software you choose to perform the survey is important and it is important to assess how well the software fits the demands (Dillman *et al.* 2014). This survey used the software Netigate to create and distribute the survey. Netigate was chosen because it fulfilled the demands of low costs, good data collection, and speed. There had to be an assessment made on if an internet survey fit the target group (Dillman *et al.* 2014). The general usage of the internet has increased, and you could assume most architects and structural engineers have access since technology is part of their jobs. Important guidelines to manage when distributing a survey are to make sure email isn't flagged as spam, be short and get to the point, be personal in messages, and give the respondents time before sending reminders (Dillman *et al.* 2014). To make sure that the email wasn't flagged as spam, the email was not sent from the school mail which has a history of being flagged as spam. The messages sent were also short, and personal, and the email emphasized how important their answers were to us.

4.4 Data analysis

4.4.1 Content analysis

For the open-ended questions, the data were analyzed through content analysis. Content analysis is a flexible method, where you quantify content and systematically divide it into categories (Bryman & Bell 2018). The answers were collected and analyzed with a content analysis by Schreier's (2012) method. The first step was analyzing the answers and identifying frequently recurring topics. Sentences were thereafter coded into these subcategories by their connections. For example, "Carbon taxes" was coded into the subcategory "Regulation". When the subcategories had been created, a few major categories were installed in the coding framework. To compare the categories, the frequency of each category was collected to investigate their opinions. Since the text must be analyzed in context as answers to questions, the frequencies of similar answers to the same questions

were in focus when creating the subcategories. The software used for the content analysis was NVivo which helped by simplifying the coding process.

The open-ended questions in this survey asked for opinions and suggestions on different factors in wood construction. For each question, we had 10 or 8 answers that were coded into certain opinions. Some of the answers were also ideas and opinions that could be used in other parts of the result other than what was intended by the questions. To present the results, this thesis will use important quotes from the respondents to showcase their views and opinions. It will also present the reoccurring opinions continuously in the text in connection to the quotes. The results of the coding can be found in Appendix 2, where categories and examples from the data are presented.

4.4.2 Descriptive statistics

For the questions with answer options, the analysis method was statistical analysis which involved investigating trends, patterns, and preferences. The statistical analysis involved calculating and summarizing the quantitative data by descriptive statistics. The descriptive statistics involved simple graphs to help the readers understand the results. The results are analyzed with simple frequencies to understand the opinions and preferences of the respondents (Robson and McCartan 2016).

4.5 Validity and reliability

The focus on reliability and validity involved making sure that the results were as accurate as possible. Validity means ensuring that the research methods are measuring what they are supposed to measure, and high reliability means that the results are the same if you repeat the research (Kirk & Miller 1986). The goal of science is to reach objectivity. One way to obtain that is by giving the readers a detailed explanation of how the study was made. By doing that, you are giving inspectors a chance to copy the experiment and see if they get the same results. Therefore, an effort was made from the researcher to elaborate the details in this chapter. Another way to seek objectivity is to justify your choice of variables and theories, to prove that they are theoretically meaningful. Therefore, the theoretical framework chapter also elaborated the background and purpose of the theories.

Dillman has identified four errors that researchers need to evade from to improve their survey (Dillman *et al.* 2014). The errors are coverage error, sampling error, nonresponse error, and measurement error. Coverage error takes place when the sampling doesn't represent the population and sampling error is the difference between results from the surveyed part of the sample and the entire sample. The action taken to evade from the coverage and sampling error was an effort to increase the sample size. Nonresponse errors happen when those who respond are different from those who don't and measurement errors occur when the survey isn't answered accurately because of poor survey design, bad interviewer and respondent behavior, mistakes in data collection, and survey mode effects. To avoid these problems, time and resources were directed at researching and designing the survey.

In content analysis, there are certain important aspects that you must adapt to when you search for reliability and validity (Graneheim & Lundman, 2003). It is important to strive for the closeness of the categories and ensure that you interpret the meaning without making far-fetched connections. You also have to focus on stability and make sure that the system you use could be remade. The accuracy is very important when you decide how you code the sentences. In this content analysis, the software NVivo was used to help to carry through the content analysis in a systematic way. The instructions from sources on how to accomplish a content analysis were carefully followed to strive for validity and reliability.

4.6 Ethics

Ethics are important both for the will to have good morals and the reputation as a researcher. The focus on ethics involved working on the safety of respondents and the people affected by the results. The goal is to make sure that there are no potential harm, anxiety, or negative consequences for any people involved (Robson & McCartan 2016). To ensure the respondents' safety, they have been anonymous, and their data is handled in accordance GDPR principles. The emails and survey also gave them much information to make sure they had given consent to use their survey results. Robson & McCartan (2016) discusses the political influences and argues the researcher should be aware of the potential biases. This thesis was part of a bigger project “Knock on wood” (Swedish University of Agricultural Sciences 2022), with the purpose to provide research on housing demand, housing supply, and governance mechanisms affecting the wood construction industry. The aim is also to support wood and climate-wise construction. Therefore, there is a risk that the results get influenced by the rest of the project. That’s why this thesis has been open about its support and bias toward wood construction and has chosen to be transparent. But that hasn't stopped the thesis from striving for credible results.

5 Empirical background

This chapter provides empirical background on the political strategies that can be connected to wood construction. After that, it presents the professions of the respondents and their roles in projects.

5.1 Political context

In Swedish housing policy, the aim for the government is to give all residents in all parts of the country a good living environment (Government offices of Sweden 2018). It is important to have a focus on social values, long-term management of natural resources, and economic development. More wood construction in Sweden could move jobs to the countryside because the production industries often place itself close to the raw material, which are forests. The government offices of Sweden (2018) want more collaborations between the Nordic countries, since they all need more housing and have large forests. Sweden has launched several programs and initiatives to increase the industrial wood construction. The Swedish strategy involves more cooperation, knowledge improvement, more research, development and innovation, and export promotion initiatives.

In Finnish politics, there is also a big support of wood construction. Finland has added long term carbon-storage products into several national programs and strategies (Ministry of Agriculture and Forestry of Finland 2022). For example, wood storage products are promoted in the National Energy and Climate Strategy, National Forest Programme and Finnish Bioeconomy Strategy. The National Wood Building Programme in Finland aims to promote growth of wood construction and long-term carbon storage in wood construction. The Programme wants more wood in urban areas, public buildings, but also in bridges and halls. The Programme develops rules and regulations, publishes reports and studies, and promotes industrial wood construction solutions.

5.2 The New European Bauhaus

The New European Bauhaus initiative was created by the European union to connect the European Green Deal to our lives and living spaces (European Union n.d). The European Green deal has the aim for the EU to be climate neutral with net-zero greenhouse gas emissions by 2050. The initiative aims to connect different backgrounds, and disciplines to increase building with participation. The new European Bauhaus supports the values of sustainability, inclusion, and aesthetics. The sustainability value involves climate goals, circularity, biodiversity, and zero pollution. Aesthetics means increasing the quality of experience and style, beyond functionality. Inclusion involves valuing diversity and securing accessibility and affordability. This has led to the creation of wood4bauhaus which is an open platform supporting wood construction. The main objectives for wood4bauhaus are to: Promote innovative uses of wood in construction through research and innovation, set up new collaborations and co-creation between stakeholders from a

range of disciplines, sectors, and societies, and promote knowledge sharing and skill development, especially for future generations.

5.3 Architect and structural engineer professions

Architects are responsible for the design of the buildings (Framtid.se n.d). They develop proposals on the design with drawings, models, and text. The design involves how the rooms should be located, where the windows should be, and which material to use. Architects can work both with new projecting for new buildings and redesigning older buildings. Architects need to have knowledge in both technical, economical, and environmental factors, as well as the aesthetical. Architects are often early into the projects and works closely with contractors, developers, and structural engineers inside the projects. There are many different specializations architecture, for example residential architects, landscape architects, and industrial architects. The educations take mostly five years but depends on the type of education.

Structural engineers are experts in the construction process and the technical parts of the construction (Framtid.se n.d). Structural engineers plan, design, and produce parts of the buildings to make sure that the construction is done correctly. A structural engineer must turn the drawings of the architects into more specific plans with more details. The focus is more on the load bearing structure and how that will be designed. To be successful in the role, it is important that they can adapt to the requirements on sustainable, cheap, and effective construction. Structural engineers work closely with architects, contractors, and developers.

6 Results

This chapter presents the results based on the web survey. The chapter will start with a description of the respondents and moves on to their opinions on weaknesses and strengths for wood. After that the identified enabling and limiting factors are presented. The chapter ends with the respondents' views on the New European Bauhaus values.

6.1 The respondents

The ages of the respondents range from 31 to 59 years. Five of the respondents were architects, four were structural engineers, and one of the respondents chose "other" as their profession. Ten respondents answered the survey, but only 8 followed through. Respondents 1 and 7 answered about 30% of the survey. Respondents 5, 6, 8, 9, 10 had experience from being at managing positions with responsibility in their roles. Seven respondents were from Sweden, two were from Finland and one chose not to answer. In Figure 1, the respondents experience in projects can be found. The results showed that eight out of nine respondents had experience in working with residential buildings. The respondents were also experienced in office buildings, schools, and warehouses. Only one of the respondents had experience in constructing libraries.

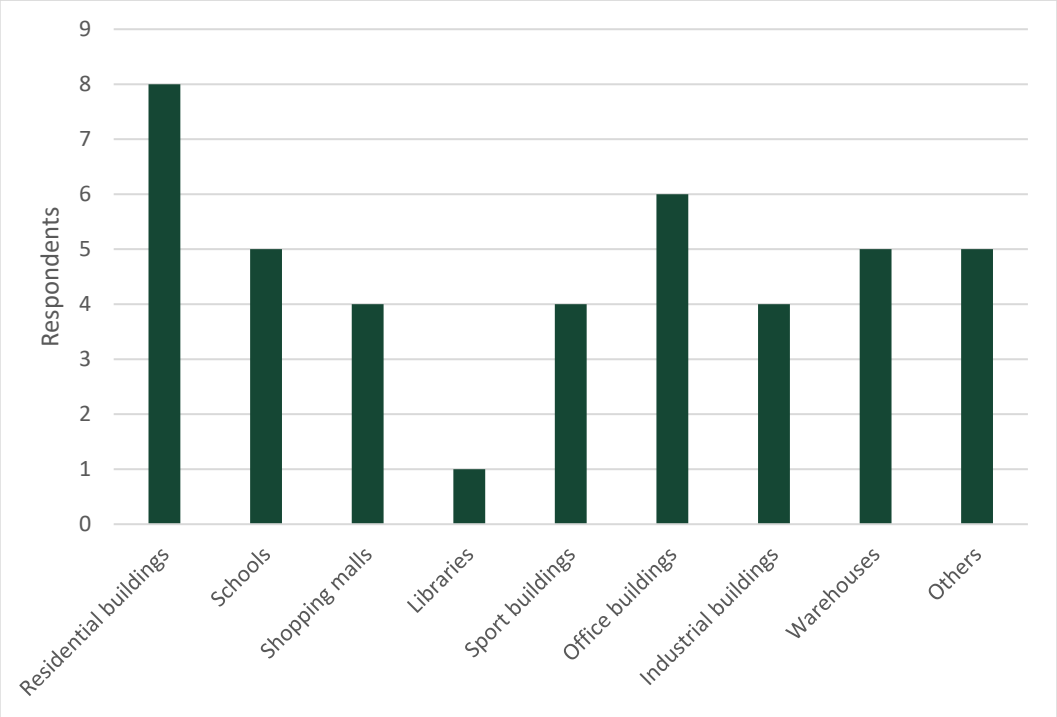

Figure 1. The respondents' answering which types of wood construction projects they have been in.

The respondents were above asked to check boxes for the types of construction projects they have experience in. The results are compiled in the figure above. On the X-axis, the different projects can be found and on the y-axis the number of respondents with experience can be found.

6.2 Advantages and weaknesses

Concrete is the biggest competitor to wood in the construction industry. Concrete is the most used material and decision-makers often must decide on wood or concrete. The respondents had to answer how wood performed compared to concrete in seven categories shown in Figure 2. As shown, architects and structural engineers experienced in wood construction had environmental friendliness as the biggest advantage with wood. Other than that, wood also performs strongly when it comes to aesthetic appeal, having fast and simple construction processes, and customers' preferences. Architects and structural engineers saw developers' preferences as the biggest weakness for wood. The costs were also a weakness for wood compared to concrete. Respondent 6 also ads that are low weight, quiet construction, and being predictable when it comes to fire risks are other strengths with wood as material.

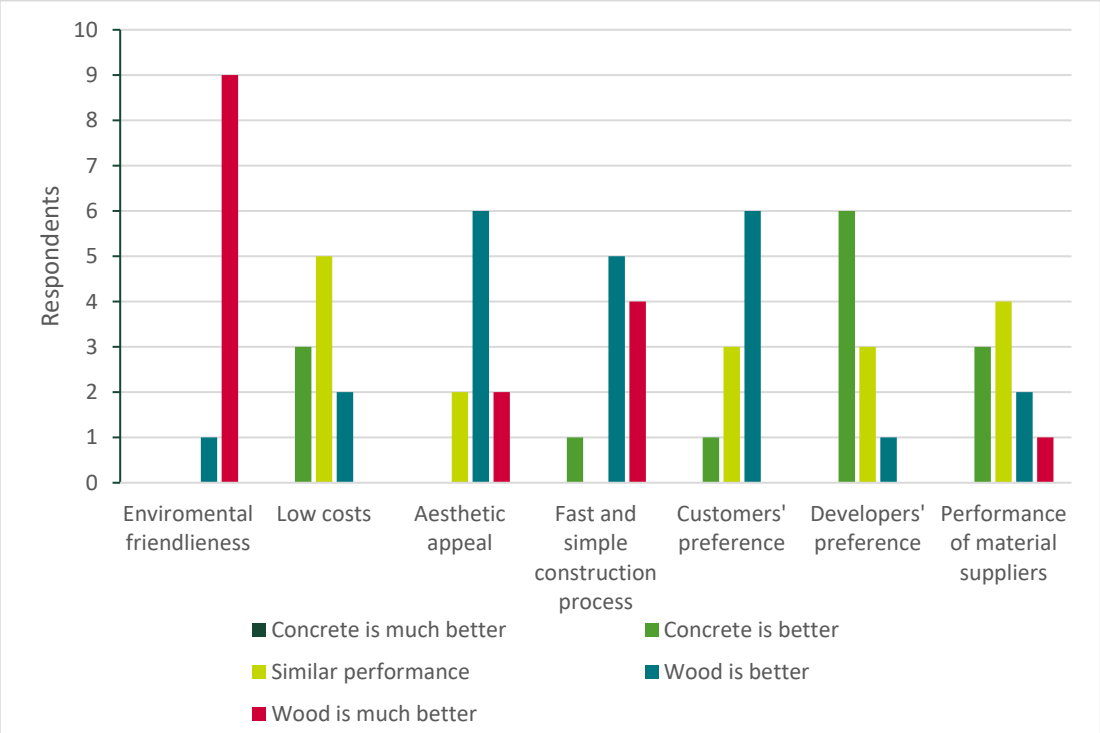

Figure 2. The respondents' ranking the performance of wood compared to concrete seven categories.

In the figure above, you can see the results from when the respondent ranked wood compared to concrete in seven categories. They chose how wood performed on a 1-5 scale, that can be found in the bottom of the figure.

6.3 Limiting factors

To understand how to improve the industry, it is important to understand the challenges and problems. The respondents were asked to rank the three biggest challenges with wood construction in Figure 3 and then explain their answers.

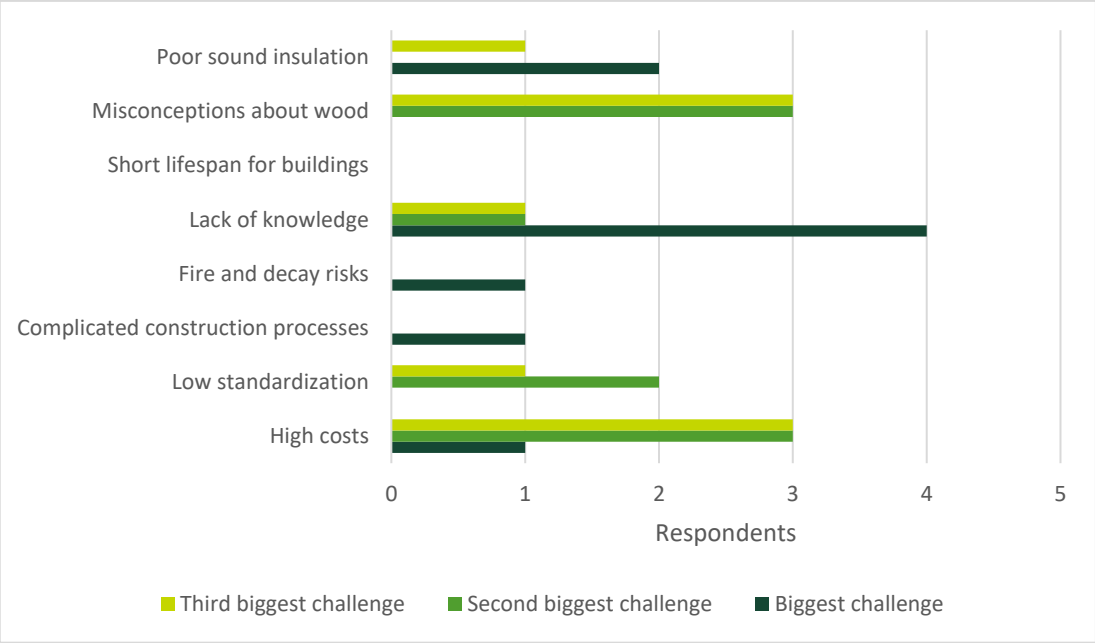

Figure 3. The respondents' opinions on the three biggest challenges for the wood construction industry.

The respondents had to choose the three biggest challenges in wood construction according to them. On the right side of each category in the figure above, the frequency of the respondent's decision can be found. If they chose it as biggest, second, or third depends in the color that can be found in the bottom of Figure 3. Based on the answers in Figure 3 and from explaining their answers, three categories of challenges were identified and explained under the subheadings.

6.3.1 Lack of knowledge and misconceptions

The lack of knowledge and education gaps among developers and contractors was the category with the biggest frequency in Figure 3. Six respondents found lack of knowledge to be a challenge, and four of them found it to be the biggest challenge. When we asked the architects and structural engineers how well their education had prepared them for wood construction, respondents 5,8,9 and 10 answered that they had not been prepared much. The respondents 2, 3, and 8 specified that lack of knowledge is a problem for all the stakeholders.

"The lack of knowledge is not only for the contractors and developers but also for engineers and architects, meaning that it could be a big hurdle to do a timber project" (Respondent 8, 2022).

As respondent 8 indicate above, the knowledge gap exists for all professions in the industry, not only developer and contractors as some think. Six of the respondents also identified misconceptions as a challenge for wood construction in Figure 3. Many of the problems around sound, fire safety, and decay risks are over-exaggerated according to the respondents, and one respondent suggests a reason for the misconceptions.

"*Metal and concrete industries have been lobbying the market and decisionmakers for years. Accurate information of wooden products, constructions and prices are needed internationally" (Respondent 9, 2022).*

As suggested above, the metal and concrete industries are responsible for some of the misinformation. They are lobbying the market and decisionmakers to benefit their businesses.

The respondents 7 and 8 both chose misconceptions and they both discussed the issue in a very similar way. They both bring up how fire risks, sound insulation, and moisture problems have proven solutions and are predictable, which makes them easy to deal with. The problems are that many actors in the industry do not know about these solutions.

"When designing a timber building you almost always get the same questions of how you can overcome fire safety, sound insulation, and moisture. There has been very much research about this in the past years and the timber industry has a lot of different proven solutions" (Respondent 8, 2022).

Some actors don't know about how to handle the challenges even though proven solutions exist. The quote indicates that it is annoying for actors in wood construction to get these questions when there is a lot of proven solutions.

6.3.2 High costs

High costs were the second most chosen answer as a challenge, in Figure 3. Respondent 9 suggested that the problems of high costs are also part of misconceptions, but high costs were for other respondents still seen as a big problem for wood construction. In Figure 1, concrete performed better as a material in terms of costs compared to wood. The costs are also affected by the state of the world now which makes the prices more uncertain.

"But with crises in the world, now both Covid, and most recently Russia invasion and war in Ukraine, then the world market will be affected and prices uncertain" (Respondent 6, 2022).

As the quote above suggests, the prices are even more uncertain right now than usually, which could make the transition even harder. The costs and uncertain prices of wood could make the transition into a riskier decision.

6.3.3 Low standardization and product gaps

Low standardization was also chosen as a challenge, by three respondents in Figure 3. Respondent 8 has opinions on the standardization problems in the industry.

"The sizes of the timber components are standardized, but not so much the connections between different timber elements. For large buildings the connections are often made specially for that building by the timber supplier. These specialty

connectors could be difficult to find, if you dont have a good contact with a timber supplier" (Respondent 8, 2022).

As they describe, the problem with standardization was the connection between different timber elements and how it led to a more complicated construction process. The connection in sizes was not the problem.

Even though respondent 8 brought up poor sound insulation as a part of the misconceptions with solutions. Respondents 6 and 2 still choose poor sound insulation as the biggest challenge and argued that the products needed development to solve this issue.

"My experience is that sounds is the most difficult challenge to handle, especially the requirements in housing, then you have to think about it, and there will be some investigation during the design" (Respondent 6, 2022).

The products being underdeveloped was limiting the industry in many ways by complicating the process, causing humidity problems, and not sound-insulating well enough. Respondent 3 who chose sound insulation as the third biggest challenge also discusses this issue.

"Acoustic performace in light weight structures are well known. There are ways of dealing with it, but they bear a significant cost, especially if designed by less knowledgeable consultant "(Respondent 3, 2022).

Respondent 3 bring up that there are well-known ways to deal with acoustic performance, the issue is that the solutions bear a significant cost. Which indicates that the limiting factors connects and affects each other.

6.4 Enabling factors for future development

6.3.1 Wood construction 2030

One question asked the respondents what they wanted the wood construction industry to look like in 2030, to understand how much can increase and not cause problem in forests. Respondent 4 wanted the industry to be more open-minded and experienced by 2030. Respondents 5 and 6 also suggested that wood should be in the discussion for every project.

"Wood is to be taken into account in every project" (Respondent 5, 2022).

As the quote above suggests, wood should be discussed in every project. The decision does not always have to land on wood, but I should be a clear option. Respondents 2 suggested that wood should be the first choice as a frame material in all projects.

"In 2030, wood should be the obvious first choice as a frame material" (Respondent 2, 2022).

The previous respondents suggests that wood should be considered in every project, respondents 2 adds in the quote above that it is especially as a frame material that wood should be the first option. Respondent 9 were even more ambitious.

"Entire new wooden constructed cities, villages and neighborhoods are in process. The new ecological, carbon-free way of living is dominant" (Respondent 9, 2022).

In the quote above, respondent 9 suggests entire wooden constructed cities. The quote also suggest that this process is already in motion and on the way.

6.3.2 Education and information

The enabling factors are the events and actions that should happen for wood to get a favorable future development. The general opinion throughout the survey is that education, information, and certain people learning things are important for the development. Lack of knowledge and misconceptions were chosen as big challenges for the industry in Figure 3. One suggestion on how to deal with those problem is through education as respondent 8 suggests below.

"We need more education, both at university and for the people in the building industry" (Respondent 8, 2022).

As the quote indicates, education is lacking both in the school system and in the industry. Which also indicates that school system and wood industry needs to find ways to spread education. Both respondents 4 and 8 think information and knowledge should be distributed more inside the industry, and respondent 8 has one suggestion below on how to do it.

"the timber industry has a lot of different proven solutions. But these can sometimes be difficult to find, it would be nice with a publication that shows different proven solutions" (Respondent 8, 2022).

The quote above suggests that if we want to overcome the problems regarding misconceptions in the industry, proven solutions to problems could be collected in some sort of publication. Because the wood industry is not fully developed, there are no clear standards on how to work. And as the quote below suggest, it is important to distribute and show examples of how other projects have worked previously.

"...is required that independent bodies or industry organizations begin to develop universal solutions. Today, every supplier has "their way" (respondent 4 2022).

As respondent 4 argues above, for developers to choose wood, there must be more universal solutions that can be followed in the projects by the other actors. Industry organizations can contribute much by developing these universal solutions. It does not only have to be industry organizations that creates universal solutions, as respondent 9 suggests below.

"By learning from each other and by unifying building codes and standards" (Respondent 9, 2022)

As suggested above, building codes and standards can be reached by collaborations with knowledge exchange between different actors in the industry. It is important to learn from each other as implied below.

"By showing the world what is possible with wood. Good examples are Mjöstornet in Norway, and Sara kulturhus in Skellefteå." (Respondent 8, 2022).

Respondent 8 also highlights the importance of projects leading the way and showing others what is possible, the respondent also gives two examples of buildings that can be inspiration.

6.3.3 Regulation and policies

To overcome problems with high costs, the respondents suggest lower taxes or carbon taxes. Respondents 10 and 6 specifically name carbon taxes, while respondent 3 specifically wants more rules around the **LCA** (life cycle assessments) and extra costs for bad LCA solutions. Requirements on the projects making life cycle assessments are also suggested as an idea on how to push decision-makers towards using wood.

"The new swedish regulations for LCA will increase the demand for wood buildings for a long time to come, if it is implemented as described by Boverket. Reducing raw material use will reduce both LCA and wood cost, thus an opportunity... Requirements on LCA. Sufficient economic cost for less good LCA solutions "(Respondent 3, 2022).

As respondent 3 explains above, requirements on LCA are something that has already been implemented and has good potential, but politicians can also add more requirements to make it more expensive for developers who don't build with sustainable methods. The state can also use its power with wood construction strategies when they distribute plots to different developers *(Respondent 8, 2022; Respondent 9, 2022; Respondent 9, 2022)*.

"National and local municipalities role in planning masterplans, zoning and detailed plans is very important. Politic pressure also from decisionmakers" (Respondent 9, 2022).

As explained above, policies around zoning and masterplans are something that can help increase wood construction. Zoning involves politicians dividing areas into zones with certain rules. The rules around zoning can be used in different ways for increasing the requirements for construction with sustainability.

When choosing between economic support, promotion, or strict regulation in Figure 4, stricter regulation is seen as the most efficient instrument. Implementing carbon taxes or other rules around emissions is seen as very important. But there is also support around economic support and encouraging developers to use wood by

making it cheaper. In Figure 4, economic support was chosen as more important that information and promotion from policymakers. By making it cheaper with different discounts, the respondents think the switch from concrete to wood will be easier.

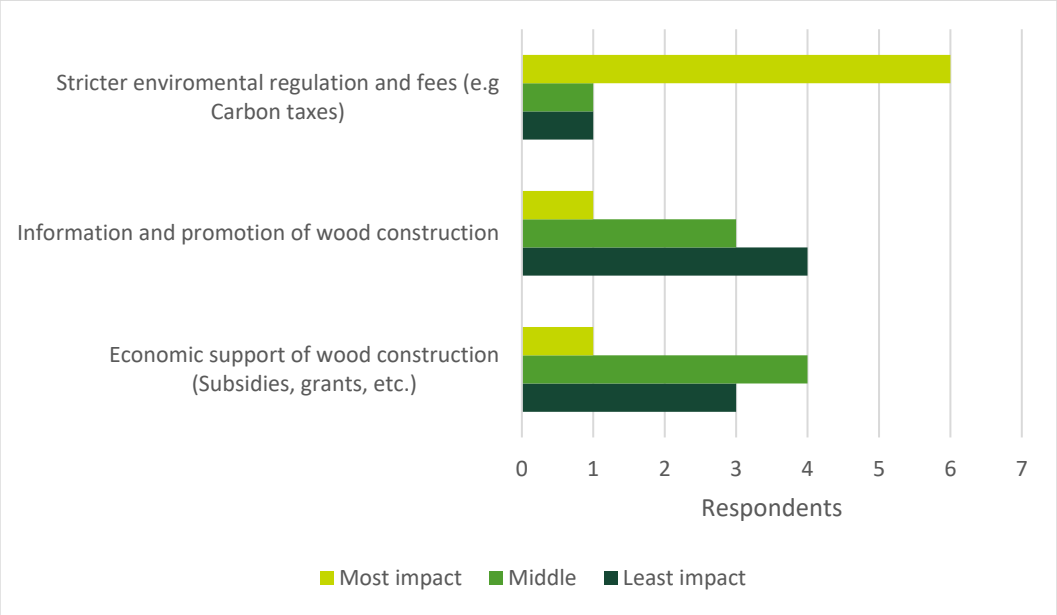

Figure 4. Views on policy instruments and their effect on wood construction in terms of impacting a transition process.

In the figure above, the respondents answered how much impact three different policy instruments can have on wood construction. The policy instruments are shown on the y-axis, and the number of respondents and their decision can be seen on the x-axis. The color of the piles decides if it was chosen as most, middle, or least impact.

6.3.4 Developing better products and processes

One repeatedly brought up enabling factor for wood construction is that wood manufacturers should become better at prefabrication. Improving prefabrication could solve problems around humidity, costs and help simplify the construction process. Becoming better at prefabrication is a highly suggested action for helping the process *(Respondent 4, 2022; Respondent 5, 2022; Respondent 10, 2022).*

"Humidity management at the site: to prefabricate building at high level in the factory indoor" (Respondent 5, 2022).

As respondent 5 suggests in the quote above, prefabrication could help the humidity management on the construction site which is a challenge. Respondent 3 also suggests that the costs of using tents in the building process were too high to be beneficial. Solving the issue around delivery times could also simply the construction process. The simple construction process becomes more complicated and expensive when delivery times are bad. To solve this issue, the industry needs increased capacity to reach shorter delivery times (Respondent 8, 2022).

Becoming better at lean processes and utilizing material could also help the process become cheaper and more sustainable, according to the respondents *(Respondent 3, 2022; Respondent 9, 2022).*

"Large scale industrial factories making really good use of the resource = High utilization of wood material in innovative, composite products" (Respondent 3, 2022).

As described by respondent 3, large factories making good use of resource are important for the industry. Another suggestion for a change in the structure is that frame designers feel that they come into the process to late, which causes a lot of problems later in the project.

"We designers need to get into earlier stages. We frame designers above all. We arrive too late, as the system has already been done, ..., which entails increased costs during planning, as well as delayed schedules" (Respondent 6, 2022).

As respondent 6 explains above, frame designers coming into the project to late causes problems with delayed schedules, which also increases costs.

Issues around sound insulation and acoustics are described as big challenges for wood construction in Figure 3. And even though some respondents suggested there are solutions to the problems, there is also a need to overcome the problems with innovation.

"*The biggest problem I experience is building in wood today. The knowledge of acousticians and the products that solve the problem of holding a frame together and sound insulate at the same time must be developed*" (Respondent 2, 2022).

As respondent 2 suggests, the sound insulation problem is big, and the industry needs to develop products and technology that helps overcome the problem.

6.4 Important stakeholders and their contribution

6.4.1 Influence over the selection

Different stakeholders have power over different areas of the construction project. To help us understand how stakeholders influences the selection, we asked the respondents to rank the stakeholders with the most influence in the selection in Figure 5.

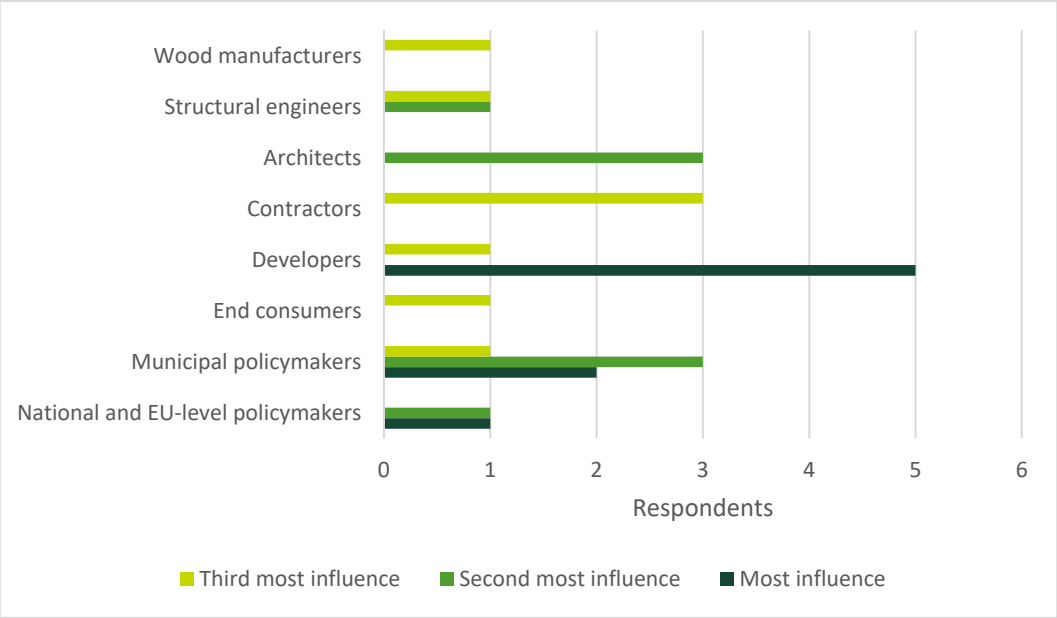

Figure 5. Stakeholders ranked after their influence over the material selection according to architects and structural engineers.

The stakeholders are listed on the left side of the figure above. Next to the stakeholders are the number of respondents who chose the stakeholder as most, second or third most influential.

Developers were chosen as the stakeholder with the most influence over the selection of building material in Figure 5. Respondent 7 describes how the power dynamic works.

"Developers are often the ones with the money, and therefore have a lot of power regarding what materials will be used" (Respondent 7, 2022).

As described above, developers are taking the final decisions and controlling the projects, which gives them a lot of influence with the final say. Municipal policymakers were chosen as the second most influential stakeholder over selection. Respondents 6 and 7 discuss how municipalities have wood construction strategies and can also influence the selection by offering cheaper and better plots for wood projects.

"Municipalities have the last few years decided that certain neighborhoods need to have a timber as a structural material, thereby forced the developers to build with wood" (Respondent 7, 2022).

Like respondent 7 explains, municipalities can use their power over land to force developers into using sustainable materials. Architects are also seen as influential in the selection because they are involved early in the projects and can therefore push the project towards a certain material.

6.4.2 Influence over the development, innovation, and improvement

To understand the measures for increasing wood construction, it is important to understand which stakeholders have the potential to improve the industry. The respondents were asked to rank the three stakeholders with most power over the development, innovation, and improvement of wood construction, in Figure 6.

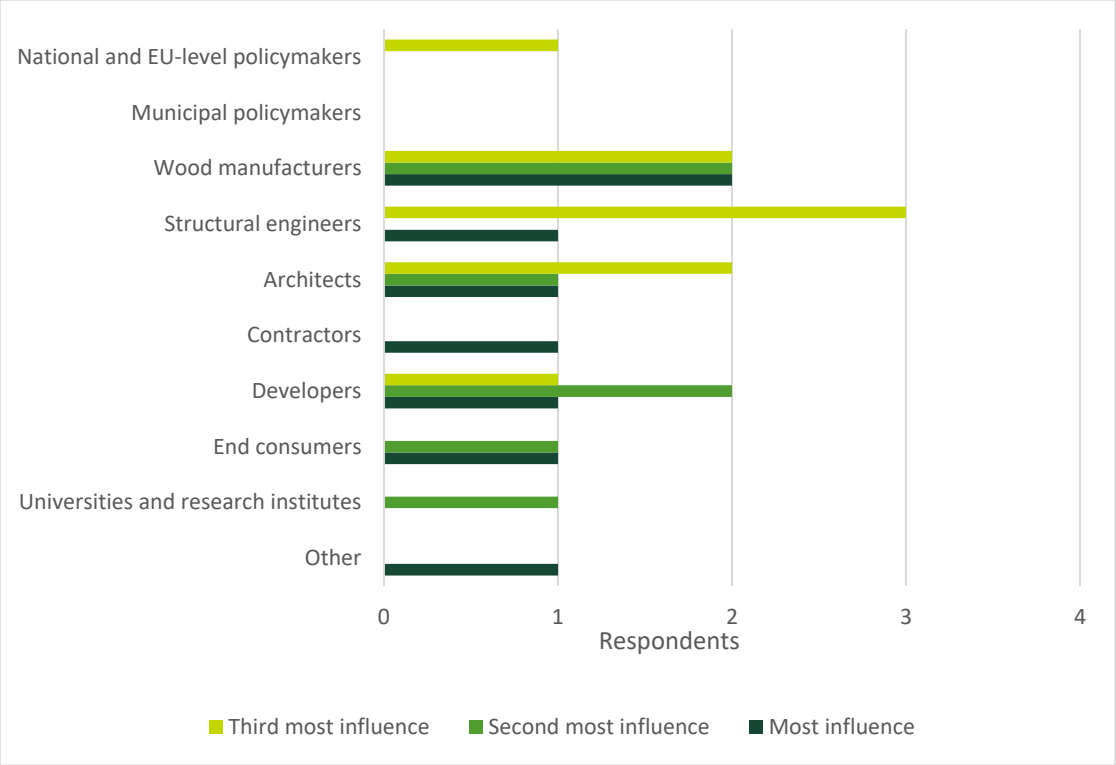

Figure 6. Stakeholders' and their influence over development, innovation, and improvement, according to architects and structural engineers.

Figure 6 are structured the same way as Figure 5 with stakeholders listed on the y-axis. Next to the stakeholders are the number of respondents who chose that stakeholder as influential, and the color depend on if the respondents chose it as first, second, or third most influential.

The answers were very different, and a lot of different stakeholders can be seen as important for the improvement of wood construction. Wood manufacturers were chosen more frequently than the other alternatives and they have historically been important for the industry. Six respondents saw wood manufacturers as influential in table 8.

"The wood manufacturers have historically done the heavy lifting regarding research and developments in structural materials such as Glulam, LVL and CLT" (Respondent 8, 2022).

Like respondent 8 describes, historically wood manufacturers have been leading the innovation and development in the wood industry. More specifically they have

achieved major progress with **CLT** (Cross-laminated timer), **Glulam** (Glued laminated timber), and **LVL** (Laminated veneer lumber).

Wood manufacturers are also the stakeholders responsible for developing more prefabricated products, which are one of the key enablers for wood construction. Developers and architects were also chosen by five respondents each as influential in Figure 6. But the structural engineers also have an important role in the development of these products and were chosen by four respondents in Figure 6.

"For innovation of building products, the structural engineer is needed, possibly employed by a university/institute "(Respondent 3, 2022).

As explained by respondent 3, structural engineers also carry an important role and if they employed by university/institute they can contribute to the development and innovation of the industry.

6.4.3 Stakeholders

To help clarify how different stakeholders can contribute, the respondents were asked about different stakeholders and their roles in developing and promoting wood construction.

Wood manufacturers
Wood manufacturers were seen as one of the most important stakeholders for development, innovation, and improvement, as you can see in table 8. When we asked our respondents for actions from wood manufacturers that could improve the wood construction industry. The respondents repeatedly brought up prefabrication as something very important that wood manufacturers could improve on (Respondent 4, 2022; Respondent 5, 2022; Respondent 10, 2022*)*. The respondents argue that they need more prefabricated products and in general learn to prefabricate better.

Respondent 2 sees room for improvement in terms of more solutions for sound insulation and fire safety. The materials the manufacturers need to improve in are CLT, Glulam, and LVL. Another respondent gives us a more detailed example of how manufacturers could improve

"Develop their production line, more cnc machining, and better machines, so manual adjustments become fewer. For example, sharp corners are with many manufacturers a costly procedure, as it must be readjusted when milling ex. one doorway. The cutter leaves a rounded corner as the radius of the cutter cannot mill sharp corners. It must be possible to develop here" (Respondent 6, 2022).

As described above, the manual adjustments should be fewer and developing machining could help by reducing those. Sharp corners are given as an example of an area for improvement. As said, research and development have been identified as two key factors in wood development and wood manufacturers have an important role in the research and development.

"They also have the most knowledge on how to build timber structures, just needs to spread their knowledge a bit better "(Respondent 8, 2022).

The manufacturers have the most information on how to build, which means they have the most potential for spreading the knowledge. Education and information were identified as an enabling factor for the industry, and the manufacturers plays a central role in spreading information.

Developers (Public and private)
Developers plays a key role in both the selection of material and the improvement of the entire industry, as shown in table 7 and 8. Lack of knowledge were seen as problem for developers and multiple respondents argue that developers need more experience and knowledge. In the subchapter "Education and information" the respondents suggested how the industry can help with schools, collaborations, and publications,

"To become more experienced with wood construction, take the plunge and build with wood. Take help from the wood manufacturers in the beginning since they have a lot of knowledge and experience" (Respondent 7, 2022).

Respondent 7 brings up that the developers need to take responsibility and commit to constructing with wood, for them to get more experience and knowledge. They can also take help from manufacturers to get started. The transition among developers is also seen as an ongoing process where wood is becoming more and more popular among developers.

"It is an ongoing process. Show the sustainability aspect and create added value for the end customer with the choice of wood" (Respondent 2, 2022).

Like respondent 2 suggests with ongoing process, wood is becoming more and more popular among developers. To benefit from the transition, the developers can use the sustainability aspect to show the end customer.

Architects
The respondents pointed out that architects sometimes make wood projects more complicated than they need to be *(Respondent 3, 2022; Respondent 5, 2022)*.

"Wooden buildings don't need to be "wow-architecture" every time" (Respondent 5, 2022).

As suggested above, being simpler in the construction process and suggesting wood to regular buildings, would help the industry. Right now, the architecture often tries to be to special. Respondent 6 also describes how the architects can imporve.

"Draw more wooden frames, learn about the limitations and possibilities there are to use wood as a load-bearing frame" (Respondent 6, 2022).

Architects also must commit to learning more and invest their time in learning more about wood construction. More specifically they need to be able to draw wooden frames that are load bearing. They can also have a different mindset in the beginning of the projects.

"Think wood construction early in the design, that will make it much easier to make a really good wood building further into the project" (Respondent 7, 2022).

As the quote above suggests, the architects can focus more on wood early in the projects, which will benefit the process later in the project.

Structural engineers
Respondent 7 makes the same suggestion as for architects, that engineers should plan for wood early in the design, which will simplify the latter parts of the project. Structural engineers can also promote wood to the other stakeholders.

"Lobby against the architect and client that wood should be an alternative. "This should work to build in wood, shall we explore that possibility? "" (Respondent 6, 2022).

Respondent 6 suggests that engineers could use their power towards lobbying and promoting wood as an alternative for their coworkers early in the process. This could influence their employers to choose wood instead of concrete.

As with the other stakeholder, the respondents also suggest that the group should educate themself and invest their time into wood. In terms of learning, the engineers need to educate themself more on wood as a material and learn more about lean processes (Respondent 2, 2022; Respondent 3, 2022; Respondent 4, 2022; Respondent 10, 2022). They can also improve in terms of calculating.

"Learn to calculate. Better common-sense regarding moisture" (Respondent 10, 2022).

As suggested above, structural engineers can improve at calculating and also learn more about dealing with moisture.

6.5 The New European Bauhaus values

6.5.1 Sustainability

The New European Bauhaus values are an initiative from the European Union to connect our living spaces to the European green deal. Building with wood can contribute to the value of sustainability by being more sustainable compared to the competing materials.

"Wood is the most sustainable building material we have today. The more we can change concrete and steel against wood the more sustainable we become" (Respondent 2, 2022).

Respondent 2 explains that wood is more sustainable than other material and increasing wood would make us more sustainable. To become even better at contributing to sustainability, the industry must invest and commit to taking environmental issues more seriously. Also becoming better at lean processes and utilizing the material.

"Take the question of sustainability and biodiversity REALLY seriously. Now this is only a "need to have" topic in the companies, although this is not the image given by their PR material" (Respondent 3, 2022)

As the quote above suggests, the mentality and attitudes need to change in companies. Sustainability needs to be taken more seriously and it should be seen as an important topic.

6.5.2 Aesthetics

Wood also has a closer connection to the aesthetics compared to the other materials in Figure 2. To help wood construction become more connected to aesthetics, the wood must become more visible in the buildings.

"Wood is sensual and beautiful. There are also studies that show better well-being in wooden buildings. If we could find ways to fireproof buildings without building in the wood material, then these added values would increase" (Respondent 2, 2022).

Respondent explains that if we can fireproof building without building in the wood, the aesthetics would be even better. The aesthetics is also described as something that can help the well-being of the people inside the buildings. It is not only an issue with costs, but also with high costs.

"Visible wood is already a strong value. But the surfaces are costly - more waste and higher requirement on mending etc. True consumer interaction is needed to find a middle way" (Respondent 3, 2022).

As described above, it is important to make the surfaces cheaper so that it can be implemented more. Because visible wood is a strong value and if issues around mending requirements and waste is solved, it could be implemented more.

6.5.3 Inclusion

Four of the respondents could not say how wood construction was connected to inclusion. Wood does not seem to connect with diversity, accessibility, and affordability, any different than other materials. But one respondent suggests that affordability could have room for improvement.

"Affordability is one keyword, meaning high material recovery and lean processes" (Respondent 3, 2022).

Wood could help contribute towards affordability by becoming better at wasting less material and in that way saving costs, making housing more affordable.

7 Analysis

This chapter aims to address the research questions, based on the theoretical framework and the empirical data. The chapter starts with a presentation of enabling and limiting factors, and it continues with an analysis of stakeholders and strategies in terms of planned behavior.

7.1 Enabling and limiting factors

7.1.1 Organizational innovation

Boons and Lüdeke-Freunds (2013) identified three business areas that need innovation to create a sustainable business model. Organizational innovation means innovating in structure, routines, and culture toward a sustainable business model. This can be connected to the innovation the industry had to do in the education and information area. This form of innovation was needed because of the problems around the lack of knowledge in and around the industry. By innovating with education, publications, and collaborations, the industry can change its structure, routines, and culture. To solve the problems regarding misinformation and knowledge gaps, becoming better at education, publications, and collaborations, are the suggestions for organizational innovation. The respondents saw room for improvement in education both in school and in the industry. To deal with the misconceptions about wood, the specifiers suggested organizations making publications that show proven solutions to the perceived problems. The respondents also suggested publications showing examples for creating a more standard way of building. Stakeholders can also commit to learning, and lobby against each other to change the organization of the industry. By implementing these measures, the industry could innovate their organizations towards a more sustainable business model.

7.1.2 Technological innovation

To reach a sustainable business model, technological innovation means innovation in production processes, services, and products (Boons & Lüdeke-Freunds 2013). The key to technological innovation is how well the business can commercialize and market the new technologies. The technological innovation that the industry needs specifically better prefabrication, which could make the building process cheaper and simpler. The materials, Glulam, LVL, and CLT are more specifically the types of materials that the respondents think manufacturers need to work with. The industry also needs to innovate its manufacturing to solve product problems around sound insulation, humidity problems, and other complicated issues in the construction process. Becoming better at lean processes and material utilization can also help wood manufacturing become more sustainable and cheaper. Wood manufacturers and structural engineers are the stakeholders with the most influence over technological innovation.

7.1.3 Social innovation

Social innovation involves how a business or industry can create social value and maximize social profit (Boons & Lüdeke-Freunds 2013). To help create social value, one improvement that can be made is to figure out how to make wood more visible in buildings since I can improve the well-being of the residents. If wood could become more sustainable with lean processes, that would also be social innovation from the wood construction industry. More lean processes could make housing cheaper which could benefit residents. Since wood products are also more climate friendly than concrete, increasing the usage of wood products are increasing the social profit in the construction industry. The environment becomes better, which benefits all. All measures to increase wood, could therefore be social innovation.

7.1.4 Policy instruments

Edmondson, Kern and Rogge (2019) listed resource effects, interpretative effects, and institutional effects as three different strategies politicians can use to change the socio-technical state. When the respondents were asked to rank these three policy instruments, they chose institutional effects as the strategy with the most impact. Institutional effects mean regulations and laws. The most suggested actions that politicians can use are creating carbon taxes, rules around life cycle analysis, and using wood strategies when zoning. Municipal policymakers and their strategies in wood construction can also have a positive effect when they develop their strategies for distributing plots based on sustainability. National policymakers can also keep implementing requirements on projects making a life cycle analysis.

But throughout the text, education, and information were involved in many suggestions, which can be linked to interpretative effects (Edmondson, Kern & Rogge 2019). It either involved that people need to learn more in their education and how key stakeholders needed to learn more on wood. Politicians can use their influence towards implementing more education on wood construction in the schools. Resource effects were chosen more than interpretive effects in table 6, but the respondents did not suggest any measures that used resource effects.

7.2 Stakeholder theory

The stakeholder theory was used by analyzing the stakeholders in relation to the enabling factors and looking at their potential to influence (Freeman *et al.* 2010*).* Developers and municipal policymakers had the most influence over the selection of material. Wood manufacturers and structural engineers had the most influence over the development, innovation, and improvement of wood. In stakeholder theory it can help your analysis to divide the stakeholders into internal and external stakeholders (Freeman *et al.* 2010*)*. Developers, contractors, architects, wood manufacturers, and structural engineers can be counted as internal stakeholders in the wood construction industry. The external stakeholders could be policymakers, and consumers.

Developers, manufacturers, and engineers were mainly responsible for spreading education and information, but other stakeholders also had the potential to educate themselves if they wanted to promote and increase wood construction. Developers had the most power over the selection of material, but the developers' preferences were chosen as the biggest disadvantage for wood as a material. In terms of developing the products and processes, wood manufacturers had the main responsibility. Wood manufacturers could influence by creating more prefabricated products and other technological innovations. Architects and structural engineers could lobby against the developers to support wood. The regulation and policies were more specifically national policymakers influencing carbon taxes and demands on life cycle analysis. Municipal policymakers could influence by implementing masterplans and zoning with a wood construction strategy when they distribute plots.

7.3 Theory of planned behavior

The theory of planned behavior is used to examine how behaviors change, based on attitudes, subjective norms, and perceived behavioral control (Ajzen 1991). The biggest disadvantage with wood as a material was the developers' perceptions of it. Since developers had the most power over the selection, for the construction industry to change, their behavior is key. The attitude towards wood is therefore seen as a problem and something that could be changed. Many of the respondents argued that misconceptions were the problem that caused the bad attitude against wood, which could then also be solved with education and information. But there are also problems around humidity and sound insulation that has affected the attitude of the developers. that would need to be dealt with through technological innovation for attitudes to change.

The subjective norm in wood constructions is how the developers perceive how others will react to their choice of material, which could be affected by the metal and concrete industries lobbying the market. Spreading education and information have the potential to change the subjective norm in the industry. The norm is affected by stakeholders having misconceptions about wood and proving the misconceptions wrong could change the norm in the construction industry.

The respondents emphasize that the decision-makers need to go and invest their focus into wood construction. Developers as well as other stakeholders had to commit to using wood and decide to learn more about the issue. Perceived behavioral control (Ajzen 1991) is to which these developers believe they can perform a behavior, which in this case is to transition to wood. Their lack of knowledge on how to build with wood is stopping them from believing they can change their construction material. Respondents also suggested that showing examples and unifying building codes would make the transition easier, which could help developers to believe they can perform the change.

8 Discussion

This chapter will be structured after the research questions. The chapter starts with a discussion of the enabling and limiting factors in wood construction. It proceeds with discussing the measures for market development and the New European Bauhaus values.

8.1 Enabling and limiting factors

From analyzing the views of the architects and structural engineers experienced in wood construction, this study identified lack of standardization as a challenge but as a smaller challenge compared to lack of knowledge, misconceptions, high costs, and sound insulation. A previous study directed at developers without wood experience found that lack of standardization and low productivity benefits made the transition too risky for the developers (Aaltonen *et al*. 2021). The respondents in this study identified the lack of standardization as a problem but saw lack of knowledge throughout the industry were a bigger challenge. The respondents in this case who are experts in the construction process did not see the standardization as a deal breaker like some developers did.

The limiting factors were very similar to the results of previous studies. Previous studies also identified lack of knowledge (Markström *et al*. 2019) and low productivity standardization (Aaltonen *et al.* 2021) as limiting factors for the industry. Previous researchers have discussed the issues around costs and how it is a complicated topic, where wood can sometimes be the financially superior option and sometimes not (Konttinen 2019). In table 5, seven architects and engineers saw high costs as a challenge for the wood construction industry in Sweden and Finland.

The negative aspects of wood as a material were mainly sound insulation, instability, and decay risks (Roos *et a. l*2010) which our study could confirm. Our study found that there were products gaps that caused problems around humidity, sound insulations, and complicated processes. But the difference is that we also found many of these perceived problems were often based on a lack of knowledge and misconceptions. The respondents found that there are solutions and ways to deal with the problems, but it’s hard to find the examples.

Architects had a more positive attitude towards wood construction, but it wasn't as adequately proven as concrete or steel (Hemström *et al*. 2011). As our study found there is a lack of building codes and standards in wood construction which makes the projects special. The respondents are asking for more simple wood construction projects with clear standards on how to work. One enabling factor in the industry could be if someone could unify building standards and show examples in publications, where experienced stakeholders could help wood become more proven. The publications could involve proven solutions to the perceived problems, according to the respondents.

8.2 Measures to improve the future of the industry

Combining the views of architects, developers, and contractors, Markström (2019) suggested incentives to select materials with a low climate impact, training and information, product development, and economic incentives as measures that can help wood construction. With architects and structural engineers experienced in wood construction, this study identified education and information, regulations and policies, and product development as the most important measure to improve the future of the industry. One thing to consider with the transition is the risk for developers who have worked with other material for years and are experienced with those (Aaltonen *et al.* 2021). For them to change, wood must be better in many aspects for them to change their conventional business aspects.

This study identified lack of knowledge and misconceptions as a challenge for the industry to confront. Multiple respondents suggested that there was a lack of wood education in their formal education. In table 8, only one respondent chose universities as influential for the development, innovation, and improvement of wood construction. Even though the respondents viewed wood as not noticeable in the education and chose lack of knowledge and misconceptions as the biggest challenges in table 5. Which means education can be in school, but also in other ways, through collaborations and publications as the respondents suggested. As Edvard and Röhr (2016) argued, co-operating and knowledge transfer are crucial for the future success of this industry. Manufacturers, architects, and structural engineers are important for the research and development but has room for improvement in terms spreading the knowledge.

Previous studies have perceived changes in regulation and law is an ineffective measure in terms of supporting wood (Toppinen *et al*. 2019) For the future development, innovation, and improvement of the industry, the architects and structural engineers in this study viewed politicians as one of the least influential stakeholders. Contradicting to those views, this study also found that law and regulation can be a good measure, that can be utilized through carbon taxes, more rules around the life cycle analysis, and zoning with wood strategies. This could solve problems around costs and give wood an advantage against concrete and steel.

Previous studies have found problems around the lack of standardizations in the wood construction industry (Aaltonen et al. 2021). Our study has gone deeper into this issue and found that the most important measure for the industry would be more create more prefabricated products in the manufacturing process. This could solve problems around humidity, and other complications at the construction site. Wood manufacturers has a big influence for the future development, and their development of prefabricated products, together with structural engineers are key for the future success. Edvard and Röhr (2016) found that the industry could benefit from more technological innovation, which our respondents suggested could be done by solving issues around sound insulation, and decay risks.

Compared to other studies that were more focused on measures that can improve the wood construction industry, this thesis also went deeper into what roles the

stakeholders have for future development. Wood manufacturers could improve in prefabrication, developers could invest their time into learning, architects and structural engineers can promote wood to the developers, and policymakers can use regulation and other measures to support wood. The results also confirmed that architects and structural engineers had a limited influence on the choice of material compared to the developers, like the other studies have shown (Roos *et al*. 2010). This study found that developers had the biggest influence over the selection of material, but municipal policymakers could also have a big influence when they distribute plots. For the future improvement of the industry many stakeholders could influence the industry, but most important was developers, manufacturers, structural engineers, and architects. Them committing and investing their time into becoming more experienced with wood would be important for the future market development of wood.

8.3 The New Bauhaus Values

To connect wood construction to the green deal, the respondents found a close connection between wood construction and the values sustainability and aesthetics. To become even more sustainable, it is important that the industry can become even better at utilizing material. To improve the aesthetics in wood construction, the wood could be even more visible and not built in. The respondents did not think wood construction contributed to inclusion, but could if wood became cheaper, which could make building less expensive for the end consumers. Wood construction could become cheaper if manufacturers became better at lean processes and utilizing material. Earlier studies have not connected the wood industry to a specific initiative and when connected to the Bauhaus values, we found that lean processes and more visible wood is key. Previous studies have found that architects and structural engineers view wood as the sustainable alternative (Roos *et al*. 2010), but this study added that there still are room for improvement by becoming better at lean processes.

9 Conclusions

This chapter addresses the research questions and explains the implications of this study. After that, the chapter reflects on the choices made and provides suggestions for future studies.

This study identified knowledge gaps among developers and contractors, high costs, and lack of standardized processes as challenges that were limiting the industry. To overcome these issues and increase the usage of wood: industry actors need more education about wood construction, carbon taxes should be implemented on materials, masterplans, and zoning with wood strategies should be implemented, and more prefabricated wood products should be made by the manufacturers.

In terms of education and information, the industry requires more education on wood both in school and in the industry. This could solve issues around misinformation, and misconceptions and help decision-makers decide on using wood. Spreading education in the industry can be done by collaborations and publications with proven solutions and examples. The regulations that can help wood construction are carbon taxes or some economic incentives for using wood. Municipalities can also use their power with wood construction strategies when zoning and creating masterplans for distributing plots.

9.1 Implications on market development

Wood manufacturers developing more, and better prefabrication products could help make the process become more simple and cheaper in wood construction projects. The manufacturers can also improve their products to solve problems around sound insulation and other complicated problems in the projects. Wood constructions are connected to The New Bauhaus Values sustainability and aesthetics. To become more aligned with the sustainability value, the industry can become better at utilizing the material better. In order to improve the aesthetics of wood construction, the wood can become more visible in the building. In terms of inclusion, the wood industry is failing at fulfilling that value, and could become better at making buildings cheaper through better material utilization.

This study can most importantly be used by stakeholders in and around the construction industry to understand how they can influence the industry. It helps different stakeholders allocate their resources towards measures that will have a positive effect on multi-story wood construction. This is important since more wood construction can have a positive impact on our environment.

9.2 Suggestions for future research

This thesis used a web survey of architects and structural engineers experienced in wood construction. They are very invested in the industry, but there is also a risk of being subjective when discussing other stakeholders and their own roles. Previous studies have used more stakeholders inside the industry but have often used a method for interviewing the stakeholder separately. For future studies, one

interesting method could be different stakeholders discussing the industry together and analyzing their opinions and arguments.

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Appendix

Appendix 1. Questions for the web survey and their connection to theory and aim

Questions	Theory and aim
What is your profession? Your age? In what country are you mainly active? Please describe your role(s) in wood construction projects What type of wood construction projects have you worked with? (Multiple answers possible) How did you start getting involved in wood construction? Please describe how your formal education has prepared you to work with wood construction Which material do you like to work with the most in construction? Wood or concrete? How does wood as a construction material perform compared to concrete in these categories? Can the advantages for wood construction (categories above) be utilized more? If yes, how?	Introduction to understand the respondents and their backgrounds
Which three of these challenges do you think are hardest to deal with for the wood construction industry? Please explain your choice of the most/second most/ third most serious challenge and how can this challenge be overcome?	Gap analysis: Analyze challenges and break them down to understand them. Then analyze solutions to overcome the biggest challenges. Identify the limiting factors of the industry and also discuss enabling factors
Which three of the stakeholders below has the most influence over the selection of building material? (Answer options) Please explain your answer above of the three groups with the most influence over the selection of building material. Which three of the stakeholders below are most important for the development, innovation, and improvement of wood construction as you see it? (Answer options) Please explain your answers above. Why are these three stakeholders most influential for the development of wood construction?	Stakeholder theory: How can the stakeholders influence the future of the industry.
Please describe the wood construction sector in Sweden and/or Finland in 2030 as you would like it to look like?	Backcasting

Please rank which of the policy instruments below have biggest positive impact on wood construction? (Answer options) More than 80% of the multistory and nonresidential construction in Sweden and Finland are with other materials than wood. If we in the future wish that wood construction becomes more mainstream in the Swedish and Finnish construction sector, what do you think will pave the way for this development? Please answer to the questions below What actions would be most important from the manufacturers of building materials in wood? What actions do you expect from the developers for wood construction to become more mainstream? (Both public and private) What regulatory changes do you think are needed? What can architects do to increase wood construction? What can structural engineers do to increase wood construction? How can the building process be improved? Is there any other measures you think will have an impact on the favorable development of wood construction until 2030? How can the wood construction industry in Finland and Sweden create export opportunities of knowhow or construction projects?	Sustainability transitions and innovations Identify enabling factors and measures for future market development.
In what ways can wood construction contribute to the value Sustainability/Aesthetics / Inclusion? And how can the industry contribute more to the value?	

Appendix 2. Results of the content analysis

Table 2: Results of the content analysis

Major category	**Subcategory**	**Illustrative examples from the data**
Limiting factors	Lack of knowledge and misconceptions	*"Almost no education"* *"Lobbying the market"* *"Proven solutions"*
	High costs	*"Significant costs"*
	Low standardization and product gaps	*"Poor sound insulation"* *"Humidity problems"*
Enabling factors	Education and information	*"University "* *"Publications"* *"Collaborations"* *"Unifying building codes and standards"*
	Regulation	*"Life cycle assessment"* *"Zoning" "Masterplans"* *"Lower taxes" "Carbon taxes"*
	Product development	*"Prefabrication"* *"Lean processes"* *"Glulam, LVL and CLT."*
Important stakeholders and their contributions	Developers	*"Power regarding what materials will be used."* *"Commit" "Learn"*
	Wood manufacturers	*"Prefabrication"* *"Develop their production line"*
	Architects	*"Learn"* *"don't need to be "wow-architecture" every time*
	Structural engineer	*"Learn"* *"Lobby"*

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