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Sustainable Value and Business Models

– How a Material Supplier in the Wood-Frame Multi-Storey Construction Industry Can Create and Deliver Sustainable Value

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Hållbart Värde och Affärsmodeller

– Hur en materialleverantör inom sektorn för industriellt trähusbyggande kan skapa och leverera hållbart värde

Alice Andreasson
Daniel Altgärde

Supervisor: Tomas Nord
Examiner: Johan Holtström

Linköpings universitet
SE-581 83 Linköping, Sweden
013-28 10 00, www.liu.se

Abstract

We live in a world of limited resources, with global challenges such as climate change and ecosystem degradations linked to a growing population. This will most likely require one of the largest changes to the society as we know it during the next coming decades (United Nations, 2018). Key actors from the entire construction value chain have agreed to work towards a climate-neutral and competitive construction industry in year 2045 (Sveriges Byggindustrier, 2018). For Stora Enso Building Solutions, the case company of this thesis, as a material supplier in the wood-frame multi-storey construction industry, to reach the industry vision of a climate-neutral and competitive construction industry in year 2045 we argue that they need to drive sustainability at both a firm level and a higher, more systemic level, thus, they need to develop a sustainable business model. A sustainable business model for material suppliers in the wood-frame multi-storey construction industry, we argue, creates and delivers sustainable value for their customers and the other main stakeholders in the construction value chain; the developer, construction contractor, architect and structural engineer. Further, a material supplier needs to create and deliver value of all aspects of sustainability, thus, economic, social and environmental value.

The purpose of this thesis is *to investigate how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.* In order to reach the purpose of the thesis, the following research questions are answered.

1. *What creates sustainable value for the actors in the construction value chain regarding the frame material?*
2. *What enables and prevents sustainable value creation with massive wood as frame material?*
3. *What elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value?*

This thesis is primarily exploratory and is performed with a combination of a quantitative and a qualitative approach. A survey with 205 respondents representing different actors in the construction value chain is conducted. Furthermore, five pre-survey interviews with different actors in two construction projects and eleven complementary interviews with two architects, two structural engineers, two private property owners, two public property owners, two construction contractors and one project developer, are conducted. In addition, interviews with the case company are conducted. The collected empirical data is analyzed through the model of analysis based on the frame of reference.

To answer research question 1, the most important potential economic, social and environmental value creating factors for the actors in the construction value chain are identified. If these factors are viewed as advantages for a certain frame material, the factors are value creating and therefore create sustainable value in the construction value chain. The identified factors are:

- The frame material's impact on the; material costs in the project, construction site's safety, energy consumption in the operation of the building, indoor environment for the end user, stability of the construction, life span of the building, construction time, construction site's general working environment and appearance of the building.
- The frame material's; fire properties, heat and cold insulating properties, modifiability, compatibility with other building materials/systems and acoustics properties.
- The amount of frame material waste arising at the worksite and from production of the frame material.
- The amount of greenhouse gas emissions arising from handling of the frame material at the construction site and from production and transportation of the frame material.
- The impact on the frame material from rain and moisture during construction.
- That the frame material is fossil free, renewable and has carbon storage properties.

To answer research question 2, the results show that some factors create value, some factors prevent value creation and some factors both create value and prevent value creation with massive wood as frame material. For example, massive wood's impact on the energy consumption in the operation of the building, construction site's safety, indoor environment and the frame material's heat and cold insulating properties create value for most of the actors in the construction value chain. Furthermore, the impact on the frame material from rain and moisture during construction prevents value creation for some of the actors in the construction value chain.

To answer research question 3, elements in a material supplier's business model which could be used to create and deliver sustainable value to the actors in the construction value chain are identified. These elements are presented below.

- Offer products with valued material properties, solutions for a high prefabrication level, complete solutions, standard solutions and services for guidance, solutions to enable visually exposed wood, products with high precision and with a wide range of dimension, and lastly hybrid materials and hybrid systems.
- View all actors in the construction value chain as customers and segment customers by type of actor and level of experience.
- Use channels such as collaborations with universities to increase the total knowledge of massive wood in the value chain. Use reference projects as a channel for marketing and communication with new customers which do not have experience of working with massive wood as frame material.
- Create customized customer relationships with the different customer segments. Create customer relationships extending the material supplier's role beyond just delivering the material in order to reduce barriers and increase the knowledge about massive wood construction in the value chain.
- Have key resources such as production facilities that enables large volumes, short delivery times and generates low amounts of greenhouse gas emissions and waste and intellectual/human resources to deliver the services required by the customers.
- Have key activities as efficient production, with high capacity and flexibility to meet customer demands, and therefore contribute to low amount of emissions and waste, and efficient transportation with low greenhouse gas emissions and communication of the sustainable value creating factors to each customer segment and communication of how to manage the factors preventing value creation for each customer segment.
- Have partnerships with actors in the value chain to offer complete solutions and high level of prefabrication and partnerships with other suppliers of materials and products to offer hybrid solutions.
- Have revenue streams from construction contractors based on the delivered products and services.
- Have a cost driven cost structure to be able to operationalize the business model.

Thus, to reach the purpose of this study, we have concluded how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.

Acknowledgments

We would like to extend our thanks to the people who have made this thesis possible and our work this spring to an exciting and developing experience. First of all, we want to thank our supervisor at Linköping University, Tomas Nord. We are so grateful for all your help and support, for our long and insightful discussions, for all the knowledge you have shared with us and the time you have put into this, you have been invaluable for our work and really made this a fun and learning experience. We also want to thank our supervisor at Stora Enso, Mikael Lindberg. Thank you for making this thesis possible, for your openness and kind support. Further, we also want to extend our thanks to all the actors in the construction value chain who have answered our survey and taken their time to be interviewed. Without you, this thesis would not have been possible.

We have been very lucky to have Anna-Cecilia Lundström and Emelie Jönsson as opponents. Your feedback has lifted this thesis to a higher level and we are so grateful for your support and encouragement! Lastly, Johan Holtström, thank you for letting us graduate!

Linköping, June 2018

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1. Introduction

In the following chapter, the introduction of the thesis is presented. First, the background to the thesis is presented which is followed by a background of the industry and the case company. Thereafter, the theoretical starting point and the problem formulation of the thesis are presented. Thereafter, the purpose of the study and research questions are presented. Lastly, the disposition of the thesis is described.

1.1 Background to the Thesis

We live in a world of limited resources, with global challenges such as climate change and ecosystem degradations linked to a growing population. This will most likely require one of the largest changes to the society as we know it during the next coming decades (United Nations, 2018). The COP21 convention in Paris 2015, where the member countries of the United Nations agreed to combat climate change and adapt to its effects, is a response to that. The central aim of this agreement, named the Paris Agreement, was to generate a strong response to the threat of the climate change, keep the global temperature increase below 2 degrees Celsius and pursue efforts to limit the increase even further, to 1.5 degrees Celsius (United Nations, 2018).

In 2017, the Swedish Parliament decided to introduce a climate policy that aims to reach the goal of zero net emissions of CO_2 by the year of 2045 at the latest (Regeringskansliet, 2018). Furthermore, one central part of the climate policy is the development of a sustainable construction industry (Regeringskansliet, 2018). Globally, the construction industry has large economic, social and environmental impacts and is important in a sustainability perspective for example because of its high potential for reducing the environmental impact of the global economy in a cost-effective way (Hurmekoski, 2017). In Sweden, the construction industry was accountable for 12.8 million tons of domestic greenhouse gases in the year of 2016 (Boverket, 2019a). This is 21 percent of the total greenhouse gas emissions in Sweden (Boverket, 2019a).

As a response to the climate policy, the Swedish Construction Federation, which is the trade association for private construction companies and employers, has developed a road map with conditions for a market that values climate-smart solutions and innovations (Sveriges Byggindustrier, 2018). Key actors from the entire construction value chain have agreed to work towards a climate-neutral and competitive construction industry in year 2045 (Sveriges Byggindustrier, 2018). In order to reach the vision, the road map ends with a request for politicians, authorities and actors in the construction value chain to develop more resource efficient processes, create new business models and cooperate across the value chain.

One key actor in the construction value chain is the material supplier (Sveriges Byggindustrier, 2018). One of the material suppliers in the Swedish construction industry is the case company of this thesis, Stora Enso, which is a material supplier of wood-frame material for industrialized house building. The initial aim of this study is therefore to understand how a material supplier in industrialized wood-frame multi-storey construction could work towards a climate-neutral and competitive construction industry in year 2045.

1.2 Background to the Industry

To understand how a material supplier in industrialized wood-frame multi-storey construction could work towards a climate-neutral and competitive construction industry in year 2045, a basic understanding of the industry is needed. Therefore, in this section, a background to sustainability in the construction industry, the construction value chain, the construction project process, industrialized house-building and the use of wood in industrialized house-building are presented.

1.2.1 Sustainability in the Construction Industry

Hurmekoski (2017) argues that the construction industry in Europe has large economic, social and environmental impacts. The construction sector is important in an economic perspective; for example, in the EU the construction industry accounted for about 8.9 percent of the GDP in 2018 (FIEC, 2018). The construction industry also has social impacts in the form of health impacts. Today, people spend around 90 percent of their time indoors, which makes the impacts the buildings have on the health important (Hurmekoski, 2017). Further, the sector has large environmental impacts and the construction and building industry accounts for nearly 40 percent of the energy related CO_2 emissions globally (World Green Building Council, 2017).

In Sweden, the average amount of emissions each year from the construction industry, if looking at the years between 2008 and 2016, has been almost 21 million tons in total if both domestic and non-domestic emissions are included (Boverket, 2019b). The emissions from construction accounts for an average amount of approximately 35 percent of the emissions from the construction industry (Boverket, 2019b). Furthermore, the production of the building material accounts for the majority, around 80 percent, of the emissions from the construction, especially due to the production of steel and concrete (Sveriges Byggindustrier, 2018).

Thus, the construction industry has large environmental, economic and social impacts, both globally and in Sweden. A large part of the environmental impact is due to the emissions from the manufacturing of the building material, especially from steel and concrete.

1.2.2 The Construction Value Chain

Besides the material supplier, the construction value chain involves a wide variation of actors. According to Sveriges Byggindustrier, the value chain in the construction industry includes: "actors who do business with each other, or in some way influence and control the development of buildings, facilities and infrastructure, to provide and control the development of ordered function." (2018, p. 41; translated by the authors). Lessing (2006) emphasizes house-building as a complex process that consists of activities involving a wide range of specialized actors performing specific activities.

Hurmekoski, Jonsson and Nord (2015) claim that *developers and commissioners*, *architects and engineers*, *builders and contractors* and *wood product suppliers* are the key actors in the wood construction value chain. This categorization is delimited to the actors directly involved in a specific construction project. In this thesis, we will base our categorization on this, however, in order to make our categorization more mutually exclusive, we adjust it to *architects*, *structural engineers*, *construction contractors*, and *property owners, both private* and *public.*

1.2.3 The Construction Project Process

Nordstrand (2008) describes that the process of a traditional construction project includes four activities: *project decision*, *project specification*, *production* and the *end use* of the building. Another similar description is the urban development process, which is given by Sveriges Byggindustrier (2017), see figure 1 below.

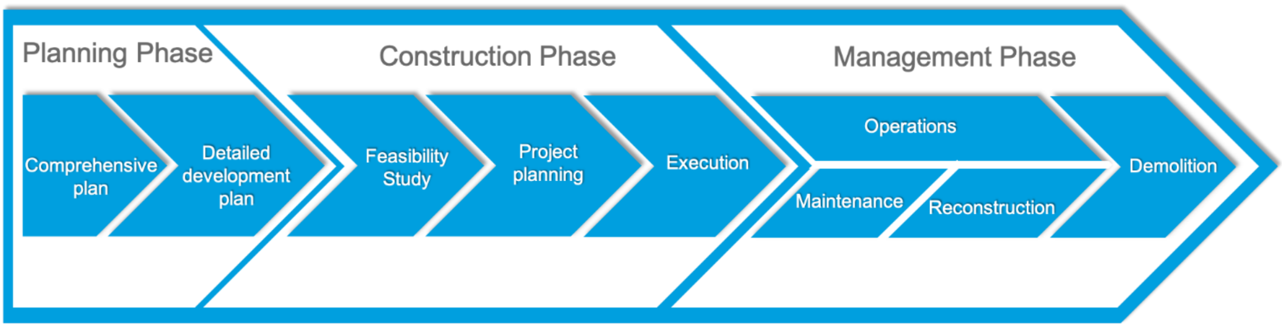

Figure 1: A conceptual model of the urban development process (Sveriges Byggindustrier, 2017).

Their description of the urban development process includes three main phases. The first phase is the *planning phase*, where a comprehensive plan and a detailed development plan is developed. The second phase is the *construction phase*, where a feasibility study, the project planning and the execution of the building project is performed. The last phase is the *management phase*, where operations, maintenance, reconstruction and finally, demolition of the building is included.

1.2.4 Industrialized House-Building

The production of multi-storey houses on the Swedish market has been at a relatively low level during several decades, however, in recent years the production has risen sharply (SCB, 2019). The productivity development in the construction industry is, compared to the manufacturing industry, significantly lower and as a response to that, a transition towards more industrialized house-building processes has started (Lessing, 2006).

The concept of *industrialized house-building* basically means that activities is moved from being performed at the construction site to being performed in an external factory, thus industrialized house-building implies a higher level of prefabrication in relation to traditional house-building (Lessing, 2006). Further, Lessing (2006, p. 93) defines the concept as *"a thoroughly developed building process with a well-suited organization for efficient management, preparation and control of the included activities, flows and results for which highly developed components are used in order to create maximum customer value"*.

In contrast to traditional processes, the industrial house-building process is designed with continuous improvements and development as a foundation (Lessing, 2006). The most obvious improvement connected to an industrial process of house-building is, according to Lessing (2006), the increased productivity. The process also implies an improvement of other aspects such as building quality and working conditions, but at the same time, it requires more extensive planning, coordination and control systems (Lessing, 2006).

1.2.5 The use of Wood in Industrialized House-Building

The use of wood in construction is not a new technology, particularly not in Sweden were the tradition of wood-based construction is strong (Brandner et al., 2016). However, the development of reinforced concrete and bricks during the early 20th century in Europe substituted wood as construction material and it is not until the last few decades that the use of wood has recaptured market shares from mineral-based construction materials (Brandner et al., 2016).

In some European countries, practices regarding industrial wood-frame multi-storey construction have been emerging with an increasing demand during the past few decades (Hurmekoski, Jonsson & Nord, 2015). The wood products most commonly used for the load bearing structures are engineered wood products such as *Cross Laminated Timber (CLT)* and *Laminated Veneer Lumber (LVL)* (Hurmekoski, Jonsson & Nord, 2015). According to Hurmekoski, Jonsson and Nord (2015), there are currently few other competing alternatives to wood-based products regarding productivity, quality and environmental performance for industrialized prefabrication.

1.3 Background to the Case Company

This thesis will use Stora Enso Timber AB (Wood Products Division, Building Solutions unit), hereinafter Stora Enso Building Solutions, as a case company representing a supplier of wood-frame material in the industrial wood-frame multi-story construction industry. Thus, Stora Enso Building Solutions is a material supplier of wood-based construction materials. They offer building systems where two of their main products are *Massive Wood Elements*[1] of *Cross Laminated Timber (CLT)* and *Laminated Veneer Lumber (LVL)* (Stora Enso Wood Products, 2017; Stora Enso Wood Products, 2018). The goal of Stora Enso Building Solutions has been to find an environmentally friendly alternative frame material to concrete and steel and at the same time create a new construction method, which is faster, cleaner and more effective (Stora Enso, 2019b). At the time of this thesis, Stora Enso Building Solutions is about to strengthen their market position in Sweden and have opened a new production unit that increases their capacity of massive wood elements (Stora Enso, 2019c).

Stora Enso Building Solutions is a part of the group Stora Enso, a renewable materials company which both develops and produces solutions of renewable material of wood and biomass for segments like building, retail, manufacturing, cosmetics, hygiene, confectionary, food and beverages, publishing, textiles and pharmaceutical (Stora Enso, 2019a). By developing products and services based on renewable materials, they aim to replace materials which are fossil based (Stora Enso Wood Products, 2017). With their 26 000 employees in more than 30 countries, Stora Enso had in 2018 the total sales of 10.5 billion euro and an operational EBIT of 1.3 billion euro (Stora Enso, 2019a).

The vision of Stora Enso is "doing good for people and planet" (Stora Enso Wood Products, 2017, p. 2). Furthermore, they "strive to improve this world, its communities and the lives of everyone that comes into contact with us through our products, activities and services" (Stora Enso Wood Products, 2017, p. 2).

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[1] In this thesis, we use the concept *Massive Wood* to define elements of *Cross Lamintated Timber (CLT), Laminated Veneer Lumber (LVL)* and *Glued Laminated Timber (Glulam).*

1.4 Theoretical Starting Point

The research on sustainability has traditionally focused mainly on sustainable innovations without expanding the view to cover a broader business model perspective. Research points out that there is a considerable amount of knowledge on what drives sustainable innovation at a firm level, but less knowledge on how these innovations can be realized and how to enable sustainability on a higher and more systemic level (Boons & Lüdeke-Freund, 2013; Boons et al., 2013). However, as Boons et al. (2013, p. 2) state: "The concept of sustainable business models can provide a link between the firm and the system level." Bocken et al. (2014) also emphasize how sustainable business models are important tools for driving and implementing corporate sustainability innovations, for embedding sustainability in the businesses purposes and processes and for improving competitive advantage. Thus, a sustainable business model can help drive sustainability at both the firm level and on a higher, more systemic level.

Shaltegger, Hansen and Lüdeke-Freund (2016, p. 6) propose that a sustainable business model can be defined as the following: "A business model for sustainability helps describing, analyzing, managing, and communicating (i) a company's sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries." Furthermore, Patala et al. (2016, p. 144) define sustainable value propositions as "a promise on the economic, environmental and social benefits that a firm's offering delivers to customers and society at large, considering both short-term profits and long-term sustainability". Thus, a sustainable business model requires a sustainable value proposition which delivers economic, environmental and social benefits.

Shaltegger, Hansen and Lüdeke-Freund (2016) describe the conventional view of a business models as being designed around a value proposition with the customers in focus. However, Shaltegger, Hansen and Lüdeke-Freund (2016) propose that sustainable value cannot be created for customers if value is not created for other stakeholders than the customers too. Furthermore, the authors describe that a business is carried by a network of stakeholders and a business that wants to contribute to a sustainable development needs to create value for a wider range of stakeholders and not only for the organization's customers and shareholders. Moreover, according to Bocken et al. (2013) sustainable business models need to capture environmental, economic and social value for the business' stakeholders. Stubbs and Cocklin (2008) also argue that organizations which try to adopt a sustainable business model must not only achieve sustainability at firm-level, they need to collaborate with key stakeholders in order to achieve sustainability for the whole system that the organization is a part of. Thus, it is critical that a sustainable business model at least creates and delivers sustainable value to the organization's customers and main stakeholders.

Further, a wide variation of actors is involved in the construction value chain and the choice of material is affected by the actors in the construction project (Roos, Woxblom & McCluskey, 2009). According to Roos, Woxblom & McCluskey (2009) the developer, followed by the construction contractor, have the most power to affect the choice of the material in a construction project. Furthermore, architects and structural engineers have limited power and the end user has the lowest power to affect the choice of material (Roos Woxblom & McCluskey, 2009). Therefore, we argue that these actors in the value chain, the developer, the construction contractor, the architects and the structural engineers, are the customers and key stakeholders for a material supplier in the construction industry.

Lessing and Brege (2015) argue that the business model could be either market-based, or resource-based. A market-based perspective takes the demands of the market and customers' as a starting point formulating the company's offer (Porter, 1996). A resource-based perspective, instead, use resources and competences as the starting point (Prahalad & Hamel, 1990). In the construction industry, Lessing and Brege (2015) argue that product-oriented business models, with a market-based outside-in perspective (de Wit & Meyer, 2017), are successful in balancing the dimensions of a business model into viable house-building concepts.

In conclusion, a sustainable business model can help drive sustainability at both the firm level and on a higher, more systemic level. A sustainable business model requires a sustainable value proposition which delivers economic, environmental and social benefits to the organization's customers and main stakeholder. When developing a sustainable business model, and a sustainable value proposition, from a market-based outside-in perspective, the starting point should be to understand what the market value. As Patala et al. (2016) claim, the first step in developing a sustainable value proposition is to identify potential economic, environmental and social impacts of the offering, the next step is to identify key value creation mechanisms, identify what type of impacts the customers and other main stakeholders value, and customize the value propositions to the needs of the customers and the main stakeholders.

Therefore, a sustainable business model, for a material supplier in the wood-frame multi-storey construction industry, needs to create and deliver sustainable value to the organization's customers and other main stakeholders in the construction value chain; the developer, the construction contractor, the architect and the structural engineer. The sustainable business model could be developed through a marked-based outside-in perspective where what the market values is analyzed.

1.5 Problem Formulation

The initial aim of this thesis is to understand how a supplier of wood-frame material in industrialized house building could work towards a climate-neutral and competitive construction industry in year 2045. For Stora Enso Building Solutions, as a material supplier in the wood-frame multi-storey construction industry, to reach the industry vision of a climate-neutral and competitive construction industry in year 2045 and their own vision of "doing good for people and planet" (Stora Enso Wood Products, 2017, p. 2) and "strive to improve this world, its communities and the lives of everyone that comes into contact with us through our products, activities and services" (Stora Enso Wood Products, 2017, p. 2), they need to drive sustainability at both a firm level and a higher, more systemic level.

Material suppliers in the wood-frame multi-storey construction industry offer products which are generally more sustainable than other comparable products on the market, for example concrete or steel constructions. This gives these actors great opportunities and a competitive advantage on the market. However, in order to reach sustainability on a systemic level, they need to expand their focus to a business model perspective; they need to develop a sustainable business model. A sustainable business model for material suppliers in the wood-frame multi-storey construction industry creates and delivers sustainable value for their customers and the other main stakeholders in the construction value chain; the developer, the construction contractor, the architect and the structural engineer. Therefore, for a material supplier in the wood-frame multi-storey construction industry to be able to develop a sustainable business model, they need to understand what these actors' in the construction value chain value regarding sustainability. They need to understand what enables and prevents sustainable value creation with massive wood as frame material, and also create and deliver the sustainable value through their business model.

1.6 Purpose

The purpose of this thesis is to investigate how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.

1.7 Research Questions

In order to reach the purpose of this thesis, the following research questions are answered.

1. *What creates sustainable value for the actors in the construction value chain regarding the frame material?*
2. *What enables and prevents sustainable value creation with massive wood as frame material?*
3. *What elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value?*

1.8 Disposition

In the following section, the disposition of the thesis is presented.

In *chapter 1*, an introduction to the thesis is presented. The disposition of chapter 1 is presented in figure 2 below.

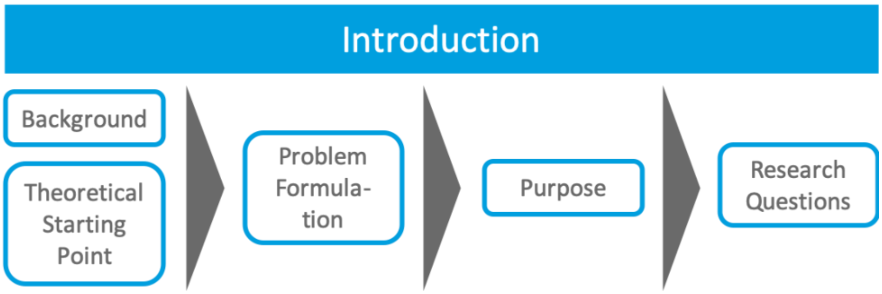

Figure 2: The disposition of chapter 1.

The chapter begins with a background to the thesis which is followed by a background to the industry and a background to the case company. This, to get an initial understanding of the industry and the case company, and the challenges and opportunities they face. Thereafter, the theoretical starting point, which the thesis takes, is presented. The theoretical starting point, together with the background, results in a problem formulation which ends up in the purpose of the thesis. To be able reach this purpose, research questions which the thesis answers are presented.

In *chapter 2*, the frame of reference is presented. The disposition of chapter 3 is presented in figure 3 below.

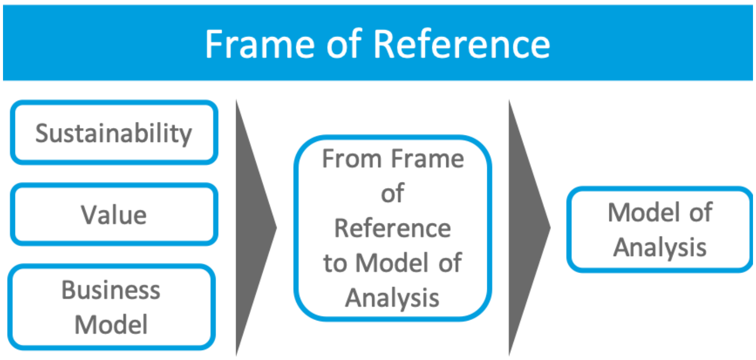

Figure 3: The disposition of chapter 2.

The frame of reference covers the three areas *sustainability*, *value* and *business models*. These areas can be found in the research questions and the purpose of this thesis. To be able to answer the research questions and the purpose of this thesis, these areas are the main areas investigated in the *Frame of Reference*. After the literature studies, the findings which are used further in the thesis are synthesized in a summary called *From Frame of Reference to Model of Analysis*. Lastly, the *Model of Analysis* is presented and explained.

In *chapter 3*, the methodology used in the thesis is presented. First, the scientific view of the authors of this thesis is presented. This is followed by a description of the overall methodology approach. Thereafter, the methodological process, the method for data collection, measurement techniques and the analysis process are described. Lastly, reliability, validity and ethical aspects of the thesis are discussed.

In *chapter 4*, the results from the pre-survey interviews with actors in two construction projects, the survey and the complementary interviews with different actors in the construction value chain are presented. The disposition of chapter 4 is presented in figure 4 below.

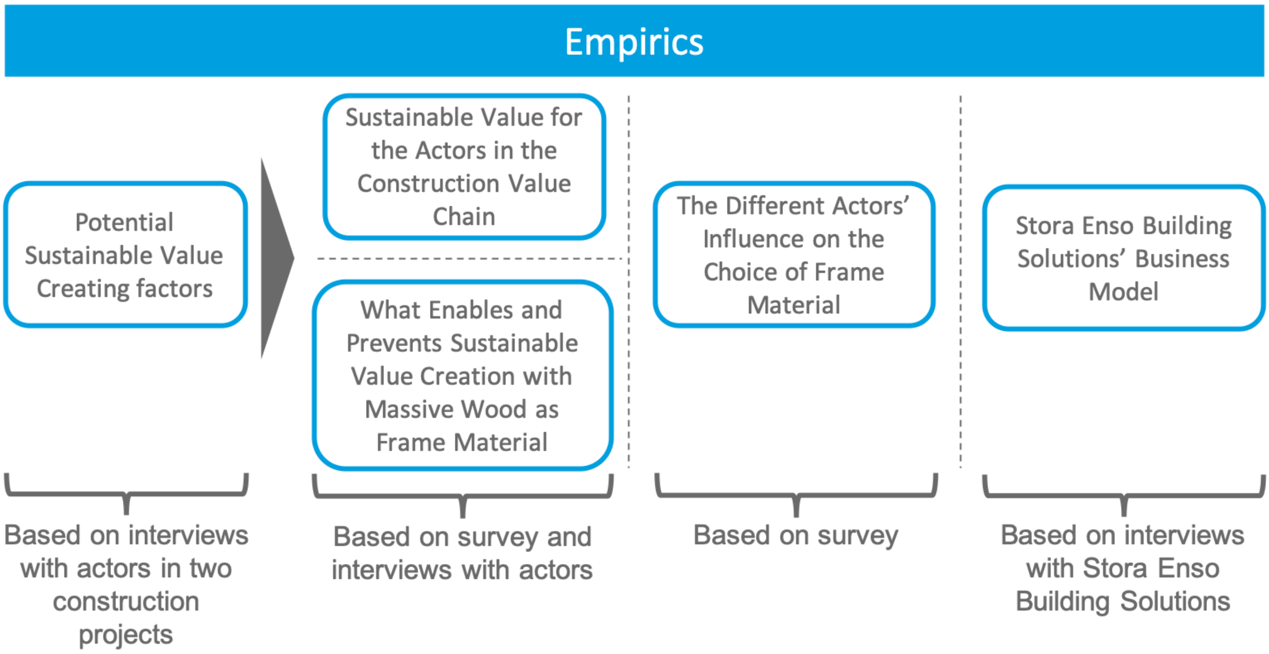

Figure 4: The disposition of chapter 4.

To answer research question 1, *what creates sustainable value for the actors in the construction value chain regarding the frame material,* the results from the pre-survey interviews with actors in two construction projects, the results from the survey and the results from the interviews with different actors in the construction value chain, investigating what creates sustainable value for the different actors in the construction value chain (private property owners, public property owners, architects, structural engineers and construction contractors) regarding the frame material, are presented.

First, the results from the pre-survey interviews are presented in section *4.1 Potential Sustainable Value Creating Factors*. In these interviews, factors which potentially could create sustainable value to the actors in the projects are identified. The interviews were performed to complement the limited literature regarding what sustainable value is for the actors in the construction value chain and to operationalize the sustainable value concept. A list of the identified potential sustainable value creating factors from the literature reviews and these interviews is presented in *Appendix 2*. These factors are used in order to operationalize the survey and the interview guide, in which the potential sustainable value creation factors are investigated more thoroughly.

Second, the results from the survey, investigating what creates sustainable value for the actors in the construction value chain regarding the frame material, are presented in section *4.2 Sustainable Value for the Actors in the Construction Value Chain*.

Furthermore, to be able to answer research question 2, *what enables and prevents sustainable value creation with massive wood as frame material*, the results from the survey and complementary interviews investigating what enables and prevents sustainable value creation with massive wood as frame material, are presented in section *4.3 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material*.

After this, the results from the survey regarding the different actors' impact on the choice of frame material is presented in section *4.4 The Different Actors' Influence on the Choice of Frame Material.* This result is used in the analysis in order to confirm that a material supplier should create and deliver sustainable value to all actors in the construction value chain, which is proposed in section *1.4 Theoretical Starting Point.*

Lastly, to be able to answer research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value,* the results from interviews with Stora Enso Building Solutions about their business model are presented in section *4.5 Stora Enso Building Solutions' Business Model.*

In *chapter 5*, the research questions of the thesis are answered by analyzing the results from the survey and the interviews with the theory from the frame of reference as described in the Model of Analysis. The disposition of chapter 5 is presented in figure 5 below.

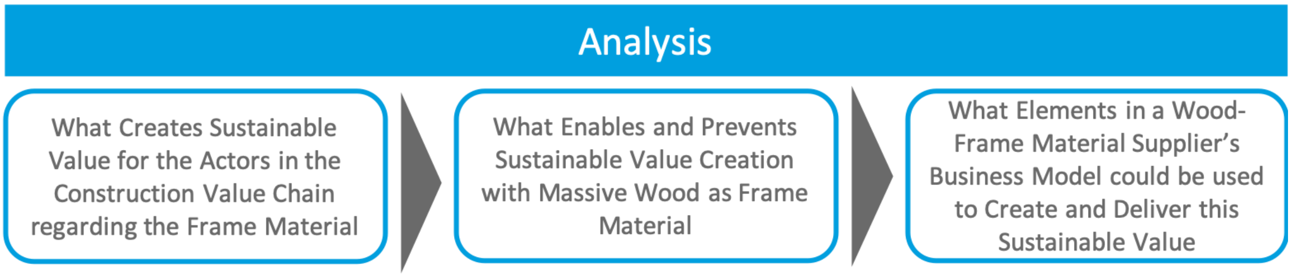

Figure 5: The disposition of chapter 5.

First, what creates sustainable value for the actors in the construction value chain regarding the frame material is analyzed. Second, what enables and prevents sustainable value creation with massive wood as frame material is analyzed. Third, what elements in a wood-frame material supplier's business model could be used to create and deliver this value is analyzed.

In *chapter 6*, a conclusion is presented followed by a discussion of the conclusion and of the thesis' academic contribution and suggestions for future studies.

Thereafter, references and appendix are included.

2. Frame of Reference

In this chapter, the theoretical fields of this thesis are further elaborated in order to achieve a theoretical anchoring to the purpose of the thesis. First, the concept of sustainability is presented, followed by the concepts of value and business models. Lastly, the frame of reference is synthesized, explaining how the different parts of the model of analysis are based on the frame of reference, before the model of analysis is presented in its entirety. The disposition of the frame of reference is presented in figure 6 below.

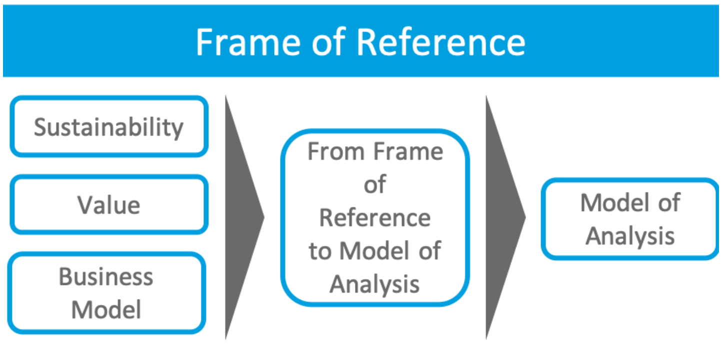

Figure 6: The disposition of the frame of reference.

2.1 Sustainability

In this section, the concept of sustainability is presented. See figure 7 below for this section's relation to the other sections in this chapter.

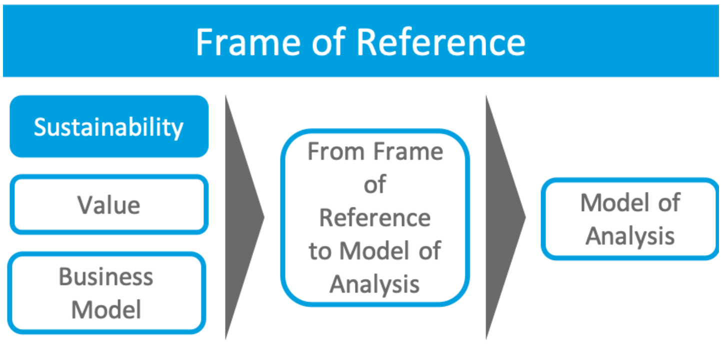

Figure 7: The concept of sustainability's relation to the other sections of the frame of reference.

First, a background to the concept is given followed by some definitions of the concept. Thereafter, a closer look of the concept in regard to the construction industry is taken. Lastly, a summary is presented.

2.1.1 Background to the Concept of Sustainability

The concept of sustainability has been increasingly used by both practitioners as well as academics since the late 1960's (Giovannoni & Fabetti, 2014; Faber, Jorna & Engelen, 2005). At the *International Conference for Rational Use and Conservation of the Biosphere* which was organized by UNESCO in 1968, sustainability including economic and social issues were discussed (Faber, Jorna & Engelen, 2005). At the conference, the meaning of what sustainability is was not explicitly stated but after the conference authors started to come up with different definitions to the concept. According to Meadows et al. (1972), sustainability was pointing out how to realize an economic development while taking the supposed environmental limits into consideration. The term sustainability got a growing awareness in the 1980's and since then sustainability has become a buzz word and become important for nations as well as for organizations (Savitz, 2014).

2.1.2 Sustainability Definitions

The number of different definitions and circumscriptions of sustainability is large and fragmented, according to Faber, Jorna and Engelen (2005), around 50 definitions can be found in the literature. To provide some examples of early definitions, Pirages (1977) defines sustainable economic growth as "growth that can be supported by physical and social environments in the foreseeable future" and Coomer (1979) defines a sustainable society as a society that "lives within the self-perpetuating limits of its environment" (Faber, Jorna

& Engelen, 2005, p. 14). Furthermore, Faber, Jorna and Engelen (2005) present the definitions of sustainable development according to Goodland and Ledec (1987, p. 15) as a “pattern of social and structural economic transformations which optimizes the economic and societal benefits available in the present, without jeopardizing the likely potential for similar benefits in the future”. The divided origins of sustainability, resulting in a lack of consistency in the literature, implies a risk that also the actual implementations of sustainability are being limited by vagueness and ubiquity (Giovannoni & Fabietti, 2014).

In 1987 the report *Our Common Future*, or the *Brundtland Report* as it is also known as, was published by the *World Commission on Environment and Development*. In the report, the exhaustion of the earth’s resources caused by both economic growth and unequal distribution of wealth were discussed. In the report, *sustainable development was* defined as “development that meets the need of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. 41). This has become a widely used definition of sustainable development and out of many different definitions the definition from the Brundtland Report is the most frequently used in quotes (International Institute for Sustainable Development, n.d.).

2.1.3 Sustainability Frameworks

To measure sustainability, the determination of the degree to which an organization is sustainable, can be difficult. The concept of the *Triple Bottom Line*, or TBL, proposed by John Elkington, is a framework to help corporations measure sustainability (Slaper & Hall, 2011). John Elkington suggests that businesses need to measure more than financial performance, the traditional bottom line, they also need to measure their impact on the environment and on the society (Savitz, 2014). Furthermore, Savitz (2014) argues that the concept of the TBL captures what sustainability is by measuring the impact on the world from the activities of the organization. Organizations use financial resources, as for example investment dollars, but also environmental resources such as energy and raw materials and social resources such as time and talent of employees and infrastructure (Savitz, 2014). The three dimensions of performance according to the TBL is the economic dimension, the social dimension and the environmental dimension, and are shown in figure 8 below. The three dimensions are also called the three Ps (3Ps): people, planet and profit (Slaper & Hall, 2011).

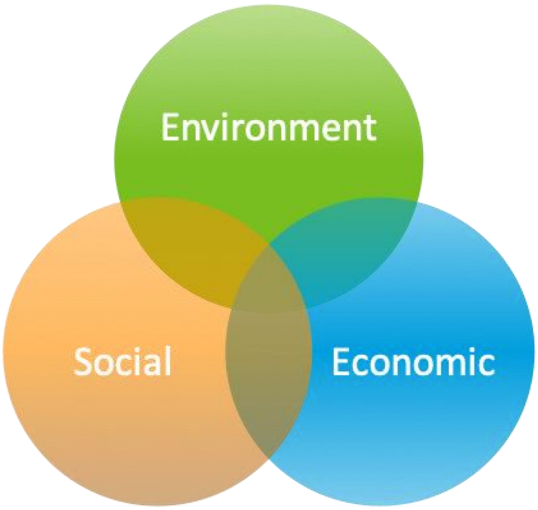

Figure 8: The three dimensions of the Triple Bottom Line.

According to Savitz (2014), a sustainable company needs to have a positive return on investment (ROI) when it comes to economic, environmental and social aspects, on the three bottom lines, and be able to provide benefits to the business’ stakeholders on the three dimensions.

Joyce and Paquin (2016) explain how the TBL is criticized for simplifying the concept of sustainability which is a complex concept. There are also challenges when it comes to using the TBL concept in practice including for example how to measure the three dimensions, however, Slaper and Hall (2011) argue how flexibility in the concept enables organizations to use the concept in a way that is suitable for them. The TBL framework has been adopted by many organizations and is a widely understood and accepted concept (Slaper & Hall, 2011). Both businesses and non-profit organizations have used the TBL as a sustainability framework for performance evaluation and the government sector has also used a similar approach (Slaper & Hall, 2011).

Patala et al. (2016) also view sustainability as the triple bottom line and provides a summary of typical sustainability impact categories in the sustainability literature; categories for economic, environmental and social impacts. These can be found in *Appendix 1* and can be used to show what sustainable impacts can be and how these impacts can be categorized into economic, environmental and social impacts.

2.1.4 Sustainability in Industrial Wood-Frame Multi-Storey Construction

In the following section, literature regarding wood-frame multi-story construction and sustainability is presented. Actors in the value chain's attitudes and perceptions of advantages and disadvantages towards the material presented in earlier studies are elaborated upon, from a sustainability perspective. The aim of the section is to generate an understanding of concepts and factors that potentially can impact sustainable value creation for the actors in the construction value chain regarding wood-frame multi-storey construction.

2.1.4.1 *Economic perspective*

If sustainability in industrial wood-frame multi-storey construction is viewed from an economic perspective, Hurmekoski (2017) argues that it is clear that the economic competitiveness varies between different markets and different regions. He explains that building practices are on average more expensive when it comes to wood-frame construction compared to other, more well-established methods. One reason for this is explained to be regulations; national construction regulations can have different effects on different materials. Further, in a study performed by Espinoza et al. (2016) investigating the European construction industry, the cost is seen as a barrier for CLT adoption. However, Hurmekoski (2017) argues that wood construction will become economic competitive in the future. For example, wood construction has benefits when it comes to industrial prefabrication, this because the material is easy to handle and because of its strength-to-weight ratio (Hurmekoski, 2017). Because of this, industrial wood construction has the potential to increase the productivity, reduce the time of construction and the overall cost (Brege, Nord & Stehn, 2017; Hurmekoski, 2017).

2.1.4.2 *Environmental Perspective*

From an environmental perspective, there is a general agreement that production of wood-frame materials will reduce the energy consumption and decrease the greenhouse gas impact compared to the production of alternative material (Sathre & O'Connor, 2010; Mahapatra et al., 2012). Also, the total emissions over the life cycle are, in almost all cases, lower for wood-frame building materials compared to the use of other building materials (Sathre & O'Connor, 2010; Mahapatra et al., 2012). Thus, increasing the use of wood-based products in construction can lower the greenhouse gas impact, and contribute to a stabilization of greenhouse gases in the atmosphere (Sathre & O'Connor, 2010). According to Sathre and O'Connor (2010), the use of wood-based products is preferred in a sustainability perspective if forests are managed in a sustainable way and the waste and by-products are handled in a responsible way.

According to Hurmekoski (2017), construction with wood can reduce the total material use, and thus, the waste amount. Ramage et al. (2017) also explain how waste properties is advantageous with wood construction, the re-use of wood products is a priority and the material can be re-used either for the same purpose, or for less demanding purposes. In the final stage, if re-use or recycling is not possible, Ramage et al. (2017) explain that the wood product can still produce energy by direct combustion or conversion to different kind of bio-fuels. In line with this, the bioenergy recovery of wood products is also a factor which Hurmekoski (2017) argues improves the energy balance in wood construction.

That wood is a renewable material and stores carbon during its lifecycle are also examples of environmental benefits of using wood construction (Hurmekoski, 2017). Through photosynthesis, trees sequester CO_2 and therefore, in wood construction, carbon is stored away from the atmosphere (Hurmekoski, 2017). Each ton of wood product used, to substitute non-wood products, results in a reduction of on average two tons of CO_2 emissions, this because of both less emission in production and the storage of carbon in wood products (Hurmekoski, 2017). Wood also has a much lower weight compared to concrete resulting in that the total consumption of material can be the half for wood construction with a wood-frame compared to construction in concrete (Hurmekoski, 2017).

2.1.4.3 *Social Perspective*

Hurmekoski (2017), Eriksson, Nord and Östman (2016) and Ramage et al. (2017) all propose that wood construction have benefits when it comes to fire safety. Eriksson, Nord and Östman (2017) explain that the number of fire incidents in Swedish wood-frame multi-storey buildings are lower than the incidents in the whole population of buildings. Furthermore, wood constructions have benefits when it comes to fire safety because, under fire, the behavior of massive wood is predictable, and when burning, a protective char layer is formed on the surface of the wood (Hurmekoski, 2017; Ramage et al., 2017). However, the results of a study conducted by Espinoza et al. (2016) indicate that fire resistance is an important topic for further research. Wood is still a burnable material and the requirement for engineering design that ensures a structural integrity of the building is therefore needed (Ramage et al., 2017).

The durability of wood used as structural material in construction is, according to Ramage et al. (2017), equivalent to other structural materials. In a study of 27 demolished buildings older than 100 years, none of the buildings were demolished due to problems with the structural material (Ramage et al., 2017).

The use of wood in construction also has the potential to reduce the disturbance to the surroundings of the construction site and increase the safety and convenience of the workers (Hurmekoski, 2017). Other possible benefits with wood construction is according to the author fitting accuracy, insulation benefits and tremor safety. Wooden surfaces are also beneficial for the air-quality indoor and might even have benefits for the human health through acoustic aspects, humidity buffering and an atmosphere which helps with stress-relieve (Muilu-Mäkelä et al., 2014 in Hurmekoski, Jonsson & Nord, 2015; Hurmekoski, 2017). On the same topic, a study performed by Markström et al. (2018) view that the use of visually exposed wood amplifies a positive attitude of an interior style.

2.1.4.4 *Attitudes and Perceptions Towards Industrial Wood-Frame Multi-Storey Construction*

Roos, Woxblom and McCluskey (2009) investigate the attitudes of architects and structural engineers towards the use of wood in construction. According to the authors, there is a lack of experience regarding wood-based construction in the industry and they claim that an increased emphasis on knowledge development, communication and building solutions could increase the interest in the technology. Additionally, Espinoza et al. (2016) also claim that the availability of technical information is a barrier for CLT adoption and that there is a need for future research, for example regarding the durability of wooden buildings. On the same topic, Lessing (2010) claims that the information deliveries are not produced in the needed rate. Furthermore, Roos, Woxblom and McCluskey (2009) argue that architects and structural engineers seems to appreciate the material from its advantages regarding high strength in relation to weight, suitability for industrial processes, flexibility and its positive climate properties regarding carbon storage. However, regarding total cost the opinions are fragmented since some of the respondents claim that it is cost effective while others claim that the increased risk of using wood will eliminate the margins (Roos, Woxblom & McCluskey, 2009). Also, regarding fire resistance properties, the opinions are fragmented and while some respondents emphasize the lower resistance to fire, others claim that the increased predictability of the fire, in relation to other materials, makes the design phase easier (Roos, Woxblom & McCluskey, 2009). Both architects and structural engineers, however, emphasize the lower moisture resistance, the lower stability and the demand for increased dimensions in beams and walls in order to fulfill the acoustic demands as disadvantages of the material (Roos, Woxblom & McCluskey, 2009).

In a literature review of perceptions, both advantages and disadvantages, of wood-frame multi-storey construction from key actors in the construction value chain, Hurmekoski, Jonsson and Nord (2015) have categorized the actors in the value chain as *developers and commissioners*, *architects and engineers*, *builders and contractors* and *wood product suppliers*. The actors' perceptions of the advantages and the disadvantages, presented in the article by Hurmekoski, Jonsson and Nord (2015), are presented in table 1 below.

Table 1: The key actors in the construction value chain's perceptions of the advantages and disadvantages of wood-frame multi-storey construction towards competing frame materials (Hurmekoski, Jonsson & Nord, 2015, p. 192).

	Advantages	Disadvantages
Developers and commissioners	• Meets durability and structural strength requirements • Less impact on environment • Practices are equal, as long as end product provides the same function	• Façade maintenance costs • Acoustic properties • Architects' and designers' lack of experience and confidence • Experimental nature • Tradition favor established practices
Architects and engineers	• May suit local building traditions • Natural, warm appearance • Environment and sustainability • Productivity and safety through industrial prefabrication • Modifiability	• Acoustic performance • Perception of costs, fire safety, durability, stability vary depending on the level of experience: The less experienced (majority) tend to be more skeptical, yet in some cases also vice versa • Professional norms not compatible: curiosity, experimental nature • Insufficient education and knowledge
Builders and contractors	• Meets durability and structural strength requirements	• Façade maintenance costs • Acoustic properties • Possible benefits not worth the risks
Wood product suppliers	• Superior solution • Easier and more cost-efficient maintenance	

Hurmekoski, Jonsson and Nord (2015) claim that several of the positive attributes of wood-frame multi-storey construction, such as reduced stress level of residents and better balance of the indoor moisture level, currently have no market value. Further, the authors find that the removing of regulatory hindrances, the overcoming of prejudices and barriers in the industry structure towards the concept as well as more competition within the sector in order to bring down the costs are key drivers for a successful market diffusion.

There are many perceptions when it comes to wood construction which for example include fire safety and issues with the strength and durability of wood construction (Hurmekoski, 2017). These perceptions do not, according to many researchers, necessarily reflect the real situation (Wang, Toppinen & Juslin, 2014; Hurmekoski, Jonsson & Nord, 2015; Hurmekoski, 2017). The perceptions are according to Hurmekoski (2017) probably based on experience from old techniques used in wood construction and are not applicable with the standards and techniques of modern wood construction.

2.1.5 Summary of Sustainability

When describing sustainability, social, economic and environmental aspects are often in some way included (Goodland & Ledec, 1987; Pirages, 1977 and Coomer, 1979 in Faber, Jorna & Engelen, 2005; Slaper & Hall, 2011; Savitz, 2014). Moreover, Patala et al. (2016) use categories for economic, environmental and social impacts when presenting sustainability impact categories in the sustainability literature. Therefore, sustainability aspects are viewed as economic, environmental and social aspects in this thesis. The sustainable impacts categories, presented by Patala et al. (2016), are used in this thesis in order to categorize different sustainable value creation factors for the actors in the value chain into potential economic, environmental and social value creation factors. These can be found in *Appendix 1*.

As presented in section *1.2.1 Sustainability in the Construction Industry*, the construction industry has economic, social and environmental impacts. Further, there are many potential sustainability (economic, environmental and social) benefits when it comes to industrial wood-frame multi-storey construction (Sathre & O'Connor, 2010; Hurmekoski, 2017; Brege, Nord & Stehn, 2017). From section *2.1.4 Sustainability in Industrial Wood-Frame Multi-Story Construction*, a list of factors which can potentially impact sustainable value creation, identified in the literature presented in this chapter, can be found in *Appendix 2*, together with identified factors from pre-survey interviews.

2.2 Value

In this section, the concept of value is presented. See figure 9 below for this section's relation to the other sections in this chapter.

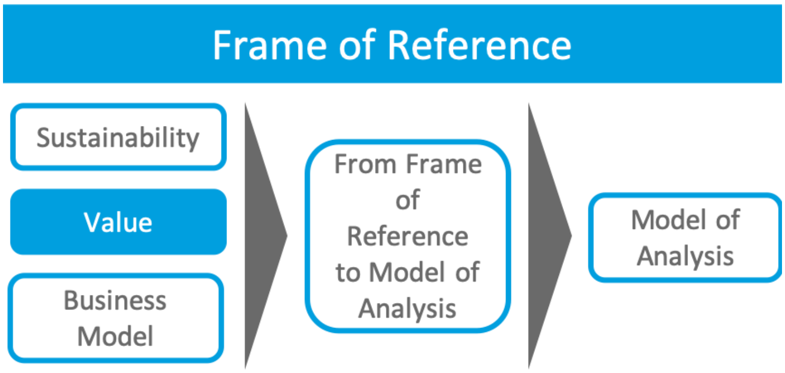

Figure 9: The concept of value's relation to the other sections of the frame of reference.

First, a brief description and background to the concept of value is given. This is followed by a description of the concepts *Customer Value* and *Sustainable Value*. Thereafter, a presentation of factors creating value in the construction industry found in the literature is given before the section ends up in a summary of the concept of value.

2.2.1 The Concept of Value

The concept of value has many meanings (Woodal, 2003), and the concept has been widely used in several different contexts, particularly in the management literature where some authors claim that the concept has been both overused and misused (Woodruff, 1997; Khalifa, 2004).

According to Kumar and Reinartz (2016, p. 36), "business is about creating value". Similar to this, Kumar and Reinartz (2016, p. 36) argue that the purpose of a sustainable business is "first, to create value for customers and, second, to extract some of that customer value in the form of profit, thereby creating value for the firm". As can be seen, Kumar and Reinartz (2016) differentiate the concepts of value for the customer and value for the firm. In line with this, Smith and Colgate **(**2007) and Terho et al. (2012) explain that a commonly used differentiation of different concepts of value is by distinguishing between value for the customer, with a focus on value received by the customer in the market exchange, and value for the firm, with a focus on creating, increasing and capturing value to maximize the economic value of a firms' activities. Additionally, Terho et al. (2012) propose that the concept of value also should include dyadic value, that integrates both of the previously described perspectives. In the management literature, a similar differentiation between customer value, shareholder value, and stakeholder value is commonly used (Khalifa, 2004).

2.2.2 Customer Value

One of the most explicit and used definition of customer value is "buyers' perceptions of value represent a tradeoff between the quality or benefits they perceive in the product relative to the sacrifice they perceive by paying the price" (Monroe, 1990, p. 46). Another, similar definition of customer value is "the consumer's overall assessment of the utility of a product based on perceptions of what is received and what is given" (Zeithaml, 1988, p. 14). However, Woodruff (1997) claims that those definitions rely too heavily on other terms and that the conceptual knowledge of customer value is quite fragmented. He emphasizes that the internal processes of an organization need to be in line with what customers value and that it is essential for the success of value-based strategies to have a clear understanding of the concept. Therefore, he provides a definition to consolidate the view of customer value as follows: "Customer value is a customer's perceived preference for, and evaluation of, those products attributes, attribute performances, and consequences arising from use that facilitates (or blocks) achieving the customer's goals and purposes in use situations." (Woodruff, 1997, p. 142).

In an effort to create a deep consensus of the concept, Woodall (2003) was bringing together a wide range of value for the customer literature ending up in the following synthetized definition: "Value for the customer (VC) is any demand-side, personal perception of advantage arising out of a customer's association with an organization's offering, and can occur as reduction in sacrifice; presence of benefit (perceived as either attributes or outcomes); the resultant of any weighed combination of sacrifice and benefit (determined and expressed either rationally or intuitively); or an aggregation , over time, of any or all of these." (Woodall, 2003, p. 21).

When trying to separate the underlying factors creating customer value, price and quality has traditionally been fundamental to the concept (Zeithaml, 1988; Monroe, 1990). Beyond that, Osterwalder and Pigneur (2010) claim that price, speed of service, design, customer experience, performance, newness, brand, customization, cost reduction, convenience and reduction of risk are examples of factors which can create value for customers.

2.2.3 Sustainable Value

Hart and Milstein (2003) define the *creation of sustainable value* as strategies and practices that at the same time contribute to a more sustainable world and drive shareholder value. Moreover, *sustainable value* can be defined as "shareholder wealth that simultaneously drives us toward a more sustainable world" (Hart & Milstein, 2003, p. 65). The authors present four strategies to create sustainable value. Each of those four strategies are explained to be linked to either economic, environmental, or social value creation. In addition, in the sustainability literature, value is usually seen as the economic, environmental and social benefits provided by the organization to the customer, the wider stakeholder network and to the society (Patala et al., 2016). In line with this, Evans et al. (2017) argue that if sustainability is viewed from the value perspective, economic, environmental and social value should be integrated in the concept, thus, an organization's value creation logic needs to consider not only economic value but also social and environmental value to get a more holistic view of value.

Different forms of economic value, environmental value and social value are presented in table 2 below. Typical forms of economic value are, according to Evans et al. (2017), traditional concepts as profit and return on investment. However, to make a business sustainable from an economic perspective, it also needs to generate a long-term liability and a stable business with financial resilience (Evans et al., 2017). Further, the environmental value form typically includes the use of renewable resources, processes with low emissions and waste, pollution prevention and a liability of the biodiversity. Lastly, the social value form includes equality and diversity, labor standards and liability of health and safety but often also a development of communities and secure livelihoods (Evans et al., 2017).

Table 2: Different forms of economic, environmental and social value (Evans et al., 2017).

Economic value forms	Environmental value forms	Social value forms
Profit	Renewable resources	Equality and diversity
Return on investment	Low emissions	Community development
Long-term viability	Low waste	Secure livelihood
Business stability	Pollution prevention	Labor standards
Financial resilience	Biodiversity	Health and safety

2.2.4 Factors Creating Value in the Construction Industry

In the U.K off-site construction industry, including several different actors in the value chain, Pan and Goodier (2012) identify three categories of factors that capture and create value of house-building businesses: process and activities, risk and financial. The value creating process and activities determine the form of the organization, the structure of the firm and it derives from land acquisition, activities performed pre-site, during the manufacturing and supply, to activities performed on-site or post-site (Pan & Goodier, 2012). According to the authors, risk factors include project, market, planning and economic risks. Finally, financial factors cover cash-flow, the payment method, capital investment and return on capital employed (Pan & Goodier, 2012).

From the perspective of architects and structural engineers, Roos, Woxblom and McCluskey (2009) have identified factors which they claim will influence the decision of material in a construction project. These factors are: functional demands, energy properties, appearance, earlier experience and knowledge about the material and the total cost of the investment (Roos, Woxblom & McCluskey, 2009).

2.2.5 Summary of Value

Value creating is a central part of a business (Kumar & Reinartz, 2016), and customer value is central when talking about value (Smith & Colgate, 2007; Terho et al., 2012; Khalifa, 2004). Therefore, creating customer value should be a central part of a business.

Based on the definitions of customer value, presented by Monroe (1990) and Zeithaml (1988), our view of customer value is that it relies on benefits and sacrifices perceived in an exchange process. Further, supported by the definitions presented by Woodruff (1997) and Woodall (2003), we claim that an advantage, or benefit, could be a value creating factor, and at the same time, a disadvantage could prevent value creation. Thus, an advantage or a benefit can be, but is not necessarily, a value creator and a disadvantage can, but does not necessarily, prevent value creation. Therefore, our interpretation is that benefits and sacrifices that the customer also sees as important in order for them to prefer, or not to prefer, the offering should create, or prevent, value for the customer.

In the search for a generic description of factors generating customer value, factors such as price, quality, speed of service, design, customer experience, performance, newness, brand, customization, cost reduction, convenience and reduction of risk is found (Osterwalder & Pigneur, 2010). Further, in research on the construction industry, factors such as processes and activities, risk, and financial are covered (Pan & Goodier, 2012). Furthermore, Roos, Woxblom and McCluskey (2009) explain that the choice of material seems to be affected by functional demands, energy properties, appearance, earlier experience and knowledge and lastly, the total cost of the investment. Thus, these factors are factors which could impact value creation in the construction industry.

When adding the sustainability dimension to the value concept, it is clear that economic, environmental and social aspects are integrated (Patala et al., 2016; Evans et al., 2017; Hart & Milstein, 2003). Therefore, in the rest of the thesis, sustainable customer value is viewed as a concept integrating economic, environmental and social aspects. The different forms of economic, environmental and social value, presented by Evans et al. (2017), are used in order to categorize different sustainable value creation factors for the actors in the value chain into potential economic, environmental and social value creation factors.

2.3 Business Models

In this section, the concept of business models is presented, see figure 10 below for this section's relation to the other sections in this chapter.

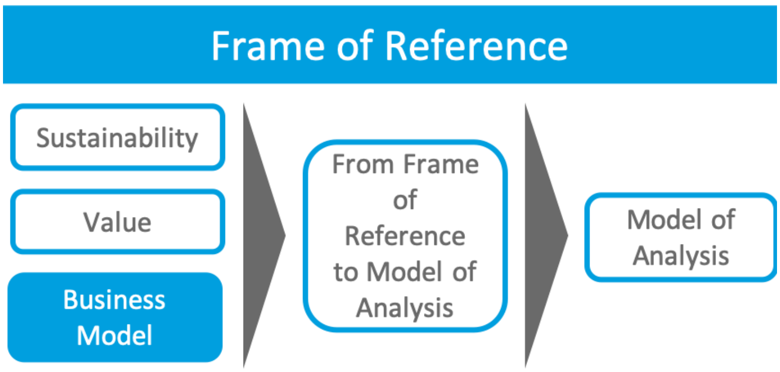

Figure 10: The concept of business model's relation to the other sections of the frame of reference.

A background to the concepts of *business models* and *sustainable business models* are given before some definitions and frameworks, both of business models and sustainable business models, are presented. In the literature presented in the sections below, the concept of value propositions and sustainable value propositions are described as central parts of business models and sustainable business models. Therefore, these concepts are presented in a separate section. A closer look into the concept regarding the construction industry are taken. Lastly, a summary of the business model concept is presented.

2.3.1 Background to the Concepts of Business Models and Sustainable Business Models

The concept of business models has its origin in writings from as early as 1954, where it was introduced by Peter Ducker, but it is not until the last decades *business model* as an expression has gained in prominence (Casadesus-Masanell & Ricart, 2010). Even though the expression *business model* has not always been used, businesses models are something that all businesses have (Magretta, 2002; Casadesus-Masanell & Ricart, 2010). The business model could be either market based, or resource based (Lessing & Brege, 2015). A market-based perspective takes the demands of the market and the customers as a starting point in the formulation of the organization's offer (Porter, 1996). A resource-based perspective, instead, use resources and competences as the starting point (Prahalad & Hamel, 1990). The distinction between market-based and resource-based approaches is by de Wit and Meyer (2017) explained as a paradox between outside-in and inside-out perspectives.

Lately, the interest of academics and practitioners for sustainable business models has had a rapidly growth (Geissdoerfer, Vladimirova & Evans, 2018). According to Geissdoerfer, Vladimirova and Evans (2018), in the beginning, the purpose of the concept of sustainable business models was to help with the transformation to a more sustainable economic system, enable the integration of considerations of sustainability in organizations and help organizations achieve their ambitions regarding sustainability. Now, sustainable business models are more and more seen as an important source to gain competitive advantage. To achieve a sustainable business model, innovation of products and services might not be enough, innovation of the actual business model can be needed (Evans et al., 2017).

2.3.2 Business Model and Sustainable Business Model Definitions

Casadesus-Masanell and Ricart (2010) explain that there are many different definitions of the concept of *business models* and how there are no specific definition which is widely accepted. However, Richardsson (2008) argues that there is a general agreement that a business model is a description of how a firm does business, which can be used as a basic definition.

Richardsson (2008, p. 136) also argues that the business model can be viewed as "the conceptual and architectural implementation of a business strategy and as the foundation for the implementation of business processes". Furthermore, Magretta (2002, p. 87) uses "stories that explain how enterprises work" to describe the concept of business models. A good business model answers, according to Magretta (2002), the questions formulated by Peter Drucker of *who the customer is* and *what the customer value*. Furthermore, it should answer how the business will make money and what the underlying logic of how the customer value at an appropriate cost will be delivered (Magretta, 2002).

To provide another example, Casadesus-Masanell and Ricart (2010, p. 197) use Baden-Fuller, MacMillan, Demil and Lecocq's definition of the business model which is formulated as "the logic of the firm, the way it operates and how it creates value for its stakeholders". Osterwalder and Pigneur (2010) also argue how value is a central part of the business model concept, they mean that the business model explains the way that a business creates, delivers and captures value.

Different definitions of the concept of *sustainable business models* also exist. These definitions, which can be found in the literature, have something in common; they view the concept of sustainable business models as a modification of the conventional concept of the business model (Geissdoerfer, Vladimirova & Evans, 2018). Geissdoerfer, Vladimirova and Evans (2018, p. 409) present the following working definition of a sustainable business model: "A business models that incorporate pro-active multi-stakeholder management, the creation of monetary and non-monetary value for a broad range of stakeholders and hold a long-term perspective." Thus, Geissdoerfer, Vladimirova and Evans (2018) take a stakeholder perspective and they also argue that sustainable business model innovation focuses on innovating the business model in order to create benefits for the organization's stakeholders.

Like Geissdoerfer, Vladimirova and Evans (2018), Shaltegger et al. (2016, p. 6) also take a stakeholder and a value perspective and present the following definition of a business model for sustainability: "A business model for sustainability helps describing, analyzing, managing, and communicating (i) a company's sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries.” Like Shaltegger et al. (2016), Evans et al. (2017) emphasize the importance of the encompassing of economic, environmental and social aspects and aligning the needs and interests of the organization’s stakeholders in sustainable business models. Also, Bocken et al. (2014) take a triple bottom line approach and consider the stakeholders’ interests in the concept of sustainable business models.

It is clear that creating value, sustainable aspects, often described as economic, environmental and social aspects, as well as considering a wide range of stakeholders, are central parts of a sustainable business model (Geissdoerfer, Vladimirova & Evans, 2018; Shaltegger, Hansen & Lüdeke-Freund, 2016; Evans et al., 2017; Bocken et al., 2014).

2.3.3 Business Model and Sustainable Business Model Frameworks

Richardsson (2008) explains that there are some common themes but also variations when looking at the components in the different business models presented in the literature. Usually, the frameworks consist of four to eight components and in total, around 24 different components have been identified in the literature (Richardsson, 2008).

Through reviews of business model framework literature, Richardsson (2008) and Ballon (2007) have investigated the most common components or aspects included in the business model concept. The most frequently included component, according to Richardsson (2008), is the value offering, or the value proposition. Some type of component describing the economic/profit/revenue model, the target markets, the customer relationships, the partner network and the roles and internal infrastructure are also often included (Richardsson, 2008). Ballon (2007, p. 8) presents the following areas which are similar to the components proposed by Richardsson (2008):

- “the products and services a firm offers, representing a substantial value to a target customer (value proposition), and for which he is willing to pay;
- the relationship the firm creates and maintains with the customer, in order to satisfy him and to generate sustainable revenues;
- the infrastructure and the network of partners that are necessary in order to create value and to maintain a good customer relationship; and
- the financial aspects that can be found throughout the three former components, such as cost and revenue structures.”

Osterwalder (2004) also presents similar four main areas of a business model. These areas, which Osterwalder (2004) calls pillars, are:

- *Product*, which includes the building block value proposition.
- *Customer Interface*, which includes the building blocks target customer, distribution channels and type of customer relationships.
- *Infrastructure Management*, which includes the building blocks value configuration (the needed activities and resources to create customer value), capability and partnership.
- *Financial Aspects*, which includes the building blocks revenue model and cost structure.

These pillars and building blocks are also presented in table 3 below (Osterwalder, 2004, p. 43).

Table 3: The four basic pillars and the nine business building blocks (Osterwalder, 2004, p. 43).

Pillar	Business Block	Description
Product	Value Proposition	An overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	Target Customer	A segment of customers a company wants to offer value to.
	Distribution Channel	A means of getting in touch with the customer.
	Relationship	Describes the kind of link the company establishes between itself and the customer.
Infrastructure Management	Value Configuration	Describes the arrangement of activities and resources that are necessary to create value for the customer.
	Capability	The ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.
	Partnership	A voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.
Financial Aspects	Cost Structure	The representation in money of all the means employed in the business model.
	Revenue Model	The was a company makes money through a variety of revenue flows.

To summarize, there is a consensus in literature reviews that business models consist of the following four basic areas/pillars: *the product/value proposition, the customer interface, infrastructure management* and *financial aspects*. Three of the most well-known business model frameworks are presented next, followed by a framework for sustainable business models. As can be seen, these business model frameworks often include, these four basic pillars, or similar elements.

2.3.3.1 *The Business Model Framework according to Mason and Spring*

Mason and Spring (2011) present a framework for business models of three elements, or cornerstones of the business model. These tree elements are *technology*, the *market offering* and the *network architecture*. The framework is presented in figure 11 below. The technology element concerns the organization's usage and knowledge of different techniques, methods and systems. The market offering element include the interaction between the producer and the user and how customer value is created. The last element, the network architecture, concerns the relationship between the firm and the organizations in its network, the organizations which the firm transacts with.

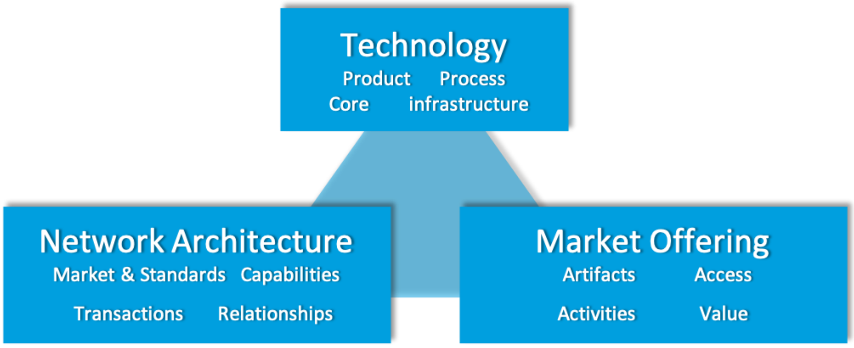

Figure 11: A framework for a business model according to Mason and Spring (2011).

2.3.3.2 *The Business Model Framework according to Richardsson*

Richardsson (2008) proposes a business model framework around the value concept and strategy execution. The author argue that this model can show how the business model framework can be used in the execution of the strategy. The framework includes three main elements: *the value proposition*, *value creation and delivery system* and lastly *value capture*. The value proposition is what the organization delivers to its customer and their approach to gain competitive advantage. The value creation and delivery system explain how the organization will create and deliver the value proposition and the source of their competitive advantage. Value capture is about revenue and profit generation. The model is presented in figure 12 below.

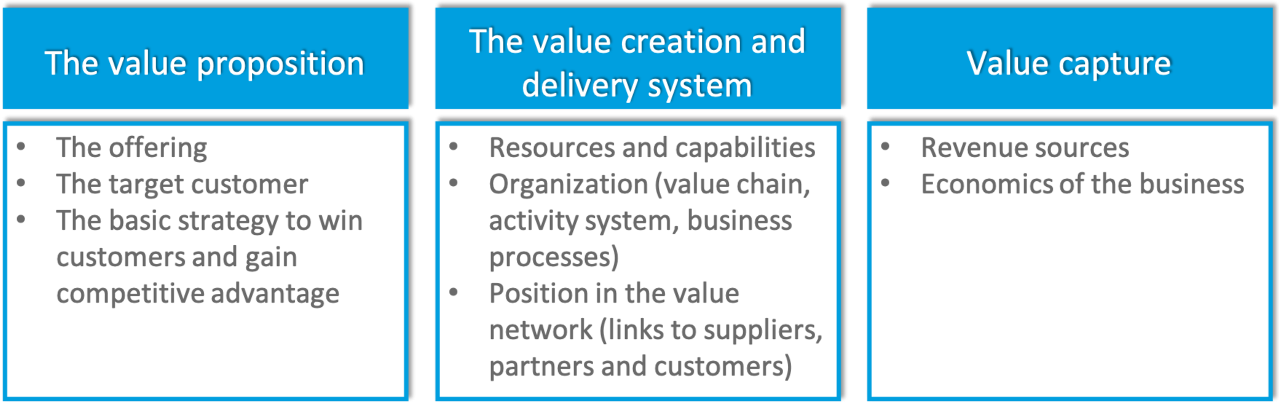

Figure 12: The business model framework according to Richardsson (2008).

2.3.3.3 *The Business Model Framework according to Osterwalder and Pigneur*

Osterwalder and Pigneur (2010, p. 14), who argue that a business model "describes the rationale of how an organization creates, delivers and captures value" present a framework for business models, or as Osterwalder and Pigneur say "a shared language for describing, visualizing, assessing and changing business models" (2010, p. 12). Their framework is called *The Business Model Canvas*, or the BMC. With the *Business Model Canvas*, the business model is described using nine building blocks which together cover the areas offer, customers, infrastructure and financial viability, of a business. The nine building blocks are: *value propositions*, *customer segments*, *channels*, *customer relationships*, *revenue streams*, *key resources*, *key activities*, *key partnerships* and *cost structure*, see figure 13 below.

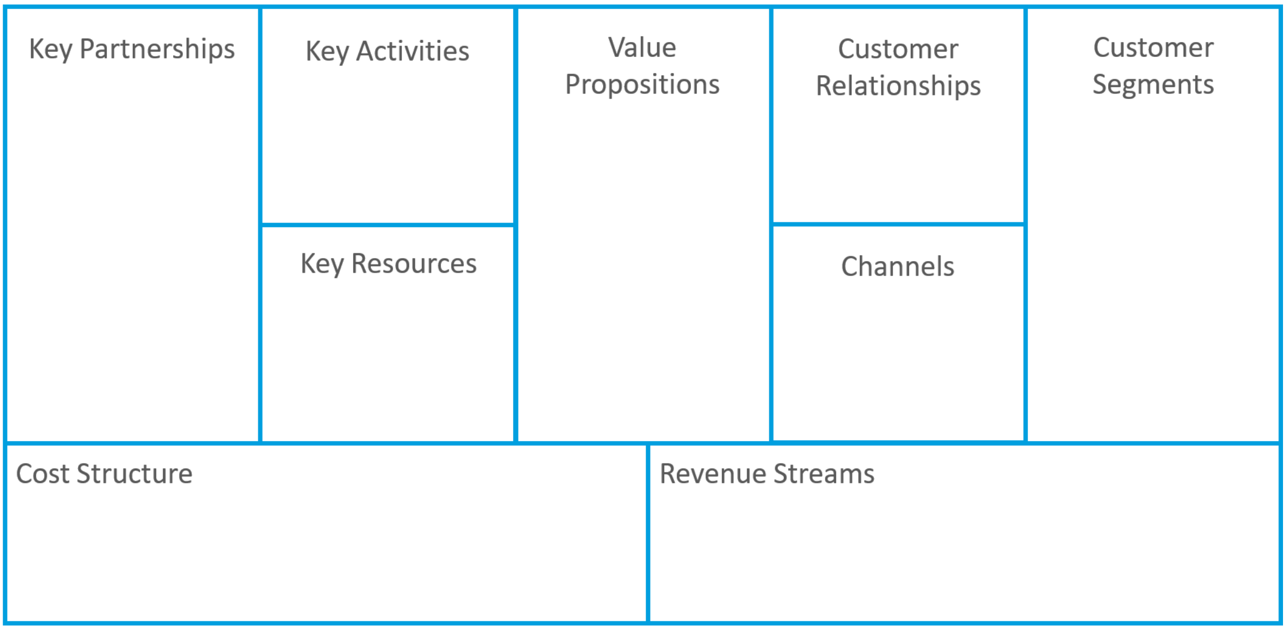

Figure 13: The Business Model Canvas (Osterwalder & Pigneur, 2010).

With the use of the business model canvas, presented by Osterwalder and Pigneur (2010), an organization can go through the different parts of their business model, investigate other solutions of doing business and find ways to improve their business model (Bisgaard, Henriksen & Bjerre, 2012).

Value Propositions

According to Osterwalder and Pigneur (2010), the *value propositions* block of the BMC defines the value proposition, the products and/or services which solves customer problems or satisfy customer needs and therefore create value for a customer segment. Price, speed of service, design, customer experience, performance, newness, brand, customization, cost reduction, convenience and reduction of risk are a few examples of elements that can contribute to value creation for customers (Osterwalder & Pigneur, 2010).

To be able to identify an organization's value proposition the following questions can be answered (Osterwalder & Pigneur, 2010):

- What is the value the organization delivers to their customers?
- What customer problem is the organization trying to solve?
- What customer need is the organization trying to satisfy?
- Which products and/or services are the organization offering each customer segment?

In the book *Value Proposition Design* the authors try to explain the relationship between the building blocks *value proposition* and *customer segments* of the *Business Model Canvas* (Osterwalder et al., 2015). The authors propose a framework, called the *Value Proposition Canvas*, which is supposed to be a practical tool to investigate whether an organization's value proposition correlations or fit with their customers' needs (Osterwalder et al., 2015). The authors argue that the *Business Model Canvas* explains how value is created for the organization whereas the *Value Proposition Canvas* explains how to create customer value. The Value Proposition Canvas have two sides with the goal to create a "fit" between these sides. (Osterwalder et al., 2015) One side shows the *pains* and the *gains* of the customers, what they struggle with and what they strive for and the other side shows the *pain relievers* and *gain creators* which the organization offers (Osterwalder et al., 2015). The canvas is illustrated in figure 14 below.

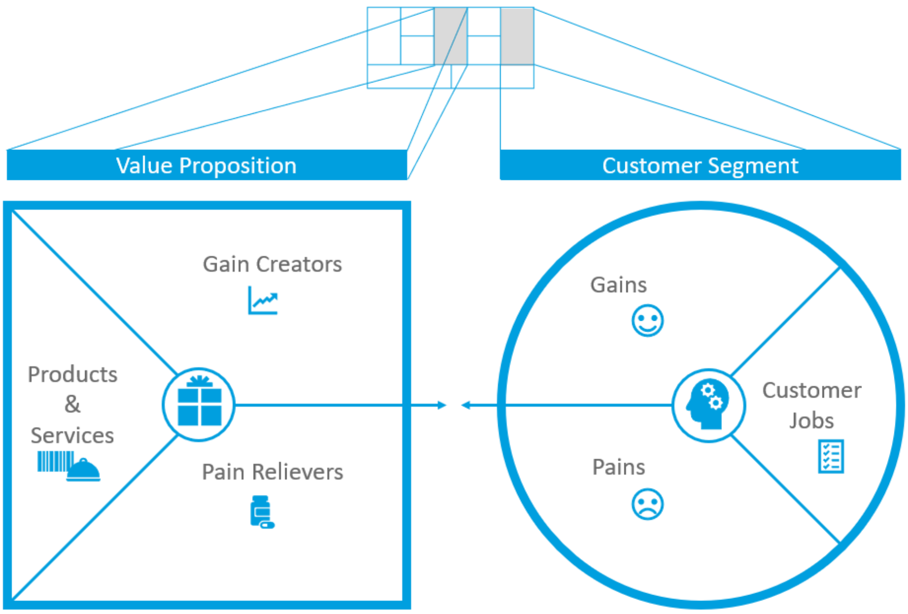

Figure 14: Value Proposition Canvas (Osterwalder et al., 2015).

Worth emphasizing is that the book is written as a practical handbook without a primary purpose to academically explain the meaning of value proposition and business models (Osterwalder et al., 2015). However, the model is visually descriptive and shows the importance of designing the value proposition based on what the customers value, as is the consensus in the academical literature presented in the value proposition section below.

Customer Segments

According to Osterwalder and Pigneur (2010), the *customer segments* block of the BMC defines the different customer segments the organization wants to reach and serve. Customers is of course a vital part to any organization and if customers are grouped into segments with, for example, common needs or behaviors, it can be easier to satisfy their needs and wants and also decide which segments the organization should serve and which segments they should ignore (Osterwalder & Pigneur, 2010).

To be able to identify an organization's customer segments the following questions can be answered (Osterwalder & Pigneur, 2010):

- For which customers are the organizations creating value?
- Which customers are the most important for the organization?

Channels

According to Osterwalder and Pigneur (2010), the *channels* block of the BMC explains the channels the organization uses; the way the organization reaches and communicates which their customer segments to be able bring the value proposition to market. These channels include channels for communication, distribution and sales and they can raise awareness of the values proposition, help customers evaluate and purchase the value proposition, deliver the value proposition and provide after sales support (Osterwalder & Pigneur, 2010). Examples of types of channels are sales force, web sales, own stores and also partner stores and wholesalers (Osterwalder & Pigneur, 2010).

To be able to identify an organization's channels the following questions can be answered (Osterwalder & Pigneur, 2010):

- Which channels do the different customer segments of the organization prefer?
- Which channels are the organization using now? How are the customers reached?
- Which channels work the best and are the most efficient when it comes to cost?
- How are the channels integrated with each other and with customer routines?

Customer Relationship

According to Osterwalder and Pigneur (2010), the *customer relationship* block of the BMC describes the different relationships the organization has with their customer segments. The relationships with the customers can be motivated by increasing sales and both acquire and retain customers and the relationship can be personal, automated or somewhere in between (Osterwalder & Pigneur, 2010). Personal assistance, self-service, automated service, communities where customers can interact and co-creation value with customers are examples of categories of different customer relationships (Osterwalder & Pigneur, 2010).

To be able to identify an organization's customer relationships the following questions can be answered (Osterwalder & Pigneur, 2010):

- What kind of customer relationship does the different customer segments expect the organization to have?
- What kind of customer relationship does the organization have with each of their customer segments?
- How costly are the organization's customer relationships?
- How are the organization's customer relationships integrated with the rest of the organization?

Revenue Streams

According to Osterwalder and Pigneur (2010), the *revenue streams* block of the BMC describes the revenue streams generated from the organization's different customer segments. Furthermore, Osterwalder and Pigneur (2010) argue that there are two types of revenue streams: transaction revenues and recurring revenues. Transaction revenues are the result of a one-time payment from a customer and recurring revenues are the result of ongoing payments from a customer. Asset sale, usage fee, leasing, licensing, fee for subscription, fee for advertising are examples of different ways to generate revenue streams (Osterwalder & Pigneur, 2010). This block of the BMC also presents the pricing mechanisms used which will fall under one of the following main pricing mechanisms: fixed or dynamic pricing (Osterwalder & Pigneur, 2010).

To be able to identify an organization's revenue streams the following questions can be answered (Osterwalder & Pigneur, 2010):

- What is the value that the organization's customers are willing to pay for?
- What are the organization's customers paying for today?
- How would the organization's customers prefer to pay?
- How are the organization's customers paying today?
- How are the different revenue streams contributing to the overall revenues for the organization?

Key Resources

According to Osterwalder and Pigneur (2010), the *key resources* block of the BMC presents the organization's key assets which the organization needs in order to deliver their value proposition and enable the rest of the business model. Different business models need different key resources and they can be physical, intellectual, human or financial (Osterwalder & Pigneur, 2010).

To be able to identify an organization's key resources the following questions can be answered (Osterwalder & Pigneur, 2010):

- What kind of key resources are required to deliver the organization's value proposition and for the distribution channels, customer relationships and revenue streams of the organization?

Key Activities

According to Osterwalder and Pigneur (2010), the *key activities* block of the BMC presents the key activities, the most important activities the organization have to perform in order to deliver the value proposition and enable the rest of the business model. As for key resources, different business models need different key activities and they can be categorized to production, problem solving or platform/network (Osterwalder & Pigneur, 2010).

To be able to identify an organization's key activities the following questions can be answered (Osterwalder & Pigneur, 2010):

- What kind of key activities are required to deliver the organization's value proposition and for the distribution channels, customer relationships and revenue streams of the organization?

Key Partnerships

According to Osterwalder and Pigneur (2010), the *key partnerships* block of the BMC explains the organization's supplier and partner networks. Osterwalder and Pigneur (2010) distinguish four different types of partnerships: strategic alliances with non-competitors, strategic partnerships with competitors, joint ventures, buyer-supplier relationships and different motivators for creating partnerships: economy of scale, optimization, risk and uncertainty reduction, resource and activity acquisition.

To be able to identify an organization's key partners the following questions can be answered (Osterwalder & Pigneur, 2010):

- Who are the key partners of the organization?
- Who are the key suppliers of the organization?
- Which key resources do the organization acquire from their partners?
- Which key activities do the organization's partners perform?

Cost Structure

According to Osterwalder and Pigneur (2010), the *cost structure* block of the BMC presents the costs the organization generates when operating their business model. The business model can have either a cost-driven or and value driven cost structure or have a cost structure somewhere in between these two extremes and can be characterized by fixed costs, variable costs, economies of scale or economies of scope (Osterwalder & Pigneur, 2010).

To be able to identify an organization's cost structure the following questions can be answered (Osterwalder & Pigneur, 2010):

- Which costs are the most important for the organization's business model?
- Which key resources, key activities and key partnerships are the most expensive?

2.3.3.4 *The Triple Layered Business Model Canvas*

Joyce and Paquin (2016) present a framework for sustainable business models, or a tool for sustainable business model innovation. The tool can be used to get a holistic view of business models by integrating economic, environmental and social dimensions. The model is called the Triple Layered Business Model Canvas and is an extension of the original, economic-oriented, business model canvas presented by Osterwalder and Pigneur (2010). *The Triple Layered Business Model Canvas* adds two more layers to the original business model canvas; an environmental life cycle layer and a social stakeholder layer (Joyce & Paquin, 2016). The model integrates economic, environmental and social value, the triple-bottom line approach (Elkington, 1997), and therefore provides a holistic view of corporate sustainability (Joyce & Paquin, 2016).

Joyce and Paquin (2016) argue that the *Triple Layered Business Model Canvas* helps developing, visualizing and communication sustainable business model innovation and supports organizations in their work for competitive sustainability-oriented change to tackle the challenges they face. Furthermore, they argue that it provides horizontal coherence within each layer of the canvas where the layers explore economic, environmental and social value separate, but the canvas also provides vertical coherence because it also integrates value creation across the three layers of the canvas, see figure 15 below.

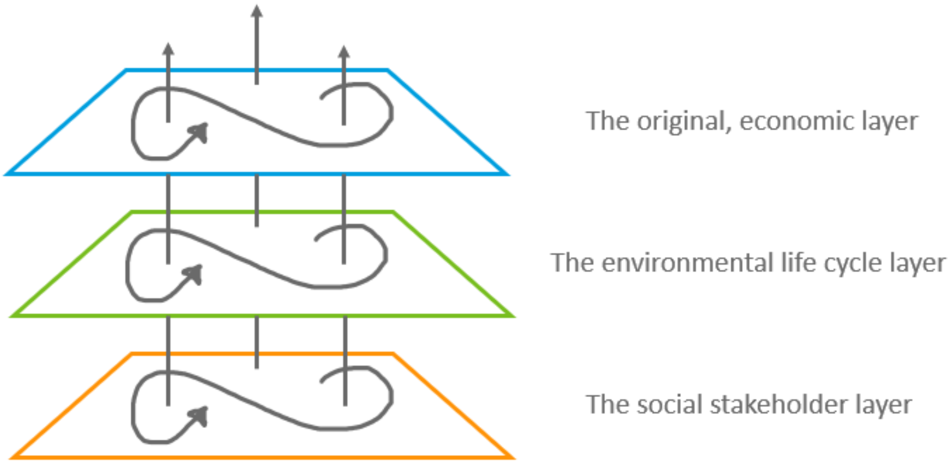

Figure 15: Vertical and horizontal coherence of the Triple Layered Business Model Canvas (Joyce & Paquin, 2016).

Joyce and Paquin (2016) explain that the environmental layer of the canvas has a life cycle perspective to explore the environmental impact of the organization. Furthermore, both the social canvas layer and the environmental canvas layer take a stakeholder management approach to be able to explore the social and environmental impacts of the organization (Joyce & Paquin, 2016). When a stakeholder management approach is used, an organization tries to balance the interests of their stakeholders instead of only trying to maximize the gain for the organizations alone (Joyce & Paquin, 2016).

2.3.4 Value Proposition and Sustainable Value Proposition

As presented in the sections above, the concept of value propositions and sustainable value propositions are described as central parts of business models and sustainable business models. Therefore, these concepts are further described in this section.

The *customer value proposition* is important in the role of communicating how an organization wants to provide value for their customers (Payne, Frow & Eggert, 2017). The concept of the customer value proposition was developed in the 1980's by strategy consultants and since then it has had a rapid growth. At that time, customer value proposition was explained as the benefit or benefits offered to which customers, for what price and at what cost (Payne, Frow & Eggert, 2017). Since the 1980's the literature of customer value proposition has developed, and some literature take a wider range of stakeholders into consideration and include social, environmental and ethical issues (Payne, Frow & Eggert, 2017). According to Payne, Frow and Eggert (2017), there are many researchers who emphasize how important it is to take a broad range of stakeholders into consideration, not just the customers, to be able to for example consider social, environmental and ethical aspects. For example, some researchers argue how organizations have to engage with other actors in the value chain to be able to deliver an appropriate value proposition (Payne, Frow & Eggert, 2017). Some researchers also emphasize the engagement and interaction with a broad range of stakeholders to enable resource integration and others argue that organizations need to involve multiple actors when developing their value propositions (Payne, Frow & Eggert, 2017).

According to Anderson, Narus and van Rossum (2006), with the understanding of what the customers actually need and value, value propositions which are meaningful and create superior value for the organization's target customers can be developed (Anderson, Narus & van Rossum, 2006). Furthermore, Anderson, Narus and van Rossum (2006) argue that there are three kinds of value propositions, which the authors call *all benefits*, *favorable points of difference* and *resonating focus*. If all benefits which the offering might deliver to the customers are listed, an all benefit value proposition is used (Anderson, Narus & van Rossum, 2006). If the offering's favorable points of difference relative alternatives are presented a favorable points of difference value proposition is used (Anderson, Narus & van Rossum, 2006).

However, the authors argue that the best kind of value proposition is the resonating focus proposition. With resonating focus, the value proposition is based on a few elements, a few points of difference, that are the most important for the organization's customers and the offering are superior on these elements (Anderson, Narus & van Rossum, 2006). The value of these points of difference are demonstrated and the value is communicated in a way that shows that the organization has a good understanding of the customer's business priorities. Thus, the resonating focus proposition focuses on the points of difference which deliver the greatest value to the customers and to be able to develop this optimal, resonating focus proposition, the organization therefore needs to investigate what the customer value and have knowledge of how their offering delivers superior value compared with the alternatives on the market (Anderson, Narus & van Rossum, 2006). The different ways to use value proposition are described in table 4 below.

Table 4: Three kinds of value propositions (Anderson, Narus & van Rossum, 2006).

	Consists of	Required	Potential disadvantage
All benefits	All the benefits the customers might receive from the offering	Knowledge of the organization's offering	Benefit assertion
Favorable points of difference	All of the offering's favorable points of difference compared to alternatives	Knowledge of the organization's offering and alternatives	Value presumption
Resonating focus	The few most important points of difference which delivers the greatest value to the customer	Knowledge of how the organization's offering delivers superior value relative alternatives	Customer value research is required

Anderson, Narus and van Rossum (2006) emphasize the importance of showing a potential customer the cost saving or added value of the organization's offering. The authors argue that the cost saving or added value can be demonstrated by using value case histories. With value case histories, the cost saving or added value reference customers have received from the organization's offering are documented and presented to potential new customers (Anderson, Narus & van Rossum, 2006).

To understand what makes a value proposition sustainable, Patala et al. (2016, p. 144) define sustainable value propositions as "a promise on the economic, environmental and social benefits that a firm's offering delivers to customers and society at large, considering both short-term profits and long-term sustainability".

In line with Patala et al. (2016), Müller (2012) also argues that in a sustainable value proposition, the starting point has to be radical orientation to the needs of the organization's customers. A sustainable value proposition has to generate benefits for the organization's customers because the customers controls the organization, the supplier, with their decisions. However, customers may not value or understand the value of sustainability. Therefore, a sustainable value proposition usually describes activities with the purpose to inform and explain the sustainable value to the customer. The customer might still have needs which do not fit with sustainability and therefore Müller (2012) argues that a distinction between needs and satisfiers are needed. The author claim that the sustainable value proposition needs to explain how the customers' needs can be satisfied in a sustainable way.

Thus, a sustainable value proposition must deliver economic, social and environmental benefits for the customers and other stakeholders and satisfy their needs in a sustainable way. The next question is how this sustainable value proposition can be developed. Patala et al. (2016) present how a customer value proposition, which is environmentally, socially and economically sustainable, is developed. Thus, they present how to develop a sustainable value proposition. They argue that the first step is to identify potential impacts of the offering, thus identifying potential key benefits which could deliver value in the economic, environmental and social dimensions for customers and relevant stakeholders. Furthermore, they argue that the next step is to identify key value creation mechanisms. Suppliers need to understand what type of impacts their customers values and customize their value propositions to their customers' needs (Patala et al., 2016).

2.3.5 Business Models in the Construction Industry

Despite the extensive amount of literature related to business models in general, the knowledge and research connecting building and construction with business models is very limited (Pan & Goodier, 2012). According to the authors "the concept of business models in business and management seems to have been used in building and construction disciplines by default" (Pan & Goodier, 2012, p. 85). Even though there are, according to Pan and Goodier (2012), no generally accepted and explicitly defined description of business models in the construction industry, they have found two studies, of typical business model constructs and their relationships with housing delivery in the UK, to review, (Callcutt (2007); Ball (2010) in Pan & Goodier (2012)). The categorization of business models which both studies presents are very similar and are developed based on house-building processes and the activities involved. Here, Pan and Goodier (2012) distinguish between *one-off producers*, with a flow nature of development and production that is limited to one site only, and *repeat builders*, where house-building activities is a part of a continuous process.

Since the article written by Pan and Goodier (2012) was released, the research on business models in the construction industry has further evolved. Similar to the categorization of *one of-producers* and *repeat builders* Brege, Stehn and Nord (2014) distinguish between *traditional building* and *industrialized building* when they are adapting a general business model construct to the concept of industrialized house building.

Lessing and Brege (2015) takes business model research on house-building businesses one step further, distinguishing between *project-oriented business models*, which are the building of one-of a-kind buildings using on-site methods, and *production*- or *product-oriented business models*, where industrialized house-building methods is used based on prefabrication strategies and product platforms. The difference between a production-oriented business model and a product-oriented business model is whether the prefabrication mode, or the product platform, is taken as the starting point of the operational platform in the business model design (Lessing & Brege, 2015). Typically for material suppliers are that they, according to the authors, have been production-oriented, with an inside-out perspective. However, according to Lessing and Brege (2015) a market-based outside-in perspective is a successful approach for balancing business model dimensions. A product-orientation, Lessing and Brege (2015) claim, is specialized on the offering and the operational platforms of the business model.

2.3.5.1 *Business Model Framework in the Construction Industry*

Brege, Stehn and Nord (2014) present a business model framework for industrialized building of multi-storey houses based on three business model blocks: *market position*, *offering* and *operational platform*, see figure 16 below.

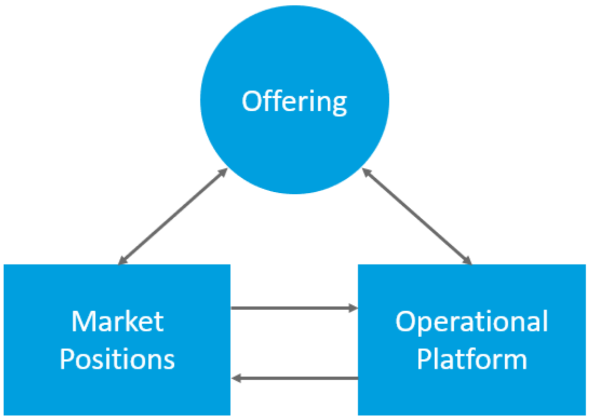

Figure 16: Business model framework for industrialized building of multi-storey houses (Brege, Stehn & Nord, 2014).

Each business model block consists of business model elements (Brege, Stehn & Nord, 2014). The business model blocks and the business model elements: *prefabrication mode, role in the building process, end-user segments, system augmentation* and *complementary resources*, presented by Brege, Stehn and Nord (2014), are shown in table 5 below.

Table 5: The relationships between Business Model Blocks and Business Model Elements (Brege, Stehn & Nord, 2014, p. 216).

Business Model Blocks	Business Model Elements	Variance
Market position	End-user segments Role in the building process	Level of standard, degree of customer adaptation Developer and main contractor, main contractor, subcontractor, supplier
Offering	System augmentation Prefabrication mode	Turnkey, climate-proof structural frame, component systems
Operational Platform	 Complementary resource base	Volume modules, floor/wall elements, component systems Design and onsite production resources

According to Brege, Stehn and Nord (2014), the business model should have a good external fit between the environment and the configuration of the different design parameters, but also a good internal fit among the design parameters themselves. Therefore, the external and internal fit between the elements generates several business model configurations that is viable to combine (Brege, Stehn & Nord, 2014).

Prefabrication Mode

Brege, Stehn and Nord (2014) use prefabrication mode as the starting point of the operational platform in the business model construct. They identify three prefabrication modes of building systems: component systems, floor/wall elements and module elements. Component systems operate at the lowest prefabrication level with a majority of the activities generated onsite. Module elements is at the highest prefabrication level with a majority of the activities generated offsite. Between component systems and module elements is the prefabrication level of floor/wall elements. According to the authors, the three prefabrication modes differ in knowledge, intensity and complexity of coordination. The higher the complexity of a building system and production platform is, the higher the requirements of an early involvement with architects and designers are (Brege, Stehn & Nord, 2014). Further, they differ from a business perspective through the focus on project or the focus on process and they also differ from a technical perspective through maintaining and developing of the building system. In addition, Lessing and Brege (2015) argue that a product-oriented business model instead of using the prefabrication mode, uses the product platform as the starting point for the business model design.

Complementary Resources

The operational platform is also dependent on complementary resources for design and onsite construction (Brege, Stehn & Nord, 2014). The authors describe this category as architectural resources, design capabilities, and assembly teams and resources. In other words, the resources directed towards the design and onsite production activities. The amount of complementary resources needed is according to the authors reversely correlated to the prefabrication level of the building system. Thus, the higher the prefabrication mode is, the lower the need for complementary resources are. Regarding the liabilities and responsibilities from a producer of frame systems (floor/wall elements), the customers may request the producer to provide onsite assembly capacities and coordination with technical sub-consultants such as architects and structural engineers during design phase (Brege, Stehn & Nord, 2014). This implies, according to the authors, a degree of risk-taking that is affecting the business model of the producer.

System Augmentation

Brege, Stehn and Nord (2014) define the offering as the system augmentation that is the most important part of the business model, ending up in a value proposition that is directed towards customers. The system augmentation refers to the value that is added in the offering and could, according to the authors, be analyzed through two dimensions: (1) the prefabrication mode, and (2) the building process positioning of the firm. From combining those two dimensions, several different offerings are accomplished (Brege, Stehn & Nord, 2014). When a floor/wall element prefabrication mode is combined with a subcontracting role, it results in an offering of a climate-proof structural frame, or a complete climate shell including cladding (Brege, Stehn & Nord, 2014).

Building Process Positioning

To define the market position, the building process positioning strategy needs to be managed (Brege, Stehn & Nord, 2014). According to the authors, a high prefabrication mode implies obstacles when it comes to coordination of subcontractors and adaptation to varying client conditions. For a producer of floor/wall elements, the level of onsite coordination and responsibilities in the design phase are at a medium level (Brege, Stehn & Nord, 2014). They offer moderate flexibility in meeting the customer demands and building specifications (Brege, Stehn & Nord, 2014).

End-user Segments

Based on a combination of theoretical and empirical findings, Brege, Stehn and Nord (2014) identify four types of interconnected dimensions that they claim are important for segmentation of end-users. Those dimensions are:

1. The level of living and architectural standard/quality (High, Medium, Low)
2. Attractiveness of the location (High, Medium, Low)
3. Type of living (Family, elderly, students, others)
4. The tenure of a dwelling (rental or condominium)

Further, the segmentation of end-users is connected to the prefabrication mode, the four dimensions could be condensed into two variables: (1) the level of living and architectural design standard, and (2) the degree of customer adaptation (Brege, Stehn & Nord, 2014). Moreover, the producer of floor/wall elements is according to the authors normally targeted towards end-user segments with high standard and towards customer adaptation in high and medium attractive locations.

2.3.6 Summary of Business Models

It is clear that value is a central part of a business model. Magretta (2002), Casadesus-Masanell and Ricart (2010) and Osterwalder and Pigneur (2010) all define a business model with value as a central part of the definition. Further, there is a consensus that creating, delivering and capturing of value is a central part of a business model (Magretta, 2002; Richardsson, 2008; Osterwalder & Pigneur, 2010). The three business model frameworks presented by Richardsson (2008), Osterwalder and Pigneur (2010) and Mason and Spring (2011) all integrate the concept of value. The business model framework for industrialized building of multi-storey houses, presented by Brege, Stehn and Nord (2014), has many similarities with the business model framework presented by Mason and Spring (2011) who also integrate the concept of value as a central part in what they call the offering.

Furthermore, the *value proposition* or the *offering* in the different frameworks presented by Richardsson (2008), Osterwalder and Pigneur (2010), Mason and Spring (2011) and Brege, Stehn and Nord (2014) are similar concepts and these concepts play a central part in each of these business model frameworks, as well as in other frameworks in the literature (Richardsson, 2008; Ballon, 2007; Osterwalder, 2004). In these models presented by Richardsson (2008), Osterwalder and Pigneur (2010) and Mason and Spring (2011), the *value proposition* or the *offering* are presented as the link between value creation and the business model and it explains how the organization will provide value for their customers. The value proposition should focus on the points of difference which deliver the greatest value to the customers and to be able to develop this optimal, resonating focus proposition, the organization needs to investigate what the customer value and have knowledge of how their offering delivers superior value compared with the alternatives on the market (Anderson, Narus & van Rossum, 2006). Thus, to understand what customers actually need and value is important to be able to develop value propositions which can create superior value for the organization's target customers.

The literature makes clear that sustainable aspects, described as economic, environmental and social aspects, as well as considering a wide range of stakeholders are central parts of a sustainable business model (Shaltegger, Hansen & Lüdeke-Freund, 2016; Evans et al., 2017; Joyce & Paquin, 2016, Bocken et al., 2014). A sustainable business model needs a sustainable value proposition which deliver economic, social and environmental benefits for the customers and other stakeholders and satisfy their needs in a sustainable way (Patala et al., 2016; Müller, 2012). The first step is to identify potential economic, environmental and social impacts of the offering, and the next step is to identify key value creation mechanisms, identify what type of impacts their customers value, and customize the value propositions to the needs of the customers (Patala et al., 2016). Even if creating sustainable value for customers and stakeholders is a central part of a sustainable business model, it is not enough for a business model to be sustainable.

The *Triple Layered Business Model Canvas* is a suggestion of how conventional business models can be interpreted as an economic layer of a sustainable business, with the focus on creating economic value, and how two more types of value need to be created through a sustainable business model: social value and environmental value. However, we claim that since the purpose of this thesis focus on how to deliver sustainable value through a business model rather than expanding it all the way to a sustainable business model, this framework will not be used further.

As elaborated through this chapter, there are many different frameworks to describe business models. The business models often consist of four basic areas: *the product/value proposition, the customer interface, infrastructure management* and *financial aspects* (Richardsson, 2008; Ballon, 2007, Osterwalder, 2004). Additionally, Brege, Stehn and Nord (2014) present similar basic areas for business models in the construction industry, however, they do not include the financial aspects into their framework. This shows that the three first areas should be valid to describe also a business model in the construction industry. We argue that financial aspects are important for all businesses and must therefore logically be included in a business model in the construction industry too. Thus, the four most common areas of a business model: *the product/value proposition, the customer interface, infrastructure management* and *financial aspects* are used further in this thesis in order to describe a business model. Further, the more detailed description of a business model, presented by Osterwalder and Pigneur (2010), and the elements of a business model in the construction industry: *prefabrication mode, role in the building process, end-user segments, system augmentation and complementary resources,* presented by Brege, Stehn and Nord (2014), are used as concepts to describe and analyze the business model of the material supplier.

2.4 From Frame of Reference to Model of Analysis

In this section, a synthesizing summary of the theoretical concepts is presented, see figure 17 below for this section's relation to the other sections in this chapter.

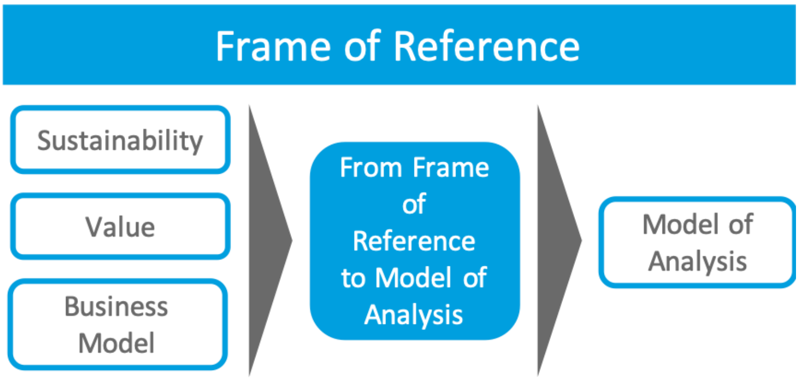

Figure 17: The synthesizing summary's relation to the other sections of the frame of reference.

There is more or less a consensus in the literature presented that sustainability is about improving economic, and social aspects *(growth, benefits, needs or quality of human life)* in the present, while maintaining similar conditions in the future. Thus, this implies a consideration of environmental aspects that, together with the economic and social aspects is central to sustainability (Goodland and Ledec (1987); Pirages (1977); Coomer (1979) in Faber, Jorna & Engelen (2005); Slaper & Hall, 2011; Savitz, 2014). Therefore, in the rest of this thesis sustainability aspects are viewed as a concept integrating economic, environmental and social aspects.

Value creating is a central part of a business (Kumar & Reinartz, 2016), and customer value, that rely on benefits and sacrifices perceived in an exchange process, is central when talking about value (Smith & Colgate, 2007; Terho et al., 2012; Khalifa, 2004). When adding the sustainability dimension to the value concept, economic, environmental and social value are integrated (Patala et al., 2016; Evans et al., 2017; Hart & Milstein, 2003). Consequently, in the rest of this thesis, sustainable value for the actors in the construction value chain, regarding the frame material, are viewed as a concept integrating economic, environmental and social value, see figure 18 below.

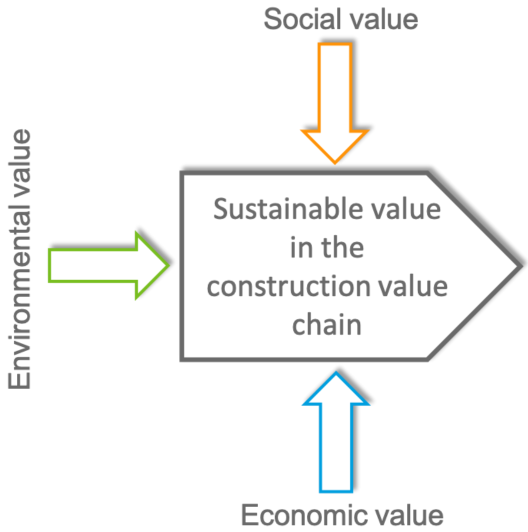

Figure 18: The authors' view of sustainability in the construction value chain.

What creates sustainable value in the construction industry regarding the choice of the frame material is not clear. As can be seen in *2.1 Sustainability*, there are many potential benefits and perceptions of advantages and also disadvantages with wood-frame material**.** In line with the definitions presented by Woodruff (1997) and Woodall (2003), we argue that an advantage or a benefit can be, but is not necessarily, a value creator and a disadvantage can, but does not necessarily, prevent value creation. If these potential benefits and advantages do create value for the actors in the construction value chain and if the potential disadvantages prevent value creation are investigated further in this thesis.

The explanation of a business model as a *story*, or a *description*, of a firm and how it does business seems to be generally accepted in the literature (Magretta, 2002; Richardsson, 2008). The business model could be either market based, or resource based (Lessing and Brege, 2015). A market-based perspective on the development of a business model takes the demands of the market and customers' as a starting point formulating the company's offer (Porter, 1996). A resource-based perspective, instead, use resources and competences as the starting point (Prahalad and Hamel, 1990). Furthermore, it is observed that business model frameworks generally consist of four basic areas: *the product/value proposition, the customer interface, infrastructure management* and *financial aspects* (Richardsson, 2008; Ballon, 2007; Osterwalder, 2004). By using the sustainable value demanded by the actors as the starting point of the business model construct, this thesis will use a market-based perspective. The more detailed description of a business model, presented by Osterwalder and Pigneur (2010) as the *Business Model Canvas* and the elements of a business model in the construction industry: *prefabrication mode, role in the building process, end-user segments, system augmentation and complementary resources,* presented by Brege, Stehn and Nord (2014), are used in order to generate a more detailed description of the business model of the material supplier. How the business model is viewed in the rest of the thesis is illustrated in figure 19 below.

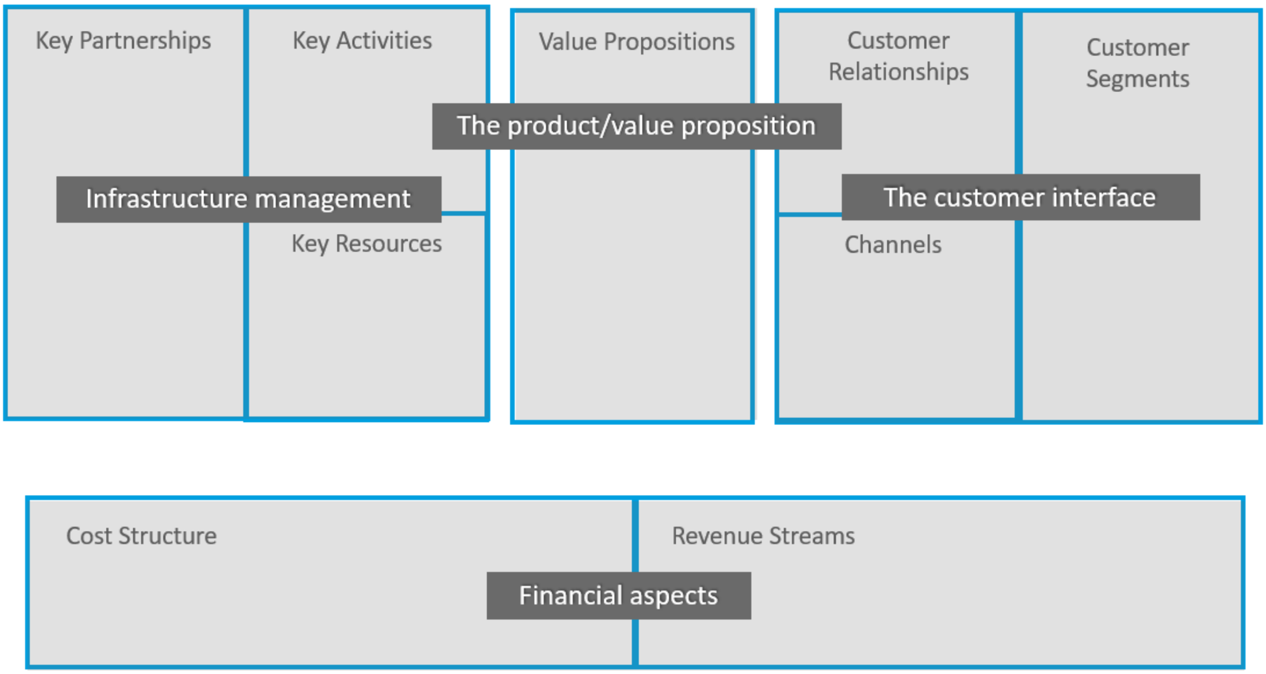

Figure 19: The view of a business model in this thesis.

It is clear that creating, delivering and capturing of value is a central part of a business model (Magretta, 2002; Richardsson, 2008; Osterwalder & Pigneur, 2010). Further, Richardsson (2008), Osterwalder and Pigneur (2010) and Mason and Spring (2011) all agree that the *value proposition* or the *offering* are presented as the link between value creation and the business model and the value proposition explains how the organization will provide value for their customers. To be able to develop an optimal value proposition, which Anderson, Narus and van Rossum (2006) claim is the resonating focus proposition, the organization needs to investigate what the customer value (Anderson, Narus & van Rossum, 2006). Thus, to understand what customers actually need and value is important to be able to develop value propositions which can create superior value for the organization's target customers.

In the same way as the value proposition is central in a traditional business model, a sustainable value proposition is central in a sustainable business model. A sustainable business model needs a sustainable value proposition which deliver economic, social and environmental benefits for the customers and other stakeholders and satisfy their needs in a sustainable way (Patala et al., 2016; Müller, 2012). Thus, a material supplier in the wood-frame multi-storey construction industry needs to understand what their customers and other main stakeholders, the actors in the construction chain, actually value to be able to develop a sustainable value propositions and a sustainable business model.

Furthermore, when developing a sustainable business model, and a sustainable value proposition, from a market-based outside-in perspective, the starting point should be to understand what the market value. Based on the approach of Patala et al. (2014), to develop a sustainable value proposition for a material supplier in wood-frame multi-storey constructon sustainable value proposition, the first step is to identify potential economic, environmental and social impacts of their value proposition. The next step is to identify key value creation mechanisms, identify what type of impacts the actors in the construction value chain value, and customize the value propositions to meet their needs. This approach is used when investigating how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model.

2.4.1 Model of Analysis

In this section, the model of analysis of the thesis is presented, see figure 20 below for this section's relation to the other sections in this chapter.

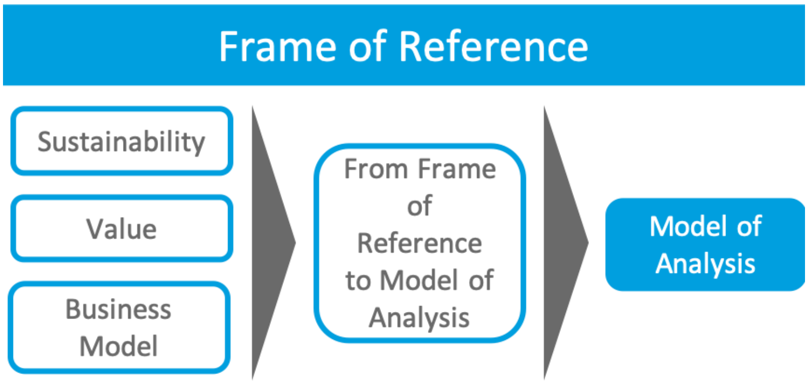

Figure 20: The Model of Analysis' relation to the other sections of the frame of reference.

The model of analysis of this thesis shows how to reach the purpose of this thesis, *to investigate how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.* The model of analysis used in this thesis is illustrated in figure 21 below.

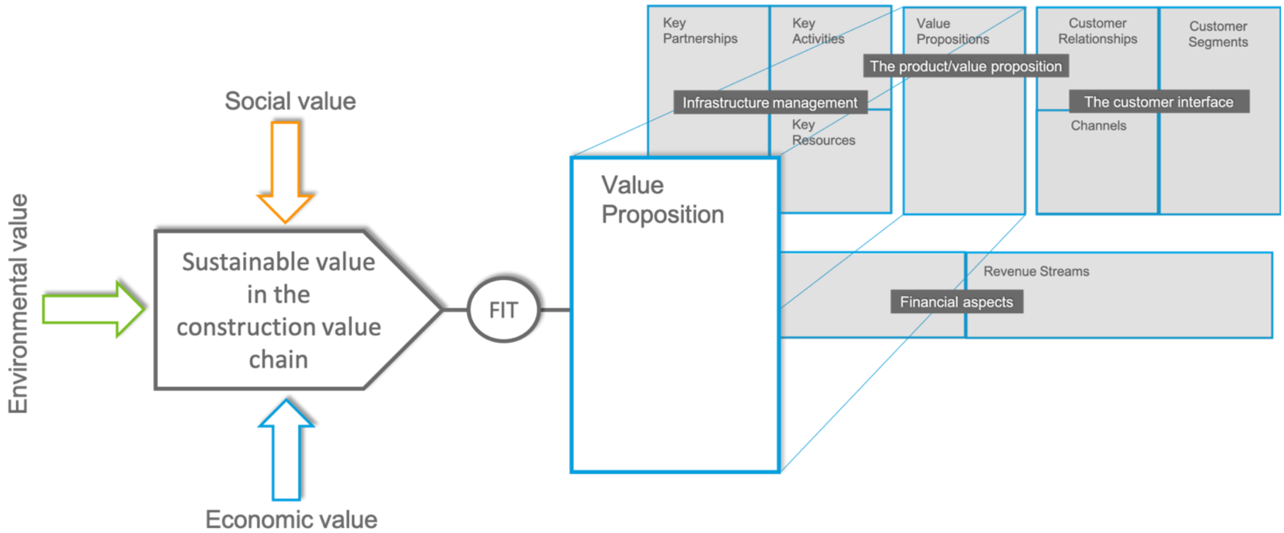

Figure 21: The model of analysis for this thesis.

The left-hand side of the model illustrates what the actors in the construction value chain value when it comes to sustainability, regarding the frame material. This aims to answer research question 1, *what creates sustainable value for the actors in the construction value chain regarding the frame material.* The right-hand side of the model illustrates the value proposition and business model of a material supplier in the wood-frame multi-storey construction industry. The *fit* in the model illustrates the fit between what the actors in the construction industry value, when it comes to sustainability regarding the frame material, and what the actors perceive that a material supplier in the wood-frame multi-storey construction industry offers, thus, it aims to answer research question 2, *what enables and prevents sustainable value creation with massive wood as frame material*. These parts are analyzed together in order to answer research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value*. How the purpose of this thesis is reached and how the research questions are answered are described in more detail in section *3.3 The Methodological Process of this Thesis* below.

3. Methodology

In this chapter, the research methodology used in the thesis is described. First, the scientific view of the authors of this thesis is presented. This is followed by a description of the overall methodology approach. Thereafter, the methodological process, the method for data collection, measurement techniques and the analysis process are described. Lastly, reliability, validity and ethical aspects of the thesis are discussed.

3.1 Scientific View

We, the authors of this thesis, have a systemic view of science and we therefore claim that research in social science should neither be based exclusively on positivistic approaches, nor it should be based exclusively on hermeneutic approaches. The systemic view is somewhere in between the positivistic and the hermeneutic view (Bryman & Bell, 2013; Arbnor & Bjerke, 2009). From the positivistic view, all knowledge is based on a classic natural scientific approach (Bryman & Bell, 2013). In other words, all relevant science and knowledge should according to a positivistic viewpoint be based on measurable facts. In contrast to positivism, the hermeneutic view of science emphasizes the need for an interpretative approach to understand the real world (Bryman & Bell, 2013). For example, in natural science, where the knowledge often is based on a positivistic view of science there is often a view of the positivism as being more genuinely scientific (Bryman & Bell, 2013). However, in social sciences many researchers claim that the involvements of human actions in complex systems needs to be handled differently to be fully understood (Bryman & Bell, 2013).

We claim that both above mentioned externalities have both advantages and disadvantages. On the one hand, we claim that social science researchers with a positivistic view of have prerequisites to generate studies with generalizable conclusions while there is a risk that those researchers do not manage to understand the situation and therefore the studies could be less relevant to practitioners. On the other hand, we claim that social science researchers with an exclusively hermeneutic view of science have the prerequisites to generate studies with a high validity, since they are able to interpret and understand the situation. At the same time, we claim that those studies sometimes could be less generalizable.

Therefore, we claim that our view of science, the systemic view, is a combination that should enable studies of complex systems and generates knowledge that is useful both for practitioners as well as academics in the field of social science. Thus, the holistic approach of the systemic view is suitable and, according to Arbnor and Bjerke (2009), it enables properties that cannot be understood if only components in isolation are analyzed.

3.2 Overall Methodology Approach

This thesis is based on previous research in the generic field of value, sustainability and business models, thus, based primarily on a deductive approach. With a deductive approach, the theory is the starting point of a research that ends up in observations and results (Bryman & Bell, 2013). However, since the specific research on sustainable value applied in this field of the construction industry was rather limited, it required to be complemented by new empirical insights exploratory gained from the pre-survey interviews to construct the survey. This implied that the research also had inductive tendencies. Inductive research is when the theory is the result of the research rather than the starting point for it (Bryman & Bell, 2013) The inductive tendencies in the deductive approach is rather common in practice and could even be preferred in a thesis where the aim is a contribution to a field without applicable theories (Bryman & Bell, 2013; Eisenhardt, 1989).

This thesis' main analysis followed a qualitative research strategy. A qualitative research strategy is described with the emphasis on words rather than numbers (Bryman & Bell, 2013). This fits the purpose of this thesis, which does not explicitly require an emphasis on numbers, but rather on words, in order to be reached and therefore has qualitative characteristics. Further, the purpose was to be reached through a case study of Stora Enso Building Solutions' business model, in order to represent a material supplier in wood-frame multi-story construction. A case study is according to Yin (2014) when one case, for example a company, is analyzed in dept. The case study is suitable when the purpose is to understand complex systems and relationships (Sjöström, 2018).

However, the sub-analysis of what creates sustainable value in the construction value chain was investigated primarily through quantitative methods, where the qualitative methods were used as a support to understand the context of the results. The advantage of the quantitative method of this stage, we argue, is that this method is more suitable for an identification of differences between variables and groups, thus what factors are important for creating sustainable value and how it differs between groups of actors. Therefore, we argue, that it is relevant to investigate the identified factors in a quantitative survey. A quantitative research strategy is, according to Bryman and Bell (2013), described with an emphasis on quantification considering collection and analysis of data. The survey used in this quantitative sub-analysis therefore enabled us to conduct a cross-sectional study, with a broad perspective of sustainable value in the construction value chain. A cross-sectional study is a study where one or more variables are analyzed crosswise (Sjöström, 2018). In other words, the answers of the respondents are bundled in order to generate connections and relationships, for example between different groups. This approach is preferable when the aim is to describe how a large target population value something (Sjöström, 2018). Thus, this approach was suitable to use in the sub-analysis of sustainable value in the construction value chain. For a description of the approach of the thesis, see figure 22 below.

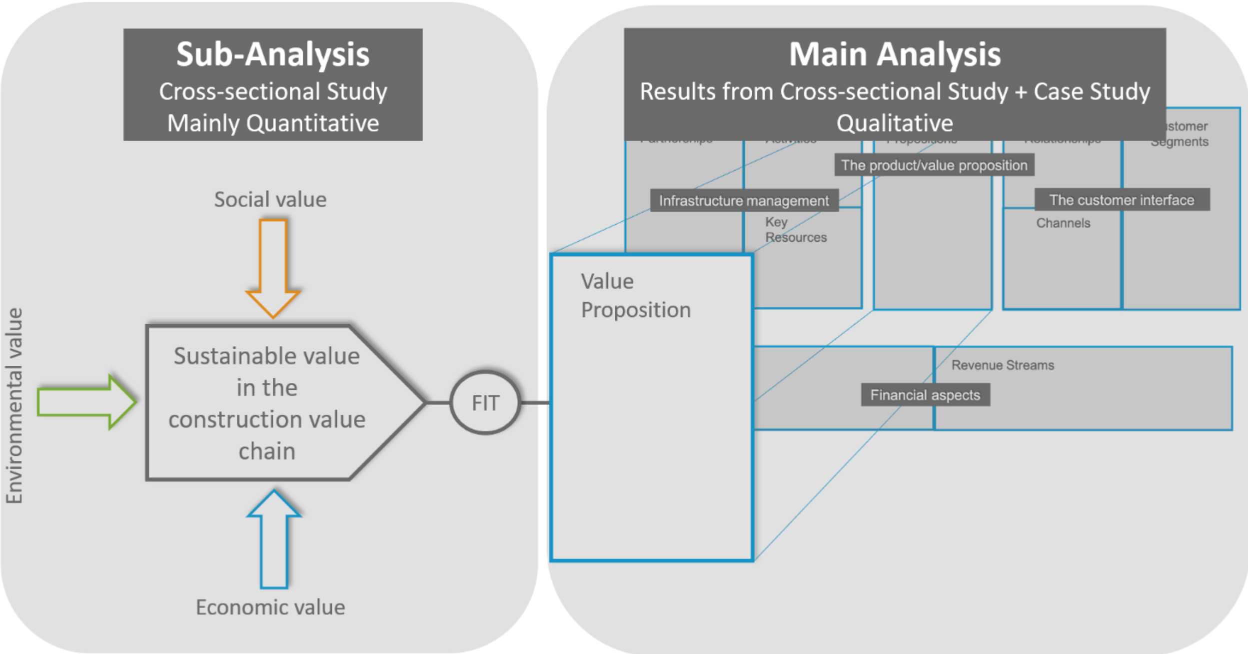

Figure 22: The overall methodology approach of the thesis.

When combining the qualitative strategy of the main study with the primarily quantitative strategy of the sub-analysis into a mixed method strategy, the ambitions is that the research questions could be answered, and the purpose of the thesis reached, with valid and reliable conclusions. The use of mixed methods research, which is combination of qualitative and quantitative research strategies, has evolved as a complement to the two distinguishing strategies (Bryman & Bell, 2013). Our strategy is therefore consistent to what Bryman and Bell (2013) emphasize is a way to manage some of the problems and limitations following the use of one separate method. A qualitative research strategy probably has lower reliability but a higher validity than a quantitative approach and vice versa (Bryman & Bell, 2013; Lekvall & Wahlbin, 2001). However, the use of a mixed method strategy does not automatically imply a more reliable or valid result, some authors even claim that the method is neither possible, nor desirable (Bryman & Bell, 2013). According to the authors, those opinions often refers to the distinguishing strategies as different paradigms that originates from non-compatible scientific views, values and methods. However, we claim, in line with Bryman and Bell (2013), that the different research strategies are not mutually exclusive, rather they have some elements in common. Thus, we claim that the characteristics of this thesis advocates the use of mixed methods research and that it implies a way to triangulate that increases the overall quality of the thesis.

3.3 The Methodological Process of the Thesis

The methodological process of this thesis follows the process presented in figure 23 below.

Figure 23: The methodological process used in the thesis.

First the problem was identified and formulated followed by the formulation of the purpose of the thesis. Thereafter, a literature review followed, and data was collected through pre-survey interviews, through a survey and through complementary interviews. After this, the data was analyzed, followed by formulation of a conclusion and by a discussion. Below, is the methodological process described in more detail.

To reach the purpose of this thesis, *to investigate how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain,* the following research questions were answered:

1. *What creates sustainable value for the actors in the construction value chain regarding the frame material?*
2. *What enables and prevents sustainable value creation with massive wood as frame material?*
3. *What elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value?*

Factors which potentially impact the sustainable value creation regarding the frame material were identified through pre-survey interviews with different actors in two construction projects, see section *4.1 Potential Sustainable Value Creating Factors,* and through literature reviews, see section *2.1.4 Sustainability in Industrial Wood-Frame Multi-Storey Construction*. A list of these identified potential sustainable value creating factors is presented in *Appendix 2*. These factors laid the foundation for the cross-sectional survey for the actors in the value chain, in which the potential sustainable value creation factors are investigated more thoroughly. The analysis of the survey aimed to answer research question 1 and 2 by identifying the most important potential sustainable value creating factors regarding the frame material and investigate if these create value or prevent value creation for the actors in the construction value chain regarding massive wood as frame material. In order to get a contextual understanding of how, and why, these potential value creating factors enable or prevent value creation when it comes to massive wood as frame material, complementary data collection through qualitative interviews with different actors in the construction value chain were conducted.

Then, what a business model of a material supplier in the wood-frame multi-storey construction industry can look like was investigated through qualitative interviews with the case company; Stora Enso Building Solutions. Finally, the results of the interviews with the case company, together with the results from the cross-sectional survey and the complementary interviews were analyzed from an expanded, business model perspective in order to answer research question 3.

3.4 Method for Data Collection

The collection of information in this case study was performed mainly through primary information from interviews and a survey. When applicable, secondary information from, for example, annual reports and companies official web pages were used. When using secondary information, Arbnor and Bjerke (2009) emphasize the importance of compatibility and trustworthiness. With that in mind, the use of secondary information was limited to fields where influence on the results and conclusions of the thesis were considered to not be compromised. For example, for general information about the case company and other organizations.

Arbnor and Bjerke (2009) emphasize that the starting point when selecting the sources for data collection of the study should be to find a representative unit that represents the larger totality and that this is crucial for whether the research will be generalizable or not. How a representative unit is found in this study is explained in the following sections. The sampling strategy used in the interviews in this thesis was what Bryman and Bell (2013) have described as purposive sampling. Purposive sampling has the goal to find interviewees that are relevant to the purpose and research questions of the study and whom is covering a variety in the resulting sample (Bryman & Bell, 2013). By using a cross-sectional survey, as earlier described as suitable for an identification of differences between variables and groups, the ambition was further to get an even better representation of the unit of analysis and to increase the validity of the result.

3.4.1 Selection of Data Sources for the Pre-Survey Interviews

The data sources used in the pre-survey interviews with different actors in two construction projects were selected from two ongoing construction projects.

The first case used was the project *Hoppet*. This specific project was chosen because of their focus on both construction and sustainability, which are both relevant topics for this thesis. Interviews with Anna Högberg, Energy and Environmental Consultant at Bengt Dahlgren AB, and Hanna Ljungstedt, who works at Lokalförvaltningen of the City of Gothenburg which runs the project, were conducted. These persons were selected as data sources because of their knowledge and understanding of the project and sustainability and to get a perspective from a project where they have not yet decided if they will use a wood construction or not.

The second case used was the project *Öxeryds förskola*. This project was chosen because it is an ongoing project which Stora Enso Building Solutions is a part of. Interviews with Fredrik Dahlström, CEO at GBJ Bygg Väst AB, Bertil Nordberg, construction-/project manager of Öxeryds Förskola, Sandra Baumann, architect at Kaka Arkitekter and Kim Grönnevik, Operation and Project Manager at WoodCon, were conducted.

Below is a list of the interviewed people, their roles and organizations.

- Anna Högberg, consultant in energy and environment, Bengt Dahlgren AB.
- Bertil Nordberg, Construction/Project Manager, Lerum Municipality (Consultant from Karlanders).
- Fredrik Dahlström, CEO, GBJ Bygg Väst AB.
- Hanna Ljungstedt, Lokalförvaltningen, The City of Gothenburg.
- Kim Grönnevik, Operation and Project Manager, WoodCon.
- Sandra Baumann, Architect, Kaka Arkitekter.

3.4.2 Selection of Data Sources for the Survey

When conducting a survey, there is a population, called the target population, which one wants to draw conclusions about (Lekvall & Wahlbin, 2001). In this thesis, the target population is the actors in the Swedish construction value chain, limited to architects, structural engineers, construction contractors and property owners, both private and public. In general, it is not possible to investigate all units of the target population and therefore which data sources, or units of the target population, to investigate has to be selected (Lekvall & Wahlbin, 2001). Thus, conclusions about a target population are drawn on the basis of the results of the units from the population that are actually examined. The validity of these conclusions may be questioned, and the validity depends on the selected units, if they are representative of the population as a whole or if they only are representative for a limited or extreme part of the population (Lekvall & Wahlbin, 2001).

To strive for representativity of the target population in this thesis, we have focused primarily on three dimensions, a sample that represents Sweden geographically, represents all the different actors, and represents actors with different levels of experience of massive wood. However, we are aware of that there probably are other important dimensions required in order to get a representative sample, that we have not addressed.

For each category of actors, the ambition for a minimum number of answers was set to 20, since a sample of at least this size implies an approximative normal distribution that enables an analysis of the sample (Blom et al., 2005). This was reached, however, we are aware of that there are still limitations with our sample size, for example that the precision of the answers, and the representativity are limited. The consequences of this are further discussed in section *3.7 Validity*.

The total number of respondents answering the survey was 205. As already explained, all groups of actors reached the goal of at least 20 respondents. 54 percent of the respondents had no earlier experience of massive wood projects, 46 percent had earlier experience. Further, there is an, approximately, even distribution based on the level of experience. The geographical coverage, covering more or less all regions, have a higher frequency in regions with larger populations. The distribution of actors is, despite the public property owners that has a large part (40 percent) of the number of respondents, relatively even. The distribution of respondents answering the survey for each category of actors, the distribution based on level of experience and the geographical coverage of the survey is presented in figure 24 below.

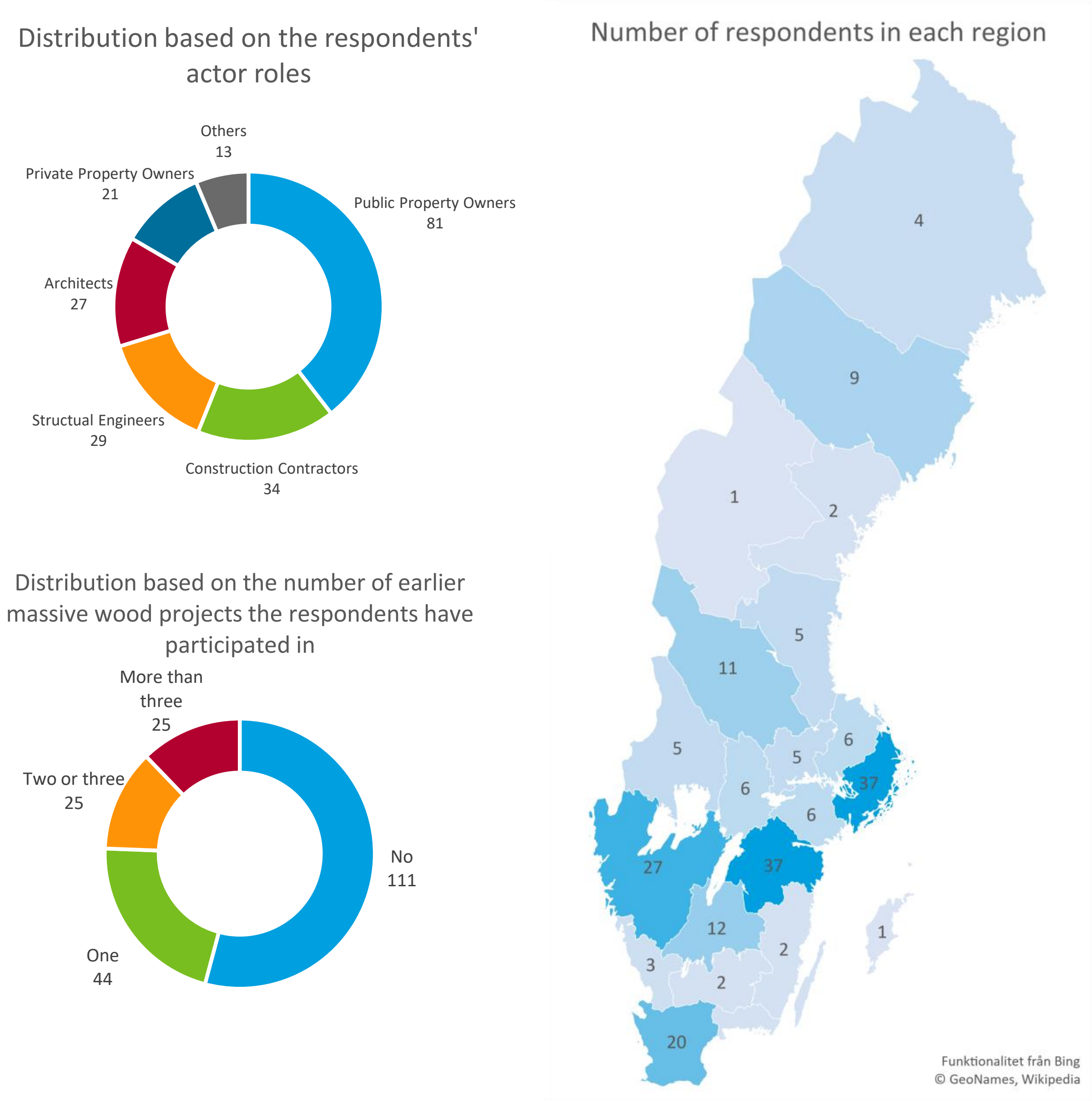

Figure 24: Distribution of the respondents based on the category of actors and the level of experience and number of respondents in each region of Sweden.

3.4.3 Selection of Data Sources for the Complementary Interviews and Interviews with the Case Company

For the complementary qualitative interviews, interviewees representing the different actors in the construction value chain were interviewed. Below is a list of the people which have been interviewed for the complementary interviews. More information about the interviewees and their organizations can be found in *Appendix 4*.

- Anders Berg, *Project Manager*, Akademiska Hus.
- Benny Valtersson, *CEO*, Stångebro Bygg.
- Carl Dalgren, *Production Engineer*, Stångebro Bygg.
- Carl Johan Danckwardt-Lillieström, *Project Manager*, Åhlin & Ekeroth Byggnads AB.
- Elzbieta Lukaszewska, *Structural Engineer and Project Manager*, Byggnadstekniska Byrån.
- Emil Falck, *Production Engineer*, Stångebro Bygg.
- Eric Borgsten, *Structural Engineer and Contract Manager*, Bjerking.
- Fredrik Engvall, *Project Manager*, Stångebro Bygg.
- Kenneth Wilén, *Vice President*, Folkhem.
- Kristina Peters, *Architect SAR/MSA and Partner/Business Manager*, Arkitema.

- Peter Lindstén, *Owner*, Lindsten Fastigheter AB.
- Sebastian Fors, *Arkitekt SAR/MSA*, Sweco Architects AB.
- Sixten Westlund, *Project Leader*, Engineering and Property Management of Karlstad Municipality.
- Torbjörn Zettergren, *Project leader*, Vasakronan.

The data source selected for the interviews with the purpose to map and understand the business model of Stora Enso Building Solutions were Mikael Lindberg, *Head of Sales Scandinavia* at Stora Enso Wood Products.

3.5 Measurement Techniques

In this section, the measurement techniques used in this thesis are presented. The two techniques used are a survey and interviews.

3.5.1 The Survey

The first part of the cross-sectional survey consisted of control variables that enabled a control of the representatively of the resulting data material. These variables were constructed as nominal scales with pre-defined alternatives. The control variables examined what type of actor the respondents were, by categorizing the respondents into different groups of actors. Another variable categorized the respondents geographically through the 21 Swedish regions. Further, a control variable, testing the respondent's earlier experience of massive wood construction, was used to categorize the respondents in groups depending on their experience.

The main part of the survey was divided into two blocks, where the first block was constructed to enable an analysis of which factors create sustainable value for the respondent regarding the frame material. The second block enabled an analysis of which factors create sustainable value and prevent sustainable value creation for the respondent regarding massive wood as the frame material.

The variables in the main blocks of the survey were constructed with an interval scale of five steps. The approach with the use of an interval scale enables an analysis of mean differences between questions (Lekvall & Wahlbin, 2001; Sjöström, 2018). Further, by constructing variables with an odd numbered scale, and with the expected value in the middle of the interval, the ambitions were to generate a result following a normal distribution, an approach explained by Sjöström (2018) as suitable for conducting statistical analyzes.

The last part of the survey included a ranking variable of the respondent's view of different actor's influence on the choice of the frame-material. It also included a few variables testing the general view of how massive wood, used as frame-material, contributes to sustainability in the construction industry distinguished in economic, environmental and social factors.

For a full presentation of the questions in the survey, see *Appendix 3*.

3.5.2 The Interviews

The interviews were performed as personal or telephone interviews and since the collection of empirical data in this thesis were performed in different stages with different aims, the tactics also varied.

When performing the pre-survey interviews, the ambition was to identify what impacts sustainable value creation for the interviewees. The tactics of those interviews were therefore unstructured in order to not expose the participants to so called cognitive priming, when one person's world view is biased by external presumptions or expectations (Yin, 2014; Kahneman, 2011).

When performing complementary qualitative interviews, the tactic was to use an interview guide with a semi-structured approach. A semi-structured interview is according to Yin (2014) often based on an interview guide with pre-defined themes to be explored. Unlike the structured interview, the semi-structured interview allows the interviewee to elaborate around ideas brought up during the interview. During these interviews, the ambitions was to get a contextual understanding, and to complement the results from the quantitative survey. Therefore, the interview guide was based on the questions, found in *Appendix 3*, and the results of the survey and modified depending on what type of actor that was interviewed.

In the fourth stage, when interviewing Mikael Lindberg, *Head of Sales Scandinavia* at Stora Enso Wood Products, with the purpose to map and understand the business model of a material supplier, qualitative interviews with another semi-structured interview guide was used. This interview guide was based on the questions presented in section *2.3.3.3 The Business Model Framework according to Osterwalder and Pigneur*.

3.6 The Analysis Process

The analysis process was separated into two different stages. First, the data collected through the survey was analyzed in order to create an understanding of which the most important potential sustainable value creating factors are for the actors in the construction value chain. Second, this result was used, together with the results from the complementary interviews with actors and the results from the interviews with Stora Enso, to analyze how the business model could be used to deliver this sustainable value.

3.6.1 Analysis of the Survey

The analysis was conducted through the statistical application IBM SPSS. After the data collection was completed, the raw data was compiled into a database, where it was processed through coding of the variables and through identification of dropouts to enable the analysis. Before the analysis process started, a qualitative quality control of the data was conducted. The variables of geographical representativity, level of experience and representativity of the different actors were controlled.

The analysis process started with a differentiation of the actors in order to analyze means and variances of each variables depending on the group of actors. By analyzing the means and variances of the answers from the first part of the survey, the most important potential sustainable value creating factors for each actor and sustainability aspect were identified. Thereafter, when analyzing the corresponding factors from the second part of the survey, through the statistical method called *One-Way ANOVA*, an understanding of how massive wood creates value for the actors in the construction value chain, was enabled.

Selection criterion of the first section in the sub-analysis – *What creates sustainable value for the actors in the construction value chain regarding the frame material*:

- The factor is interpreted as important if the mean value is significantly (α=0.05) higher than the mean value of the category (economic, social and environmental).

Selection criterion of the second section in the sub-analysis – *What enables and prevents sustainable value creation with massive wood as frame material:*

- The factor is interpreted as *an advantage* if the mean value is significantly (α=0.05) higher than 0.
- The factor is interpreted as *a disadvantage* if the mean value is significantly (α=0.05) lower than 0.
- The factor is interpreted as *both an advantage and a disadvantage* if the mean value is not significantly higher, or lower, than 0. This result theoretically means that we cannot reject a null hypothesis and the value could be lower or higher than 0, but it could also be exactly 0.

If the factor is identified as *both an advantage and a disadvantage,* a further analysis is conducted through a separation based on level of experience. By this separation, we could identify if the opinions varied with the level of experience. The separation based on experience level was defined as follows:

- *No experience* – The respondent has not participated in a project using massive wood as the frame material.
- *Earlier experience* – The respondent has participated in one or more projects using massive wood as the frame material.

3.6.2 Analysis of the Interviews

Through the analysis process of the complementary interviews, the ambition was to enable a contextual understanding of the result from the survey, in order to answer research question 2, w*hat enables and prevents sustainable value creation with massive wood as frame material* and research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value.* Therefore, the interviewees' explanations of how and why the factors create and prevent value for them and how the actors in the value chain explain that a material supplier can create and deliver sustainable value to them are analyzed qualitatively in order to find similarities, or differences, from the literature presented in the frame of references.

Through the analysis process of the interviews with Stora Enso Building Solutions, the ambition was to get an understanding of how a material supplier's business model looks like in order to understand how a material supplier can create and deliver sustainable value through their business model. This, to be able to answer research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value.*

3.7 Validity

Validity is about studying what is relevant in the specific context, thus, observing, identifying and measuring the right things (Bryman & Bell, 2013; Lekvall & Wahlbin, 2001). The concept can be divided in three types: construct validity, internal validity and external validity (Yin, 2014; Bryman & Bell, 2013).

Construct validity is about using sufficient measures for the concepts being studied (Yin, 2014). As argued in section *3.2 Overall Methodology Approach* the mix of qualitative and quantitative methods enabled the research questions to be answered, and the purpose of the thesis to be reached. We argue that the approach was suitable to both get a contextual understanding and to enable an identification of differences between variables and groups, thus what factors are important for creating sustainable value and how it differs between groups of actors.

External validity is about the generalizability of the findings of the study (Yin, 2014). When using a survey, Yin (2014) emphasizes that the results should be valid for the whole target population and therefore, the data sources used for the survey must be representative for the target population. As presented in section *3.4.2 Selection of Data Sources for the Survey*, the total number of respondents of the survey was 205, and all analyzed groups were larger than 20. Further, we focused primarily on controlling representativity from three dimensions, a sample that represents Sweden geographically, represents the role of actors, and represents actors with different levels of experience of massive wood. For the analysis, the sample sizes enabled us to find significant differences between variables and groups in our sample. However, the representativity and generalizability towards the target population is rather limited. In order to draw conclusions representative and valid for the entire target population, the sample size would have required to be larger and other dimensions of representativity probably should have been controlled. On the other hand, the ambitions of this survey have been primarily explorative, exploring what creates sustainable value for the actors in the construction value chain regarding the frame material, and what enables and prevents sustainable value creation with massive wood as frame material.

Internal validity is about causal relationships, if there can be other possible explanations for the study's findings (Yin, 2014). There is a risk that the results of the survey, the interviews with actors and the interviews with Mikael Lindberg at Stora Enso show the data sources' personal values and not the values of which they represent. The internal validity might be most limited for the results from the interviews with Stora Enso, because the results were based on only one data source. Furthermore, there is also a risk that our results have an unbalanced representation towards those which have an optimistic view of the research topic since they might potentially be more interested in participating. However, with internal validity in consideration, we have always tried to find different explanations for the results through complementary interviews and literature reviews of earlier research.

3.8 Reliability

Reliability in a study implies that the study uses reliable measuring methods. For a study to have high reliability, the study should result in the same findings and conclusions if it was conducted over again with the same methods (Yin, 2014). To strive for a high reliability, it is important to minimize errors and biases in the study (Yin, 2014).

The selection criteria for the analysis of the survey was, as explained in section *3.6.1 Analysis of the Survey*, based on if the mean value is significantly (α=0.05), (1) higher than the mean value of the category (economic, social and environmental), and (2) lower or higher than 0 (neutral). Several other methods could have been used as selection criteria’s, which could have led to other conclusions. For example, a fixed value could have been used for the first selection criteria. However, we argue that this method was sufficient for analyzing research question 1 and 2, *what creates sustainable value for the actors in the construction value chain regarding the frame material,* and *what enables and prevents sustainable value creation with massive wood as frame material* since sustainable value include all three aspects of sustainability. Thus, we argue that this method was sufficient to analyze what creates economic, social and environmental value for architects, structural engineers, construction contractors and property owners.

Further, to strive for a high reliability and to minimize the errors and biases in the analysis of the interviews of this thesis, the interviews have mostly been conducted through two interviewers, thus, with two observers who can agree on what they hear. Notes were taken and, in some cases, the interviews were also recorded. The recordings were used to control the information from the interviews. Moreover, for pre-survey interviews, the documentation from the interviews were sent back to each respondent for revision or approval before using it in the thesis. This was done to ensure that the interviewers had got the facts correct, thus, to minimize errors.

Lastly, the ambition has been to conduct this thesis transparently, to enable other researchers to repeat the procedures and arrive to the same findings and conclusions. This through our transparency regarding methods used during the process, for example through to the use of the survey, which is easy to replicate.

3.9 Ethical Aspects

This study applied ethical principles of research. The participants in the survey and in the interviews were informed about the purpose and approach of the thesis, which included the awareness that the participation in the study was voluntarily. If other was not agreed upon, all information about the respondents and interviewees has been handled confidentially and with regard to the participants’ interests. If the interviews were recorded, the interviewees were informed about the recording prior to the interviews and had the opportunity to approve it. Lastly, all respondents and interviewees have been offered a summary of the survey result as a compensation for participating.

4. Empirics

In this chapter, the results from the survey and the interviews are presented. The disposition of the empirics is summarized in figure 25 below.

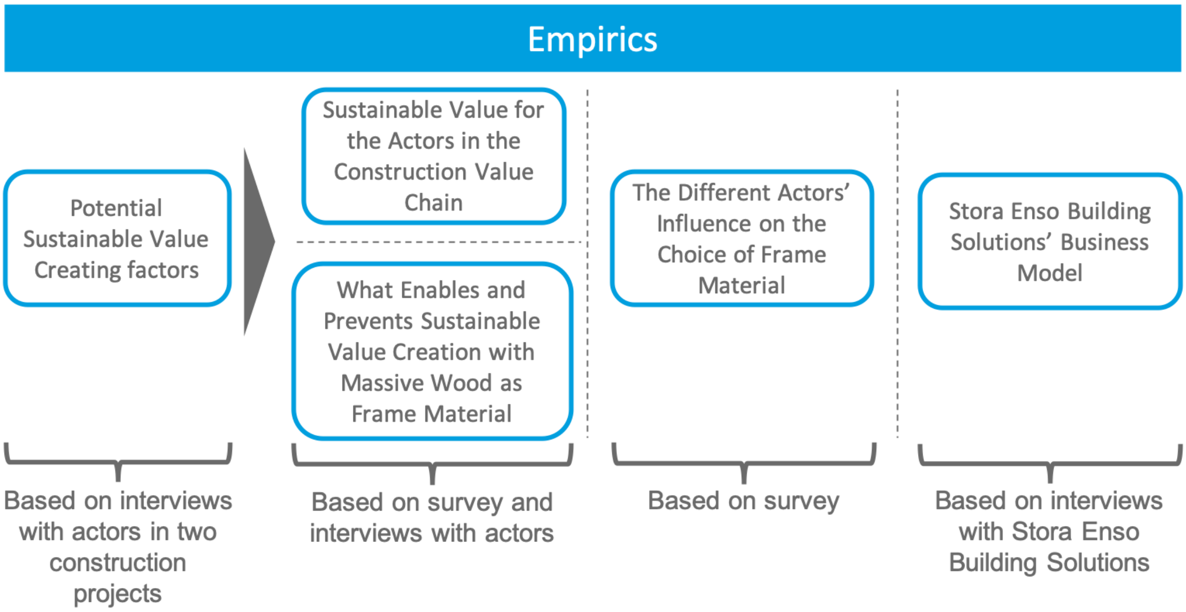

Figure 25: The disposition of the empirics.

4.1 Potential Sustainable Value Creating Factors

To understand what could potentially create sustainable value for the actors in the construction value chain, regarding the frame material, the theoretical insights from the frame of references are complemented with qualitative pre-survey interviews. The two projects *Hoppet* and *Öxeryds förskola* are used where interviews with different actors from the projects are conducted. Potential sustainable value creating factors for the actors in the construction value chain, regarding the frame material, identified in these interviews and in the frame of reference are presented in *Appendix 2*. These factors are used in order to operationalize the survey and interview guide, used for the complementary interviews with different actors, where the potential sustainable value creation factors are investigated more thoroughly. See figure 26 below for this section's relation to the other sections in the empirics.

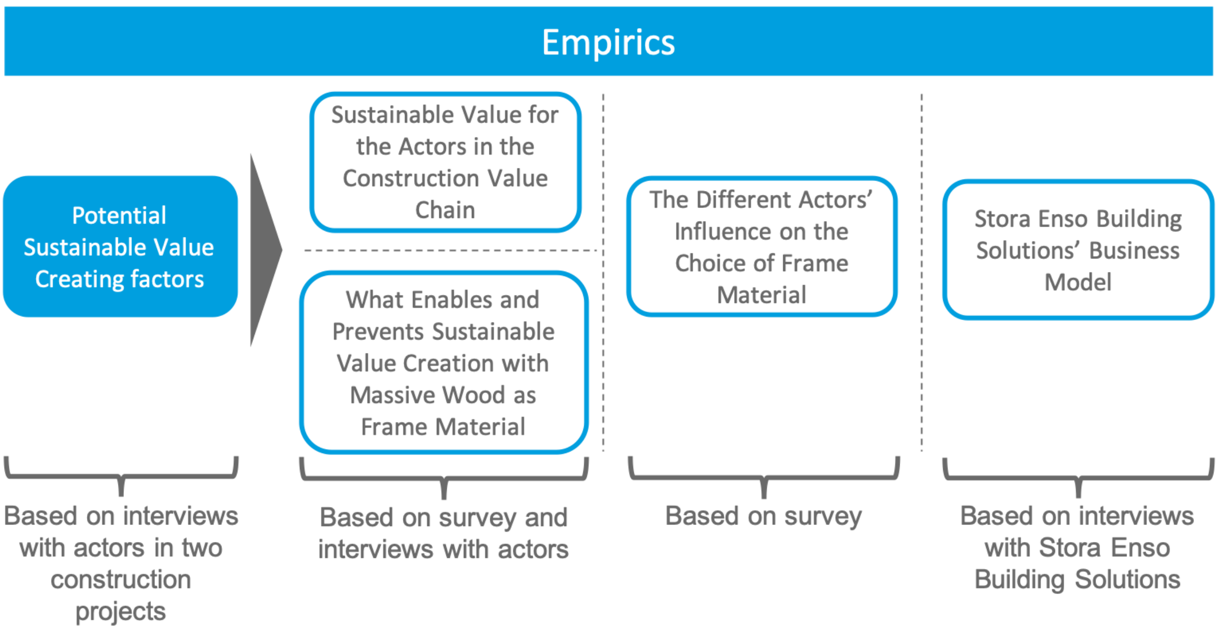

Figure 26: This section's relation to the other sections in the empirics.

4.1.1 The Project Hoppet

Hoppet is the first fossil-free construction project in Sweden, initiated by the City of Gothenburg as a part of their climate strategy program (Göteborgs Stad, 2019). The climate strategy program is according to themselves a program which aim to enable the City of Gothenburg to achieve their goal of a climate-neutral Gothenburg in 2050. In the project Hoppet, they explore the potentials of building with as much fossil-free processes and materials as possible and they try to find the optimal solutions for this (Göteborgs Stad, 2019). The first step in the project is to build a fossil-free preschool, a project which will start in 2019 and is planned to be finished in 2021 (Göteborgs Stad, 2019).

To be able to get a deeper understanding of the project, and how sustainability is viewed, an interview with Anna Högberg, Energy and Environmental Consultant at Bengt Dahlgren AB and Hanna Ljungstedt, who works at Lokalförvaltningen which runs the project, was conducted.

At the time of the interview, the building material of the fossil-free preschool had not yet been determined, but there was according to the interviewees a possibility that the preschool will be based on a wood-frame construction (Ljungstedt & Högberg, 2019). Except using a wood-frame, they have also investigated the possibility for construction materials like hemp and clay.

In the interview, Ljungstedt and Högberg (2019) emphasize the importance of considering the total emissions from the Swedish construction industry and the total emissions from a construction project, thus, both domestics emissions and emissions from abroad. Even though emissions from abroad accounts for a large proportion of the total emissions, they are often neglected (Ljungstedt & Högberg, 2019). To be able to investigate which solutions and materials to use to build the fossil-free preschool, the project uses the standard BS EN 15804[2] for life cycle analyzes. Emissions are categorized on the basis of raw material, manufacturing, transports, construction, operations and waste/recycling (Ljungstedt & Högberg, 2019). When they select materials in the project, they have chosen to neglect the emissions from waste/recovery to some extent due to the expectation of long lifetimes of the buildings (Ljungstedt & Högberg, 2019).

In the interview with Ljungstedt and Högberg (2019), they discussed some of the challenges they have faced in the project. They explain that one main challenge is to achieve climate neutrality for the products being used, both in finding information of the products' environmental impact and in finding products that are fossil-free, in both the raw material and in their value chain. They see a need for more information regarding fossil-free materials and other fossil-free solutions. For example, if all material suppliers provided *Environmental Product Declarations (EPD)* an environmental comparison between different materials and products would be enabled (Ljungstedt & Högberg, 2019).

Ljungstedt and Högberg (2019) have identified aspects they find important when they consider the use of wood construction. These critical aspects are for example:

- the amount of waste from production of the material and from the construction site
- the energy consumption and the energy mix used in manufacture
- sustainable forestry (FSC)
- the fire safety, which is an important aspect for insurance companies
- the acoustics performance of the material
- flexibility in the detailed development plans regarding the height of the building since there could be a need for thicker beams when using wood.

Ljungstedt and Högberg (2019) explain that they are aware of the fact that wood binds carbon but that they declare carbon sinks separately in this project. In their experience, material suppliers of wood sometimes "hide" behind wood's carbon storage properties when they instead could put more emphasis to optimize their processes in order to reduce their environmental impact even further (Ljungstedt & Högberg, 2019).

Lastly, Ljungstedt and Högberg (2019) explain that in their experience many construction contractors are familiar with using concrete and that it could be a challenge to find construction contractors who are positive

[2] BS EN 15804 gives guidance around core product category rules relating to Environmental Product Declarations (EPDs) for construction products and services (The British Standards Institution, 2019).

to wood-based constructions. They explain that the perceptions of using wood varies in the industry, where a few municipalities and a handful of other actors are more positive than others and that those actors have been key drivers in the development of wood-based construction. Ljungstedt and Högberg (2019) believe that generally architects are quite positive to wood-based construction while structural engineers are less positive because of the lack of experience.

4.1.2 The Project Öxeryds Förskola

Together with GBJ Bygg, the Lerum Municipality build a new preschool with two floors of massive wood, in Öxeryd (Lerums Kommun, 2019). The preschool, which is expected to be finished in November of 2019, is planned to be for about 80 children (Lerums Kommun, 2019). Stora Enso Building Solutions is a material supplier and delivers CLT to the project. To be able to get a deeper understanding of how different actors in the construction value chain value sustainability aspects, interviews with different actors in the project were conducted.

4.1.2.1 *Interview with Public Property Owner*

The construction and project manager of the preschool in Öxeryd, Bertil Nordberg, a consultant from the consultancy firm Karlanders working for Lerum Municipality, was interviewed. He represents the view of the public property owner.

Nordberg (2019) describes that the massive wood construction in the project is a result of recommendations and earlier experience from the construction contractor during the process rather than of inputs from the initial planning. After involving the architects in the project, and after a comparison of total costs between massive wood construction techniques and other traditional construction techniques, the decision of using a massive wood construction was made (Nordberg, 2019). Additionally, the sustainability gains of using wood matched well with the municipality's sustainability vision "to become the leading ecomunicipality in 2025 or earlier" (Nordberg, 2019).

Nordberg (2019) describes both opportunities and challenges with the use of massive wood in construction. He argues that the main opportunities include the significantly lower emissions of greenhouse gases, and the carbon storage capacity of the material. The main challenge according to Nordberg (2019) is related to knowledge, experience and information of the material. He argues that there is a need for increased knowledge, experience and information for all actors in the construction value chain. First, decision-makers need information about the environmental benefits of the material to make the right decisions. Second, architects and structural engineers need increased knowledge about the properties of the material. Third, construction contractors need knowledge and experience of how to handle the material, e.g. regarding the effect of rain and moisture during the construction phase. However, he emphasizes that for this specific project the attitudes have been almost entirely positive and most of the negative perceptions are based on lack of knowledge and experience and the amount and availability of information rather than on limitations or disadvantages of the material.

4.1.2.2 *Interview with Construction Contractor*

The construction contractor of the preschool in Öxeryd is GBJ Bygg Väst. Dahlström, CEO at GBJ Bygg Väst was interviewed.

Today, GBJ Bygg Väst is one of the constructor contractors with the most experience of building with massive wood in Sweden (Dahlström, 2019). This is partly due to a strategic choice GBJ Bygg Väst made a few years ago, a choice to start build more with massive wood (Dahlström, 2019). They saw a growing market and they understood that they needed to develop their competences in wood-frame construction in order to compete for these kinds of contracts. Växjö municipality requested wood-frame constructions and therefore increased the demand (Dahlström, 2019). GBJ Bygg Väst also wanted to get a "greener" profile and they saw the competence in wood construction as a competitive advantage.

According to Dahlström (2019) there are both advantages and disadvantages when it comes to the use of massive wood in construction. He argues that the main advantage is the environmental aspect; that wood is a 100 percent natural material and when building with massive wood, one does something to actively prevent the greenhouse effect. He also argues that construction with massive wood results in a better workplace environment. The workplace environment is dryer when using wood in comparison to using concrete, this because the casting process of concrete is supplied with a lot of water and when using wood, this is not required (Dahlström, 2019). Furthermore, he argues that construction with massive wood also results in a better residential environment for the end user.

Dahlström (2019) also presents some disadvantages when it comes to the use of massive wood in construction. He argues that the project in total becomes more expensive. The buildings become more expensive to produce, partly due to the poor competition on the market for material suppliers (Dahlström, 2019). He explains that there are three main suppliers of massive wood and for other materials, there are a lot more suppliers to choose from. When GBJ Bygg Väst choose which material supplier to work with, they usually look at the factors price, time and project planning capacity (Dahlström, 2019). The material suppliers they usually work with have the same standard when it comes to sustainability, therefore sustainability does not affect the choice of supplier (Dahlström, 2019). Furthermore, the buildings are in his opinion also more expensive to produce due to the many working hours required in wood-frame construction. The use of massive wood compared to conventional building materials result in more working hours on the work site (Dahlström, 2019). At the same time, he argues, most customers are not willing to pay more for wood-frame houses than for other types of houses (Dahlström, 2019).

Another disadvantage according to Dahlström (2019) is that there has been a lack of mature technology available and that GBJ Bygg has been constrained to develop solutions for fire safety and acoustics, among other things, by themselves. Lastly, Dahlström (2019) explains that a lot of the material in wood constructions comes from abroad, something they see as a disadvantage. According to him, some of their customers value if the forest used for the material comes from Sweden, thus, is locally produced. Therefore, GBJ Bygg see Stora Enso’s new production site of CLT in Gruvön as something very positive (Dahlström, 2019).

According to Dahlström (2019) there are some common preconceptions when it comes to wood construction in the construction industry. One perception is that a building with a construction of wood cannot be exposed to rain and moisture during the construction process, resulting in the need to use weather protection. Another preconception is that a building in concrete will have a longer lifetime than a building in wood.

4.1.2.3 *Interview with Architect*

The architects of the project in Öxeryd is Kaka Arkitekter. Sandra Baumann, one of the architects from Kaka Arkitekter, was interviewed.

According to Baumann (2019), sustainability is important for Kaka Arkitekter, it is a natural part of a building project and something they have in mind in all of their projects. Kaka Arkitekter have not been involved in any project built in cross laminated timber before (Baumann, 2019). However, Baumann (2019) claims that a big part of their jobs as architects are to educate themselves of the new materials and techniques required for each project and even though they have not worked with cross laminated timber before they have experience of working with wood. Therefore, they do not see any major challenges of using wood as the frame material in this project. However, Baumann (2019) mentions fire safety as a challenge if one wants to visually expose some of the load-bearing wooden walls, which they like to do. How to handle fire safety can also be viewed as a challenge because for wood construction it is new area where there is a need of more information and knowledge (Baumann, 2019).

Another challenge with using wood is the impact of wood over time, wood ages (Baumann, 2019). Baumann (2019) argues that it is important to understand how the material used changes over time so that the different parts of the construct, for example the colors, will fit together over time too. Therefore, information about how the material is affected by aging is important for architects. Some material companies are eager to show examples of how the material is affected of factors like age and wind and how different material treatment methods impact the material which is appreciated by the architectures (Baumann, 2019). According to Baumann (2019), generally, they see a need to have more and closer contact with the material supplier, in order to get more of this information.

The architects in this project see an important opportunity in creating something good for the children of the preschool and for the local community with this project (Baumann, 2019). They also see an opportunity to integrate the local history in the project. There has been a sawmill nearby and the community have in the past harvested a lot of forest, a story they can show in the project when they build with wood (Baumann, 2019). Thus, one benefit with using wood as material in this project is that it can be connected to the region. Furthermore, the architects see wood as a beautiful and natural material, a suitable material when building in the middle of the forest which is the case for this project. They also see the significantly lower environmental impact of wood as an important benefit.

Baumann (2019) identifies for example non-toxic, low emissions, transports, natural ingrediencies in the materials as important environmental aspects when they choose materials. Usually, the developer has requirements on the material being used. When the architects choose or recommend a material, they have their own requirements which they try to match with the developer's requirements to make sure that all materials are okay (Baumann, 2019). However, in the end, it is usually the construction contractors who have the final say because they are the buyer of the material (Baumann, 2019). The architects also see fair conditions for the workers in the manufacturing of the material as an important aspect. Sometimes they are offered to visit the factories, something they value. Baumann (2019) also emphasizes the importance of that the buildings they draw are appreciated by the people living nearby and the local society in general.

4.1.2.4 *Interview with Project Leader for the Delivery of Material*

Another actor involved in the preschool in Öxeryd is WoodCon. Kim Grönnevik, Operation and Project Manager at WoodCon, was interviewed.

In this project WoodCon is the project leader for the delivery of material and they also have the responsibility for the transports of the material (Grönnevik, 2019). They see themselves as partners to Stora Enso Building Solutions. WoodCon are proud to work with massive wood because of its climate-positive properties. They try to get a holistic view of sustainability and they therefore look at different aspects of sustainability where they for example put a lot of emphasize on transports. They value short transports and try to use train as much as possible for transporting the material.

Regarding the industry in general, there is a great interest for massive wood because of its climate-positive nature (Grönnevik, 2019). He argues that the working environment is more comfortable when using wood as construction material compared to concrete. This, he claims, is mainly because the concrete dust is avoided. Compared to concrete, wood is also generally easier to handle in the construction phase. Grönnevik (2019) also has the perception that there are fewer work-related accidents linked to massive wood frames in relation to other materials, which might be due to a rapid assembly, few people on the working site and because of the reduced weight of the material which result in fewer risks when assembling.

Grönnevik (2019) mentions acoustic properties as a challenge for wood construction. However, the challenges are primarily due to lack of knowledge and experience, it can be solved, but it requires another approach compared to construction with other materials. The concrete industry has a 100-year lead and therefore they have come further in developing solutions and handle problems, for example regarding acoustic properties. Grönnevik (2019) also mentions fire safety and moisture as fears which can come up when talking to the actor for the first time. The developer or the construction contractor might not be familiar with the material but with more knowledge and experience these fears will usually be reduced. Grönnevik (2019) explains that construction contractors who have no experience of working with wood constructions often include weather protection and a higher risk level in their financial calculations than those with previous experience. With more knowledge and experience, there is an increased understanding that weather protection for wood constructions rarely is needed (Grönnevik, 2019). Furthermore, Grönnevik (2019) argues that Stora Enso Building Solutions need to consider all of the actors in the construction value chain and not only their primary customer, that normally is the construction contractor. Depending on the project and what type of tendering, each actor in the construction value chain can affect the choice of material. Generally, the construction contractor has the final say but the developer becomes more and more important according to Grönnevik (2019). However, sometimes architects win architectural competitions with land directions. If they have drawn a wooden building, then the material is already determined. Therefore, Grönnevik (2019) emphasize the importance to provide value for each actor in the construction value chain.

4.2 Sustainable Value for the Actors in the Construction Value Chain

In this section, the results from the survey regarding how different factors impact sustainable value creation for the actors in the construction value chain, regarding the frame material, are presented. The data the figures presented in this section is based on, can be found in *Appendix 5*. See figure 27 below for this section's relation to the other sections in the empirics.

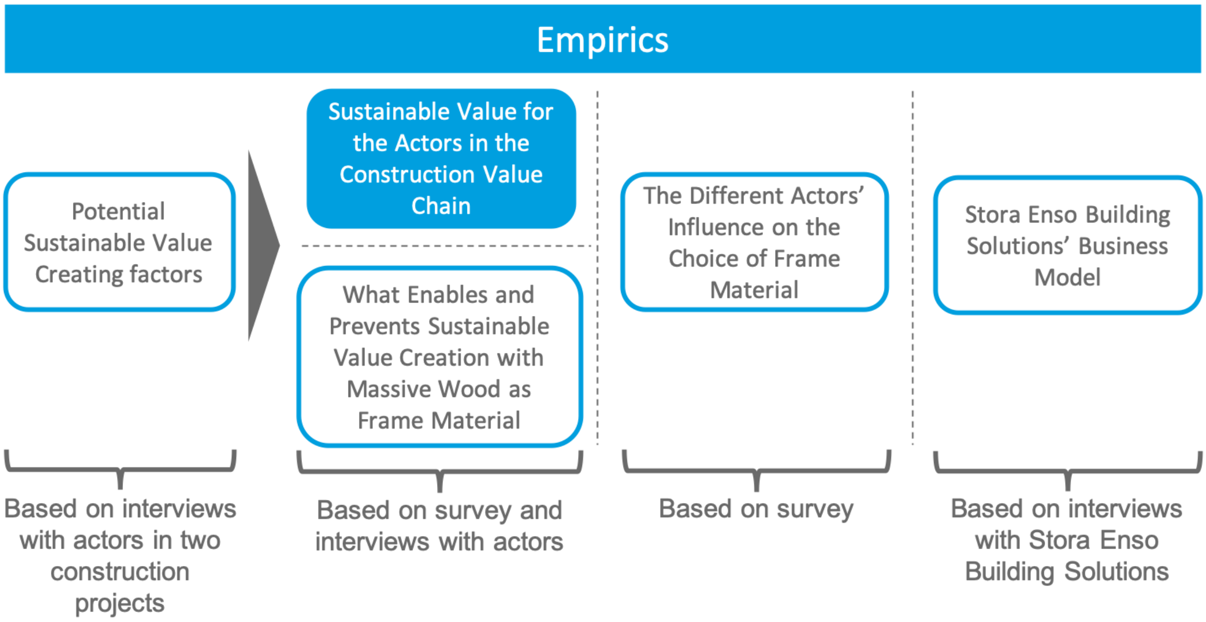

Figure 27: This section's relation to the other sections in the empirics.

The figures presented in the following sections show the mean values of how important the actors in the construction industry, both generally and divided into each category of actors, think the different factors are for them to prefer a certain frame material. The error bars represent a two-sided confidence interval (95 percent) for the sample. The differences between two groups of actors are significant when their confidence interval does not overlap. The scale of the charts reaches from 1 to 5, where 1 represents that the factor is not important for the respondent to prefer a certain frame material and 5 represents that the factor is very important for the respondent to prefer a certain frame material. Thus, the higher mean value of a factor, the more important the respondent think the factor is for them to prefer a certain frame material.

4.2.1 Sustainable Value Generally for the Actors in the Construction Value Chain

The results from the survey of how important different economic, social and environmental factors are generally for the actors in the construction industry to prefer a certain frame material are presented in figure 28, 29 and 30 below.

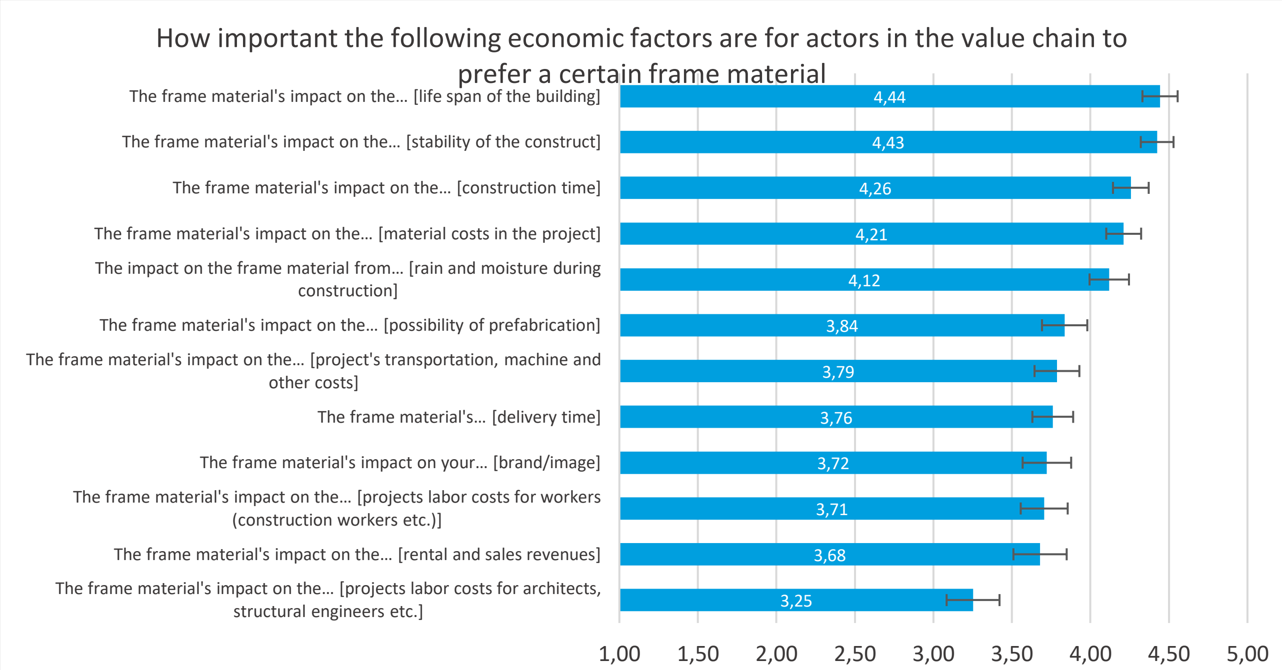

Figure 28: How important different economic factors are generally for actors in the construction industry to prefer a certain frame material.

The mean value of all economic factors for all the responding actors in the value chain is 3.94. The economic factors with significantly higher mean values than this are; the frame material's impact on the *life span of the building, stability of the construct, construction time, material costs in the projects* and the impact from *rain and moisture during construction*.

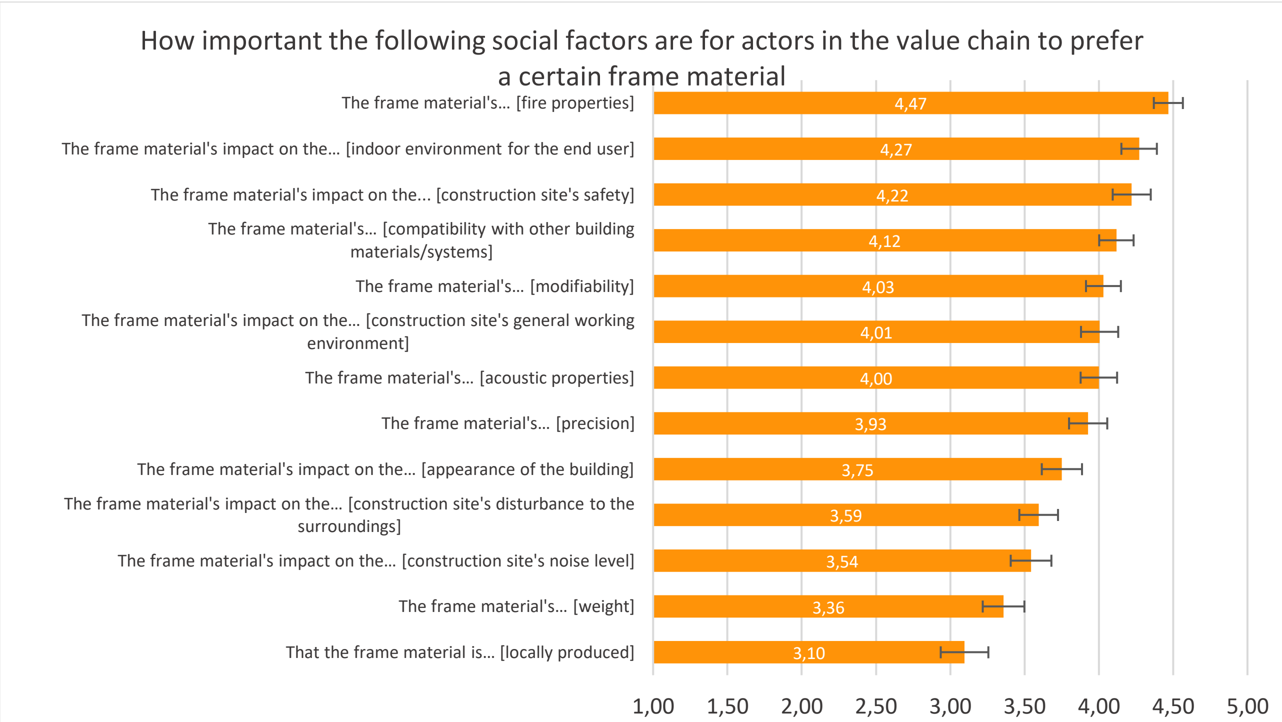

Figure 29: How important different social factors are generally for actors in the construction industry to prefer a certain frame material.

The mean value of all social factors for all the responding actors in the value chain is 3.89. The social factors with significantly higher mean values than this are; the frame material's *fire properties*, impact on the *indoor environment for the end user, construction site's safety, compatibility with other building materials/systems* and *modifiability*.

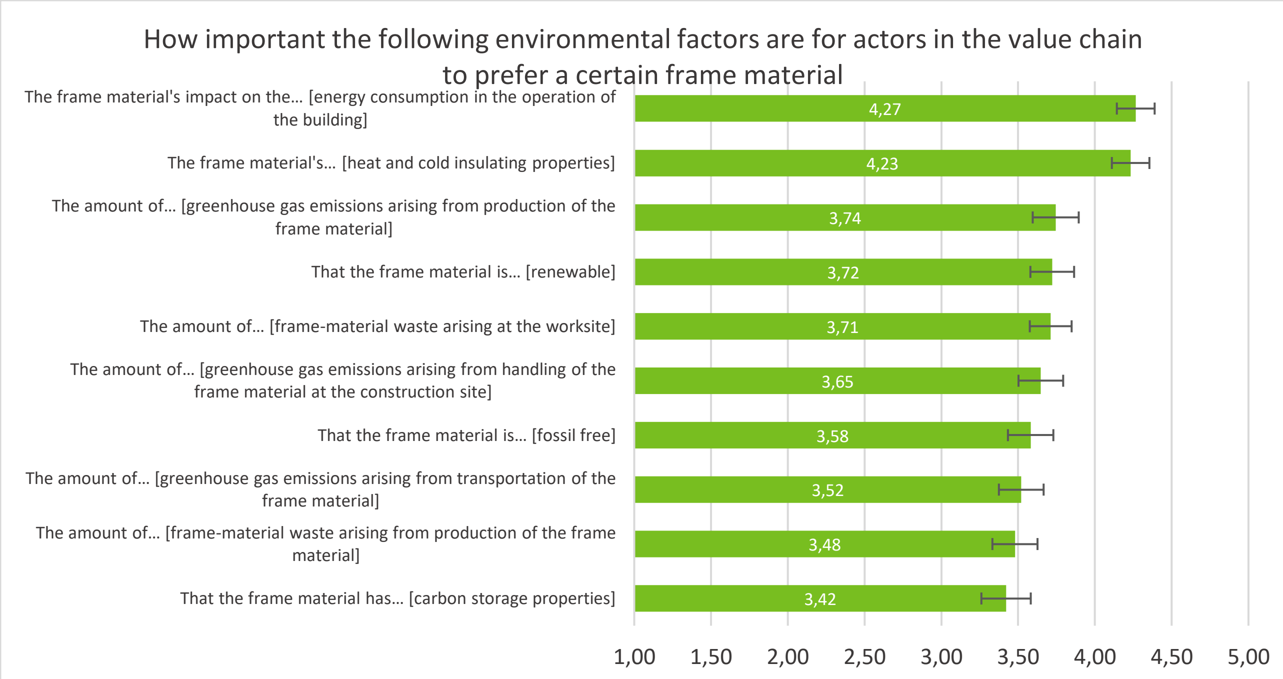

Figure 30: How important different environmental factors are generally for actors in the construction industry to prefer a certain frame material.

The mean value of all environmental factors for all the responding actors in the value chain is 3.73. The environmental factors with significantly higher mean values than this are; the frame material's impact on the *energy consumption in the operation of the building* and the frame materials *heat and cold insulating properties*.

4.2.2 Sustainable Value for Private Property Owners

The results from the survey of how important different economic, social and environmental factors are for private property owners in the construction industry to prefer a certain frame material are presented in figure 31, 32 and 33 below.

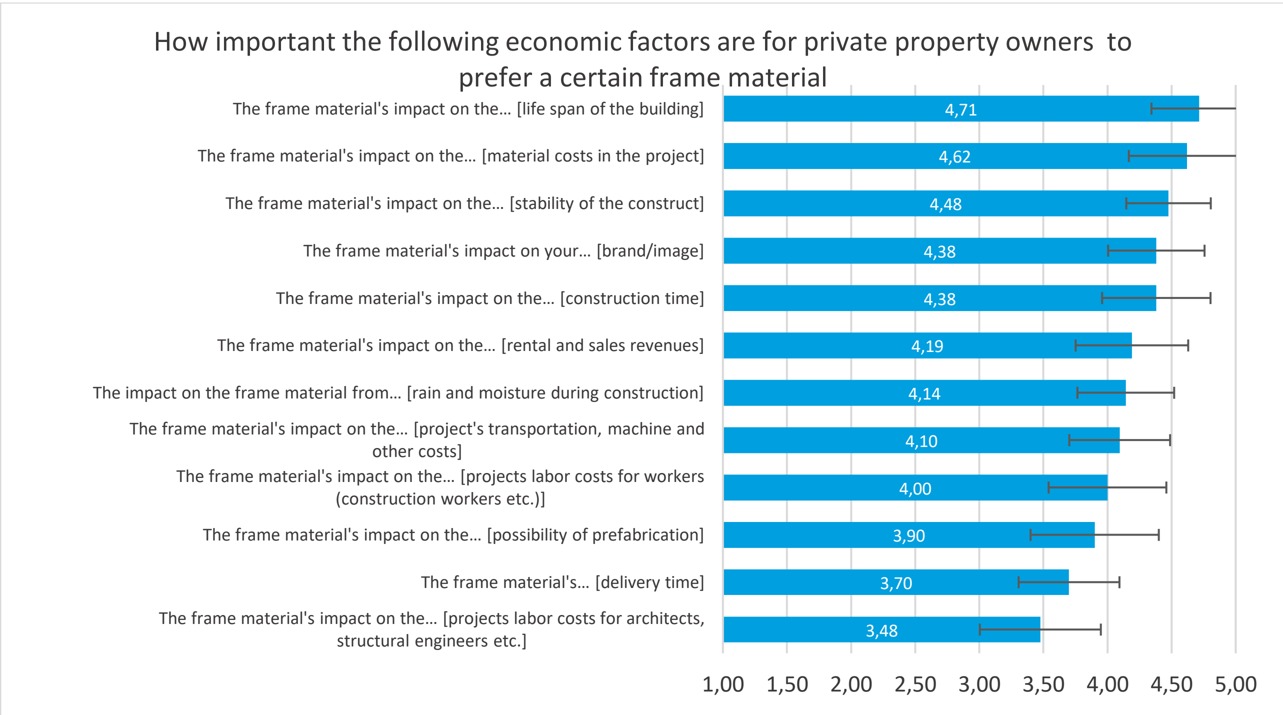

Figure 31: How important different economic factors are for private property owners to prefer a certain frame material.

The mean value of all economic factors for the responding private property owners is 4.15. The economic factors with significantly higher mean values than this are; the frame material's impact on the *life span of the building* and *material costs in the project.*

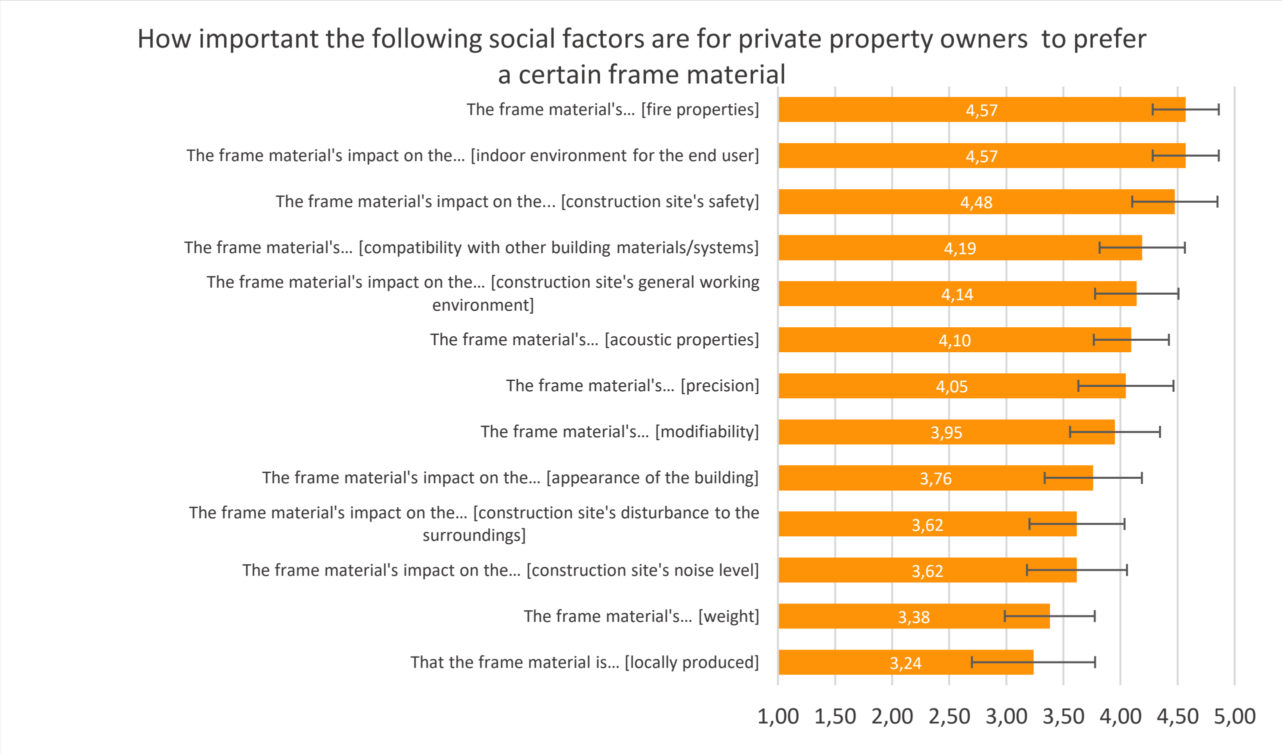

Figure 32: How important different social factors are for private property owners to prefer a certain frame material.

The mean value of all social factors for the responding private property owners is 3.97. The social factors with significantly higher mean values than this are; the frame material's *fire properties* and the frame material's impact on the *indoor environment for the end user* and *construction site's safety.*

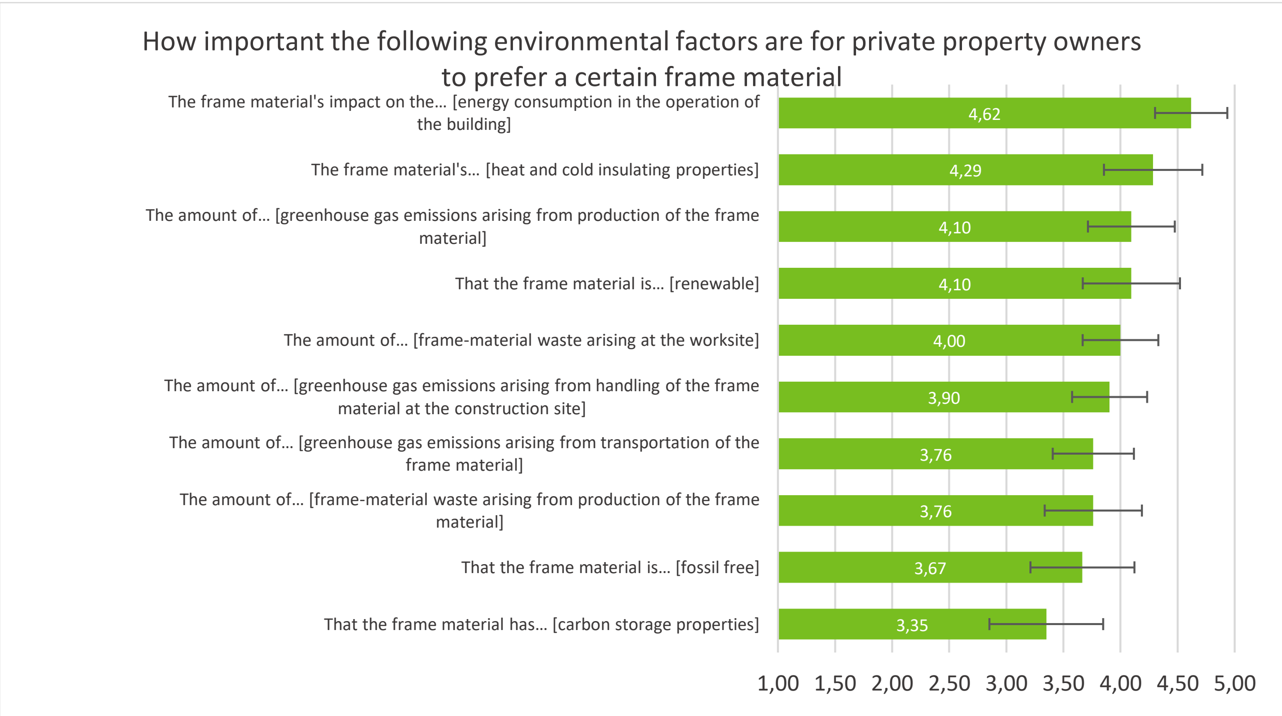

Figure 33: How important different environmental factors are for private property owners to prefer a certain frame material.

The mean value of all environmental factors for the responding private property owners is 3.97. The environmental factor with significantly higher mean value than this is; the frame material's impact on the *energy consumption in the operation of the building.*

4.2.3 Sustainable Value for Public Property Owners

The results from the survey of how important different economic, social and environmental factors are for public property owners in the construction industry to prefer a certain frame material are presented in figure 34, 35 and 36 below.

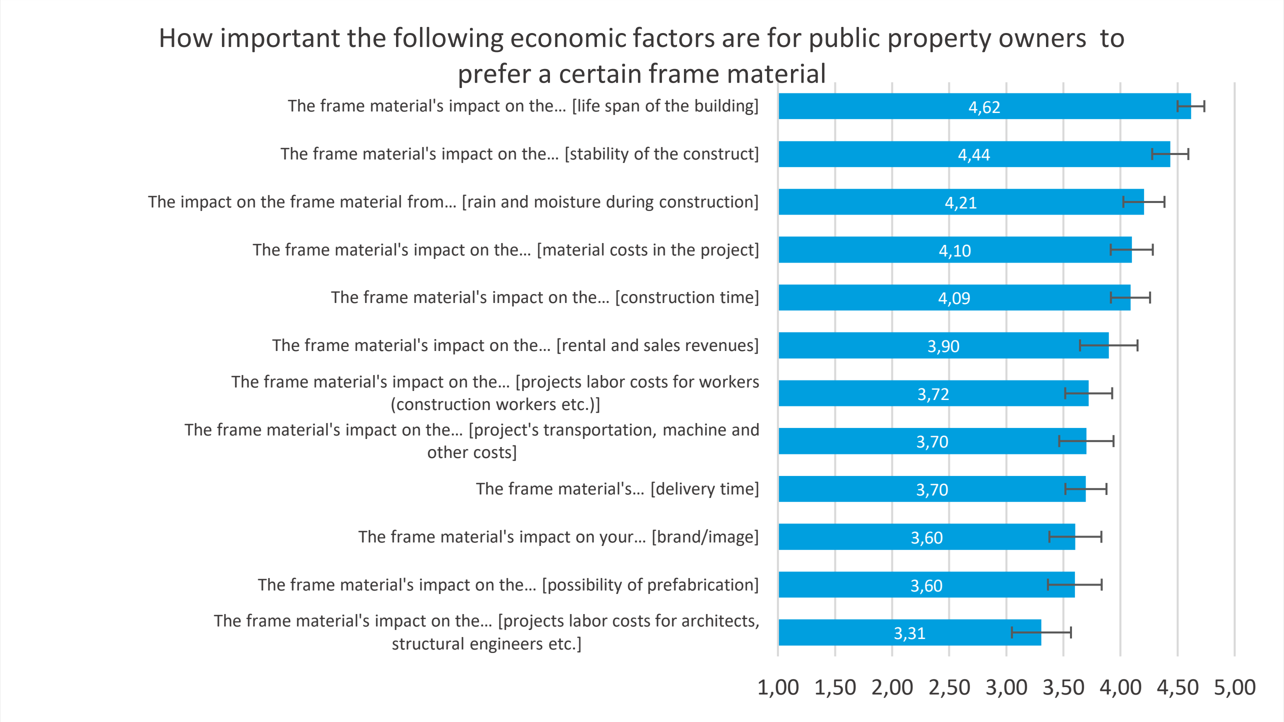

Figure 34: How important different economic factors are for public property owners to prefer a certain frame material.

The mean value of all economic factors for the responding public property owners is 3.92. The economic factors with significantly higher mean values than this are; the frame material's impact on the *life span of the building*, *stability of the construct*, *material costs in the project*, *construction time* and the impact on the frame material from *rain and moisture during construction.*

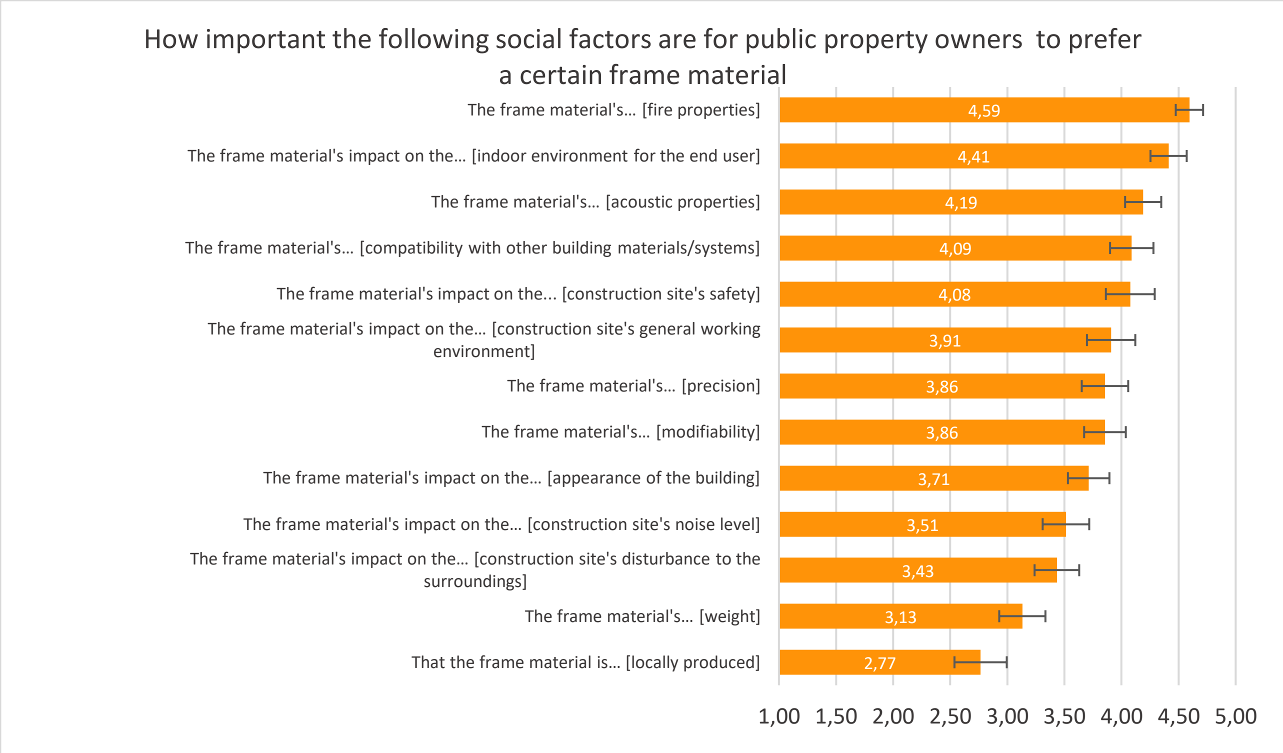

Figure 35: How important different social factors are for public property owners to prefer a certain frame material.

The mean value of all social factors for the responding public property owners is 3.81. The social factors with significantly higher mean values than this are; the frame material's *fire properties*, *acoustic properties* and *compatibility with other building materials/systems* and the frame material's impact on the *indoor environment for the end user* and *construction site's safety*.

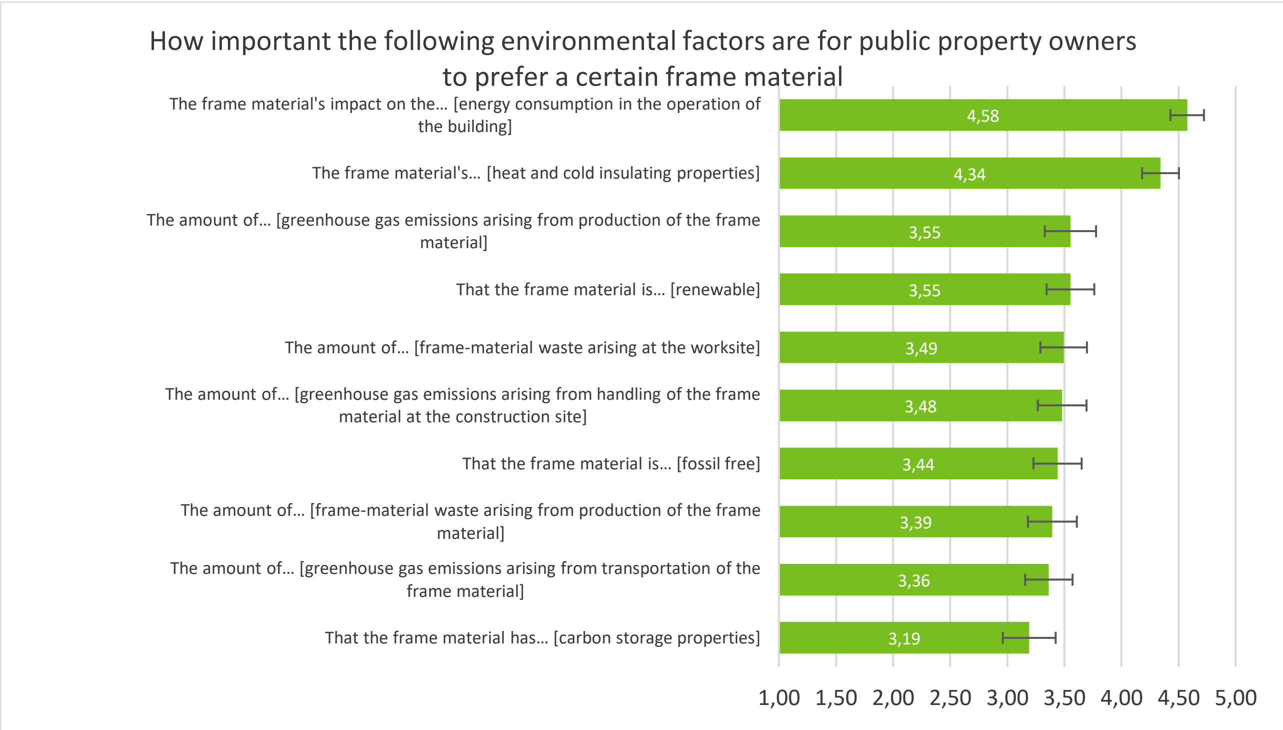

Figure 36: How important different environmental factors are for public property owners to prefer a certain frame material.

The mean value of all environmental factors for the responding public property owners is 3.60. The environmental factors with significantly higher mean values than this are; the frame material's impact on the *energy consumption in the operation of the building* and the frame material's *heat and cold insulating properties.*

4.2.4 Sustainable Value for Architects

The results from the survey investigating how important different economic, social and environmental factors are for architects in the construction industry to prefer a certain frame material are presented in figure 37, 38 and 39 below.

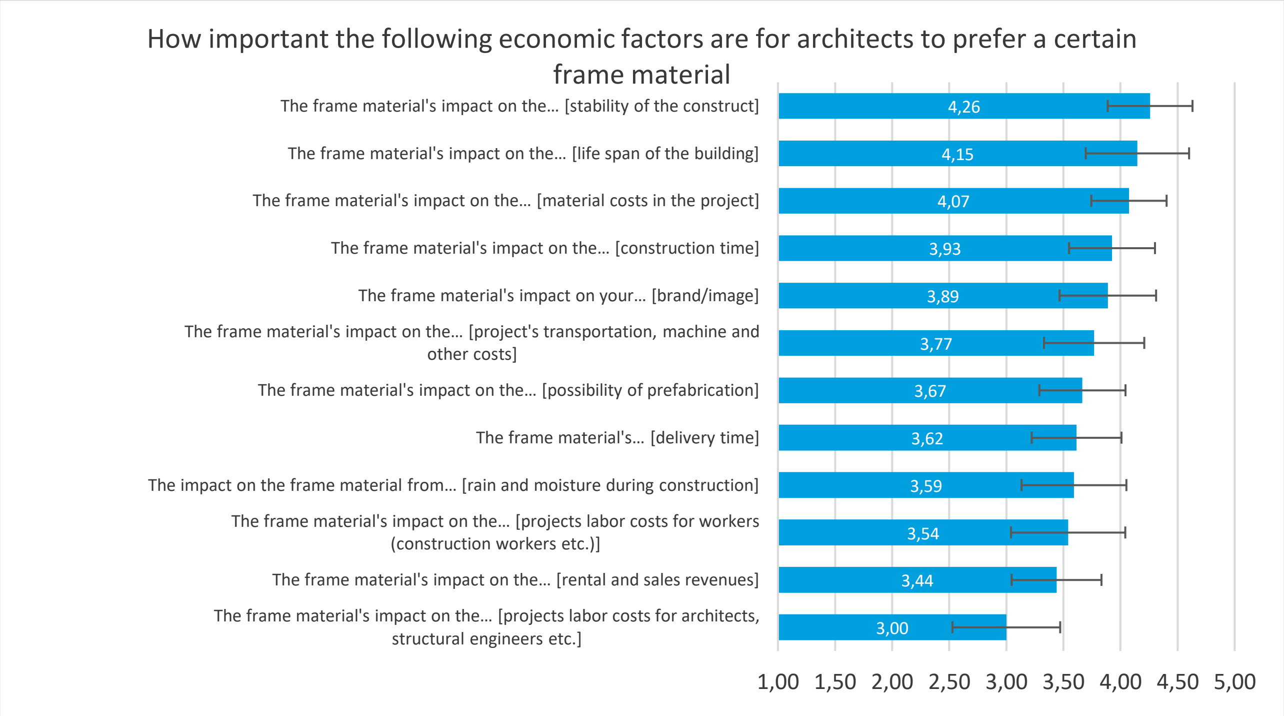

Figure 37: How important different economic factors are for architects to prefer a certain frame material.

The mean value of all economic factors for the responding architects is 3.72. The economic factors with significantly higher mean values than this are; the frame material's impact on the *life span of the building*, *stability of the construct* and *material costs in the project.*

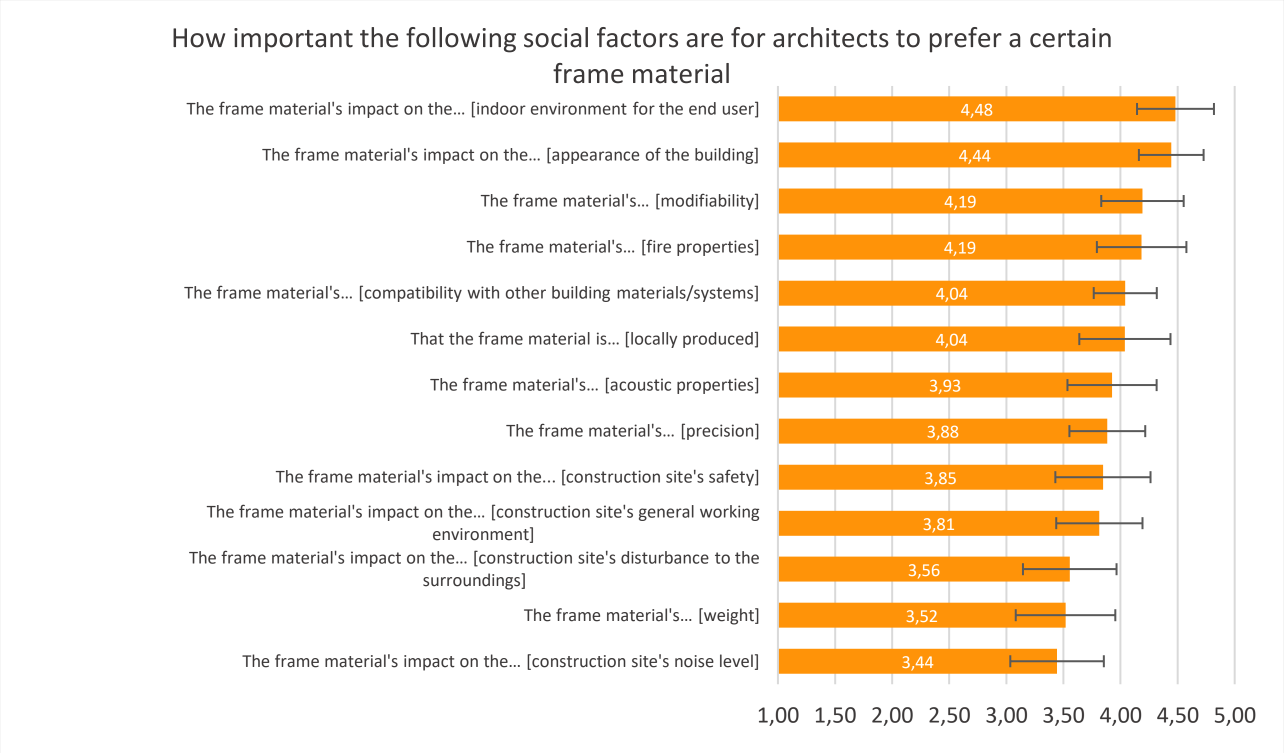

Figure 38: How important different social factors are for architects to prefer a certain frame material.

The mean value of all social factors for the responding architects is 4.04. The social factors with significantly higher mean values than this are; the frame material's impact on the *indoor environment for the end user* and *appearance of the building*.

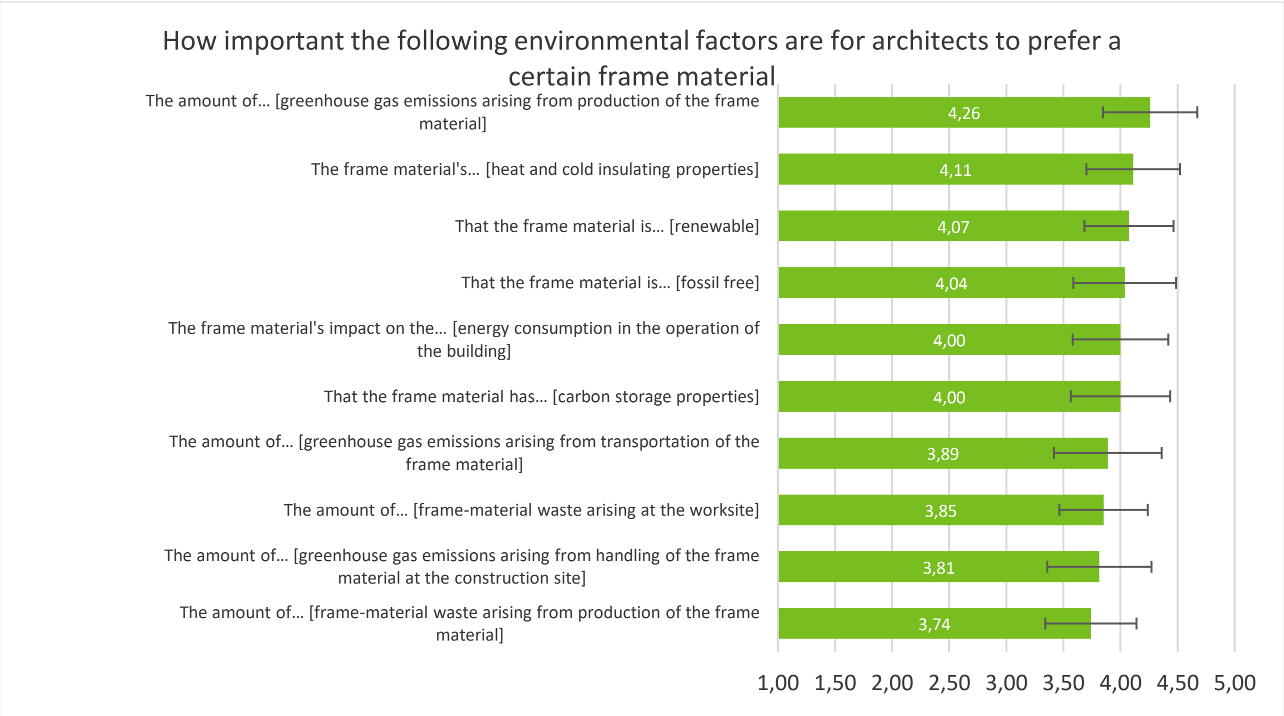

Figure 39: How important different environmental factors are for architects to prefer a certain frame material.

The mean value of all environmental factors for the responding architects is 3.98. None of the environmental factors has significantly higher, or lower, mean values than this.

4.2.5 Sustainable Value for Structural Engineers

The results from the survey of how important different economic, social and environmental factors are for structural engineers in the construction industry to prefer a certain frame material are presented in figure 40, 41 and 42 below.

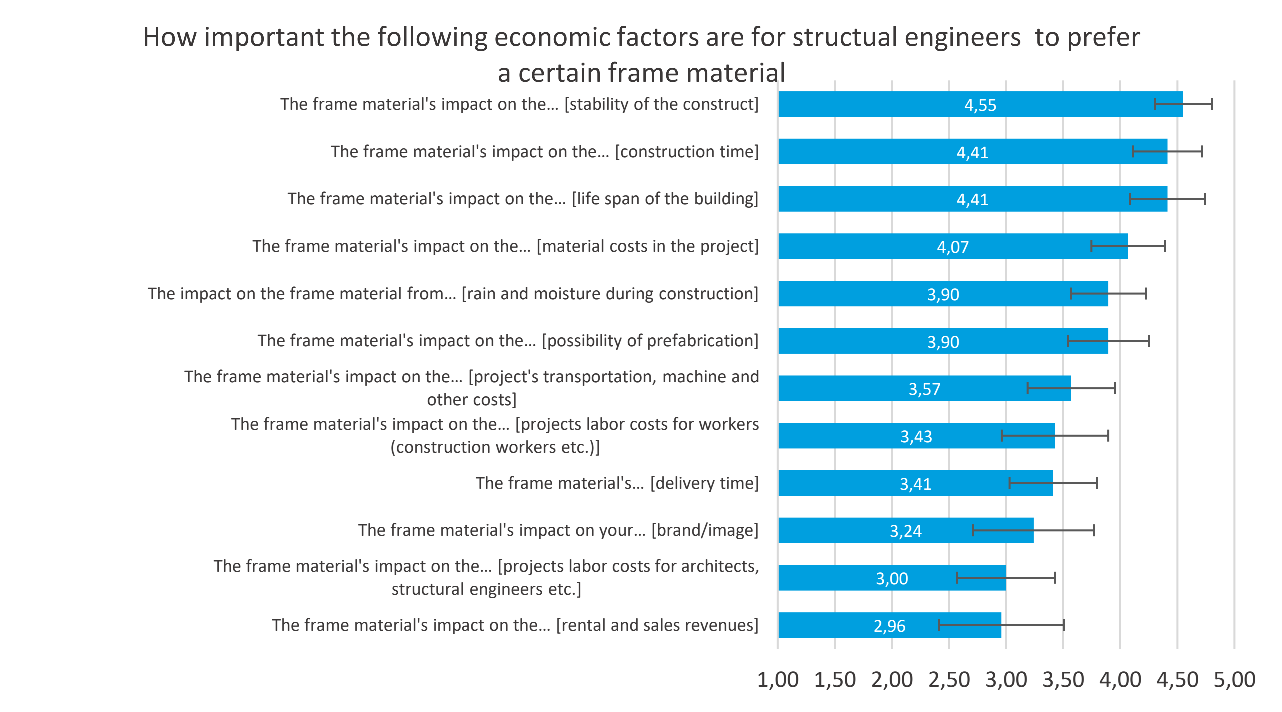

Figure 40: How important different economic factors are for structural engineers to prefer a certain frame material.

The mean value of all economic factors for the responding structural engineers is 3.77. The economic factors with significantly higher mean values than this are; the frame material's impact on the *stability of the construct, construction time, life span of the building* and *material costs in the project.*

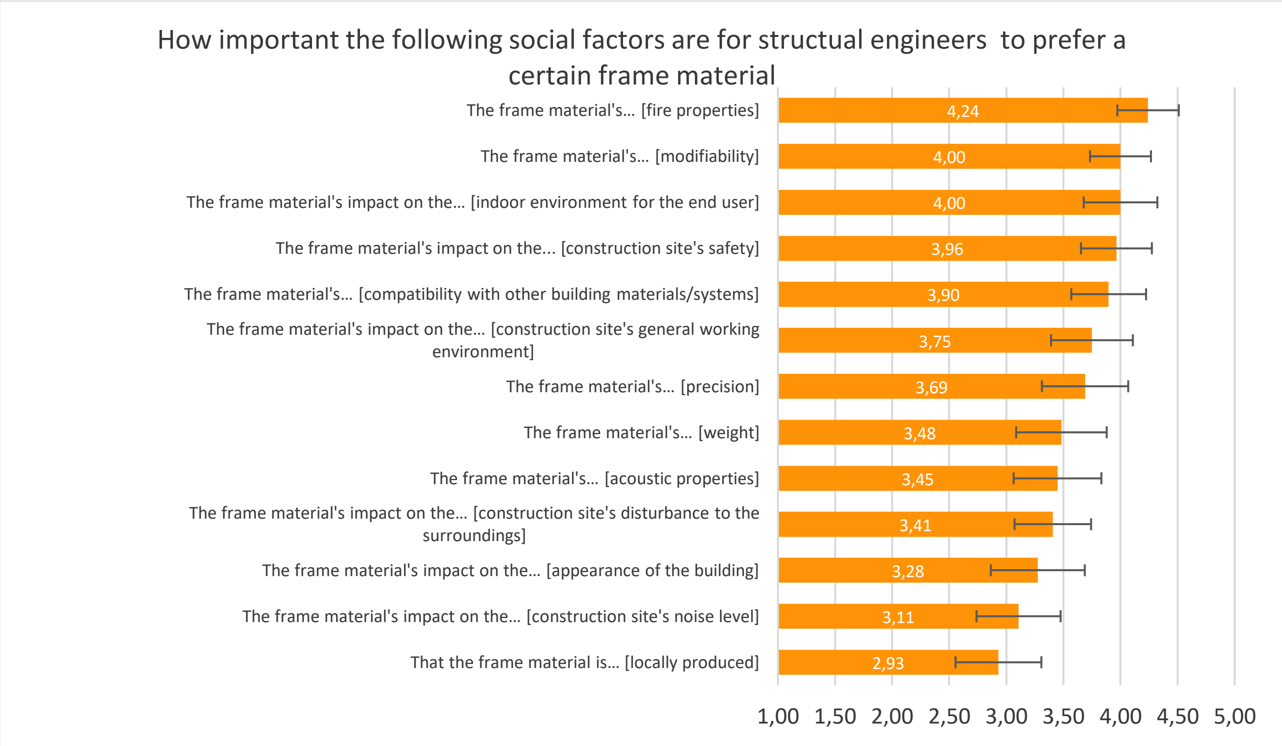

Figure 41: How important different social factors are for structural engineers to prefer a certain frame material.

The mean value of all social factors for the responding structural engineers is 3.66. The social factors with significantly higher mean values than this are; the frame material's *fire properties* and *modifiability* and the frame material's impact on the *indoor environment for the end user* and *construction site's safety*.

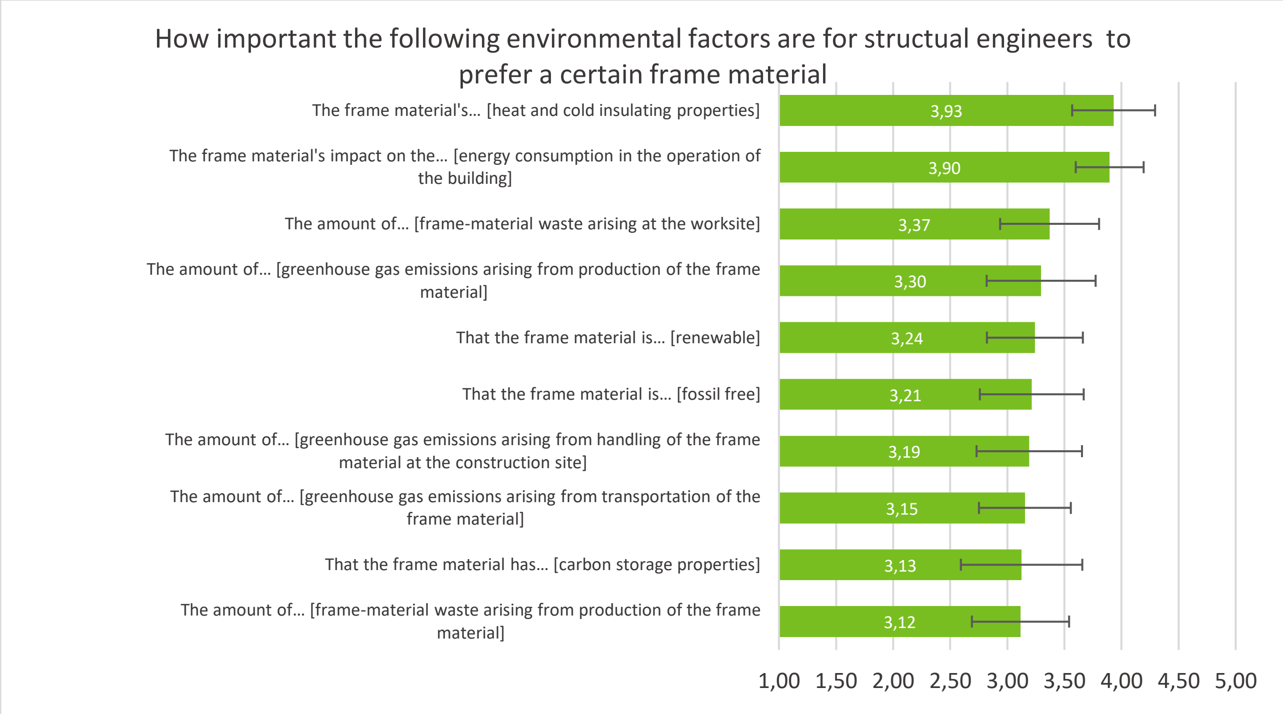

Figure 42: How important different environmental factors are for structural engineers to prefer a certain frame material.

The mean value of all environmental factors for the responding public property owners is 3.43. The environmental factors with significantly higher mean values than this are; the frame material's *heat and cold insulating properties* and the frame material's impact on the *energy consumption in the operation of the building.*

4.2.6 Sustainable Value for Construction Contractors

The results from the survey of how much different economic, social and environmental factors affect construction contractors in the construction industry to prefer a certain frame material are presented in figure 43, 44 and 45 below.

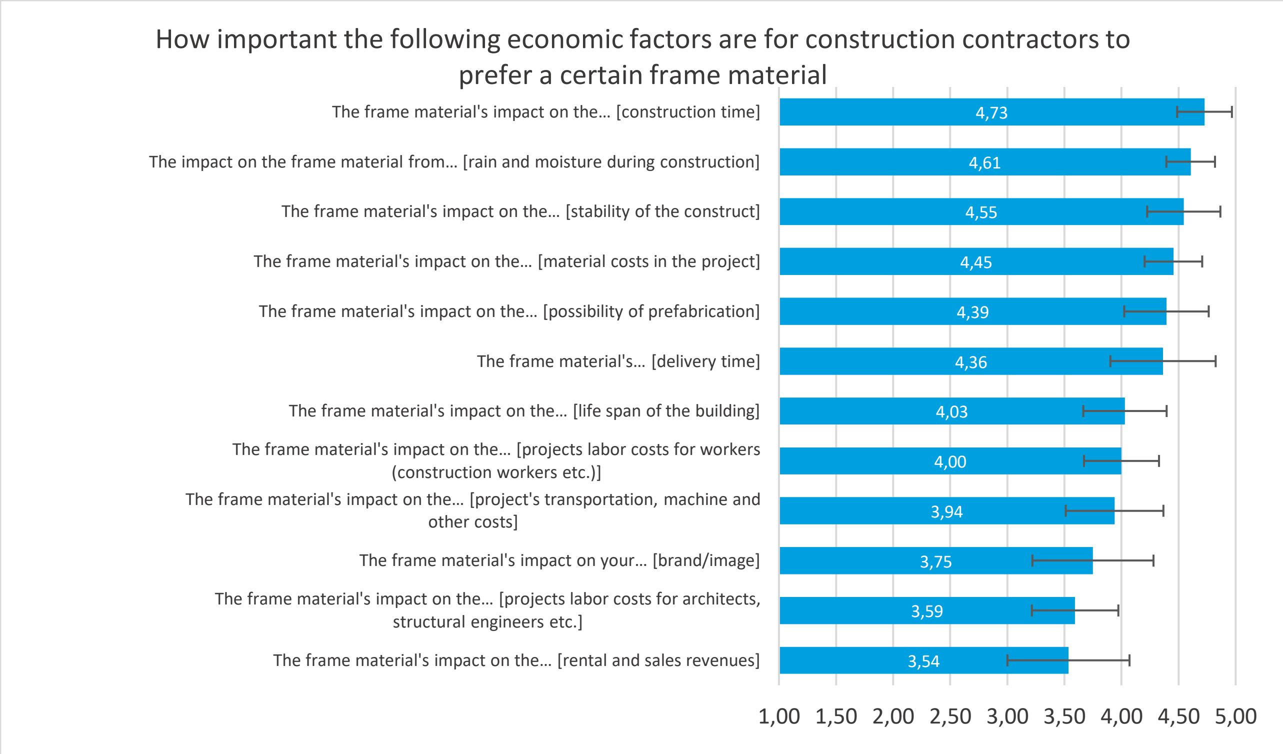

Figure 43: How important different economic factors are for construction contractors to prefer a certain frame material.

The mean value of all economic factors for the responding construction contractors is 4.17. The economic factors with significantly higher mean values than this are; the frame material's impact on the *construction time*, *stability of the construct* and *material costs in the* project and the impact on the frame material from *rain and moisture during construction.*

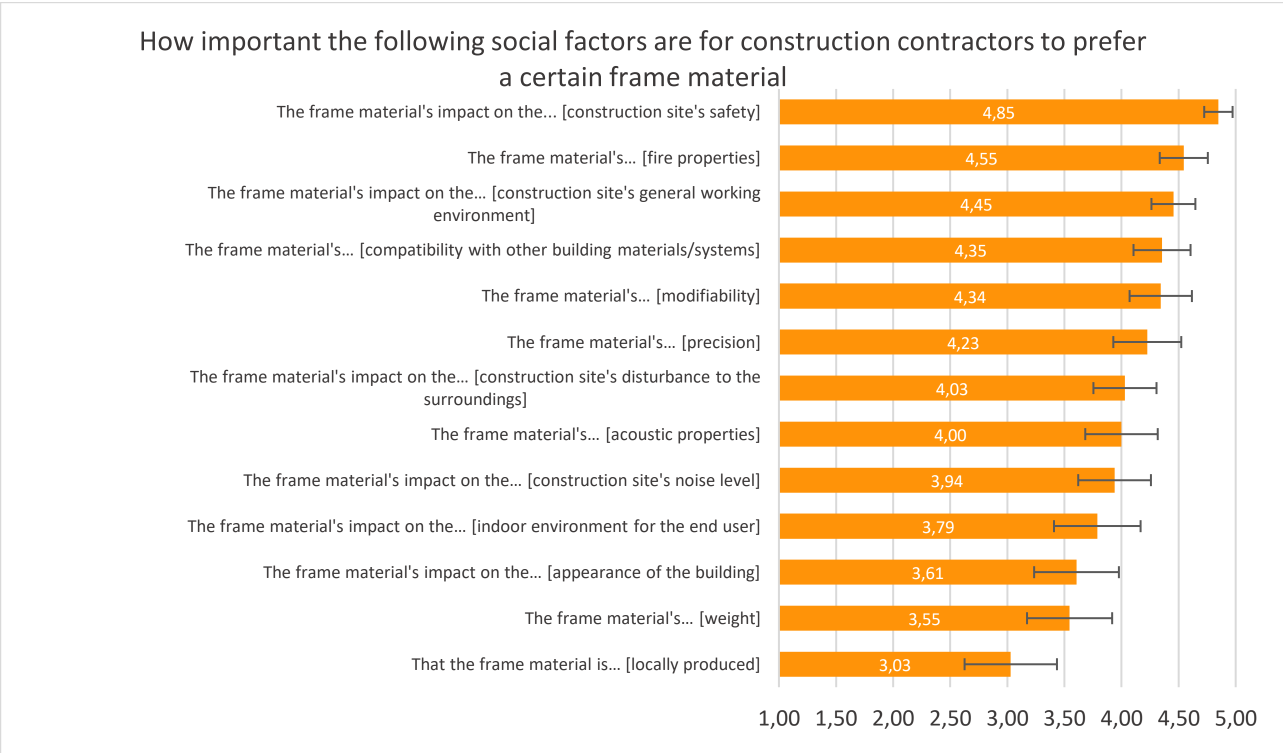

Figure 44: How important different social factors are for construction contractors to prefer a certain frame material.

The mean value of all social factors for the responding construction contractors is 4.06. The social factors with significantly higher mean values than this are; the frame material's *fire properties*, *compatibility with other* *building materials/systems* and *modifiability* and the frame material's impact on the *construction site's safety* and *construction site's general working environment.*

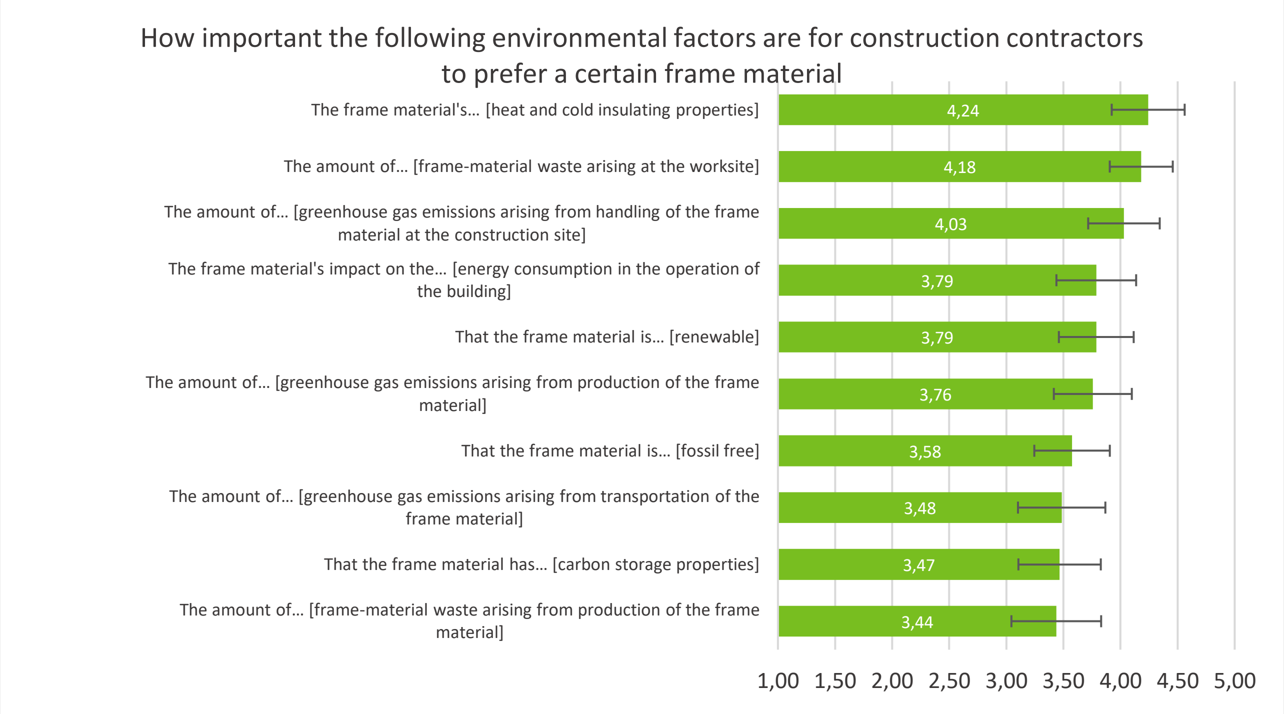

Figure 45: How important different environmental factors are for construction contractors to prefer a certain frame material.

The mean value of all environmental factors for the responding construction contractors is 3.74. The environmental factors with significantly higher mean values than this are; the frame material's *heat and cold insulating properties* and amount of *frame-material waste arising at the worksite.*

4.2.7 Comparison of how Important Different Economic, Social and Environmental Factors are for the Different Actors

In this section, a comparison of the different actor groups' responses to the questions in the survey, which investigate how important different economic, social and environmental factors are for them in order for them to prefer a certain material, is presented. Only those factors where we found significant differences between at least two actor groups are presented.

The differences between two groups of actors are significant when their confidence intervals do not overlap. The actors who think that the factor is significantly more important than one or multiple other actors think have a dark color of their bar. The actors who think that the factor is significantly less important than one or multiple other actors think have a light color of their bar. The rest of the players have a gray color on their bars.

Figure 46: Comparison of how important some of the economic factors are for the different actors.

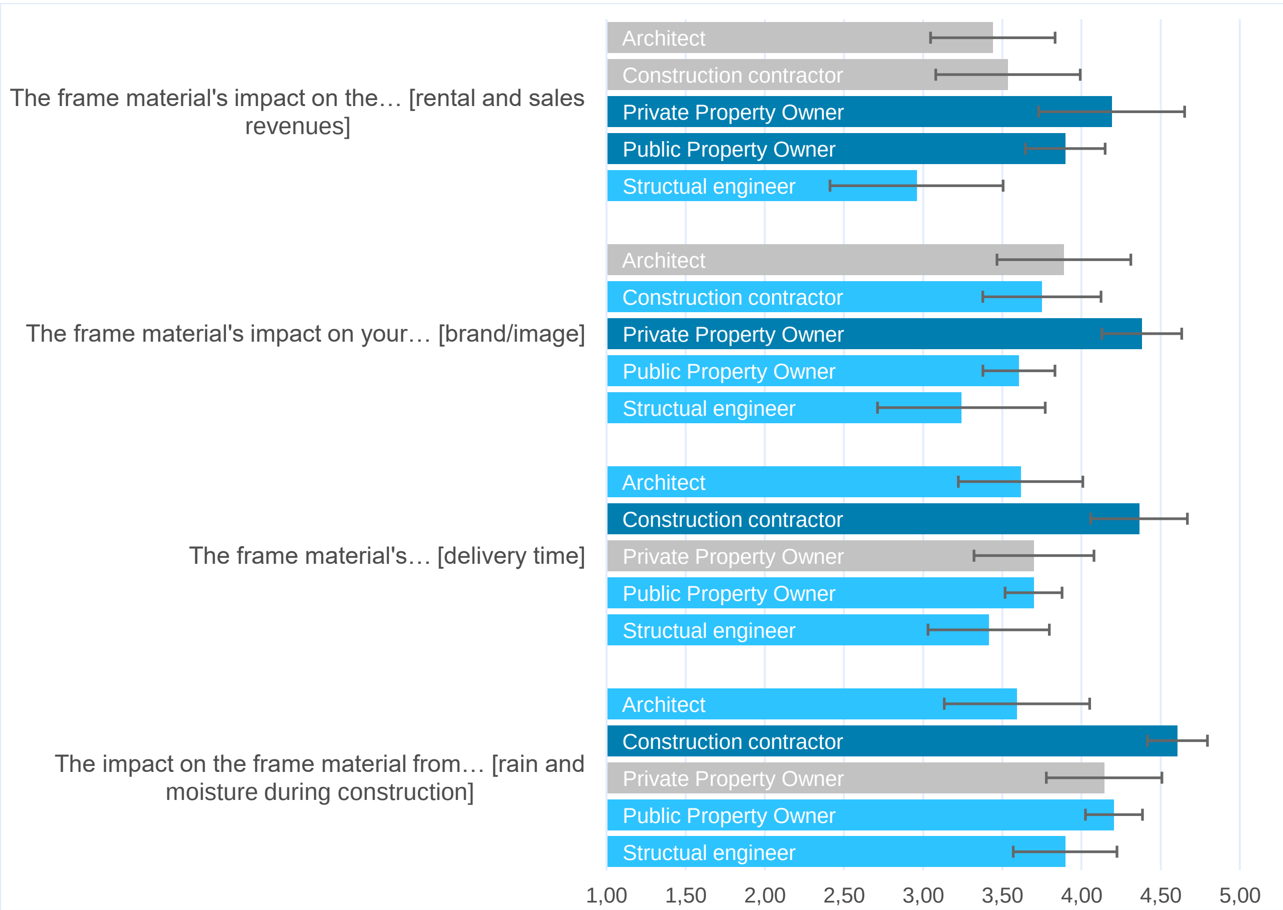

Figure 47: Comparison of how important some of the economic factors are for the different actors.

Figure 46 and 47 above shows that the frame material's impact on the *construction time* and on the *possibility of prefabrication are* more important for construction contractors than for public property owners. The frame material's impact on the *life span of the building* is more important for construction contractors than for property owners. The frame material's impact on the *material costs in the project* is more important for private property owners than for public property owners and structural engineers. Furthermore, the frame material's impact on the *rental and sales revenues* is more important for property owners than for structural engineers. The frame material's impact on your *brand/image* is more important for private property owners than for public property owners, construction contractors and structural engineers. Moreover, the frame material's *delivery time* and the impact on the frame material from *rain and moisture during construction* are more important for construction contractors than for architects, public property owners and structural engineers.

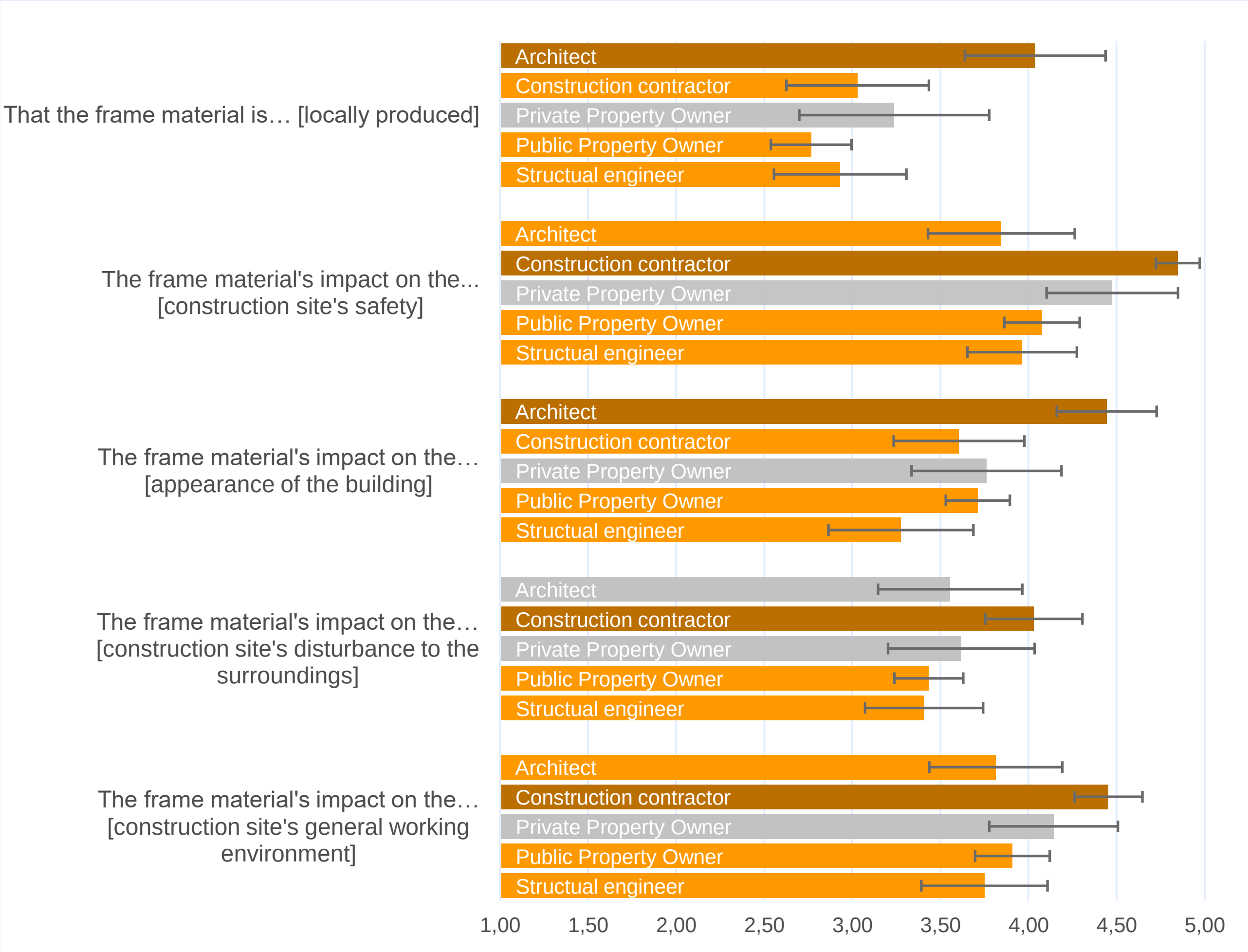

Figure 48: Comparison of how important some of the social factors are for the different actors.

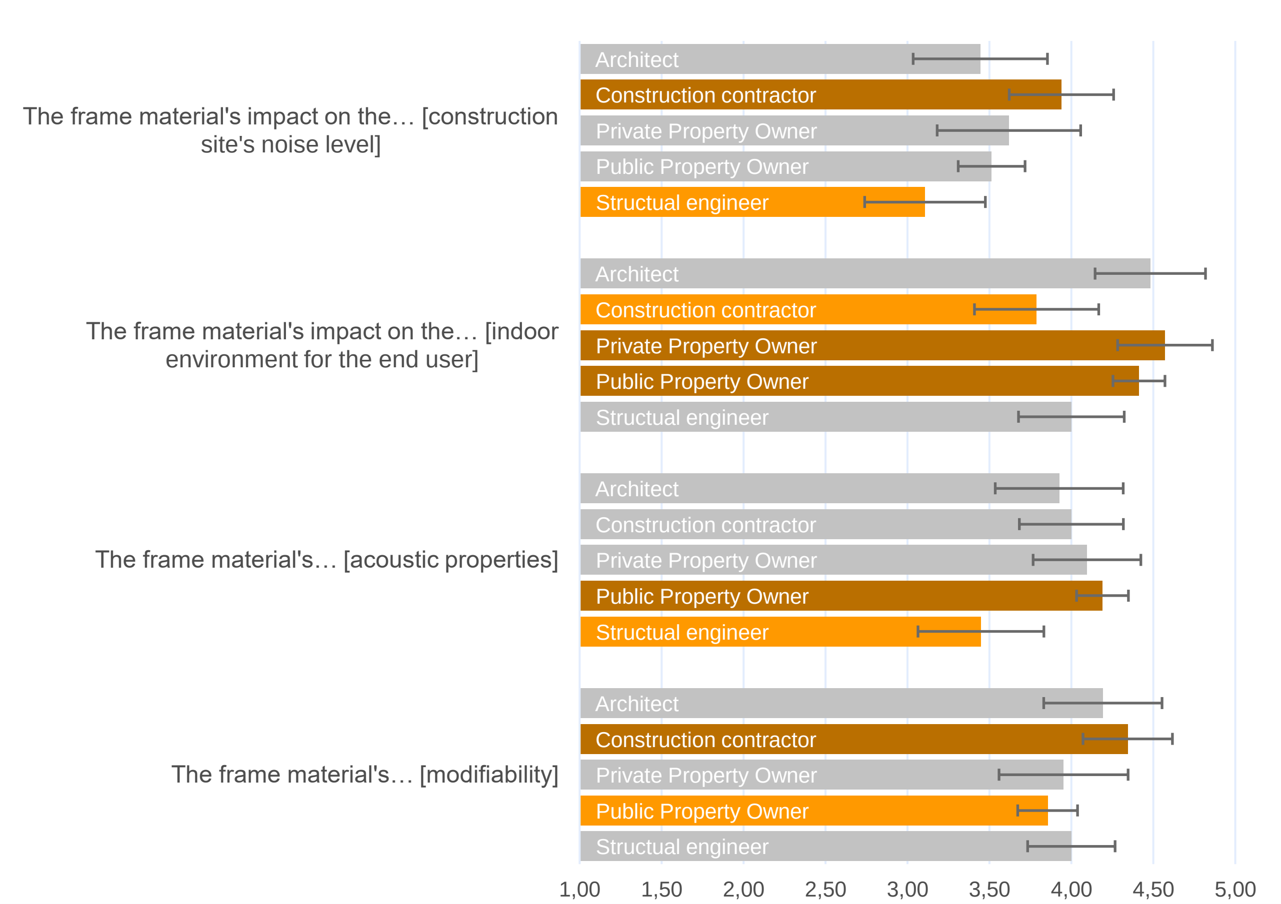

Figure 49: Comparison of how important some of the social factors are for the different actors.

Figure 48 and 49 above shows that the frame material's impact on the *appearance of the building* and that the frame material is *locally produced* are more important for architects than for construction contractors, structural engineers and public property owners. Furthermore, the frame material's impact on the *construction site's safety* and *general working environment* are more important for construction contractors than for architects, public property owners and structural engineers. The frame material's impact on the *construction site's disturbance on the surroundings* are more important for construction contractors than for public property owners and structural engineers. Moreover, the frame material's impact on the *construction site's noise level* is more important for construction contractors than for structural engineers and the frame material's *modifiability* is more important for construction contractors than for public property owners. The frame material's impact on the *indoor environment for the end user* is more important for construction contractors than for property owners. Lastly, the frame material's *acoustic properties* are more important for public property owners than for structural engineers.

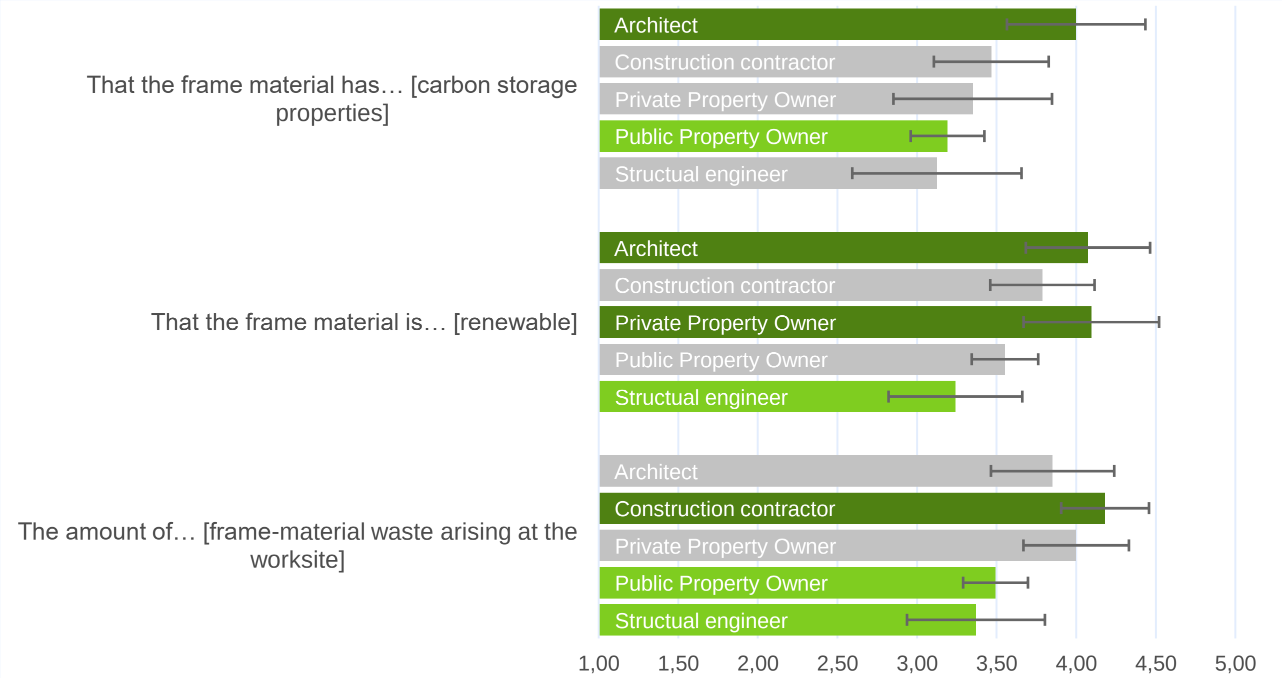

Figure 50: Comparison of how important some of the environmental factors are for the different actors.

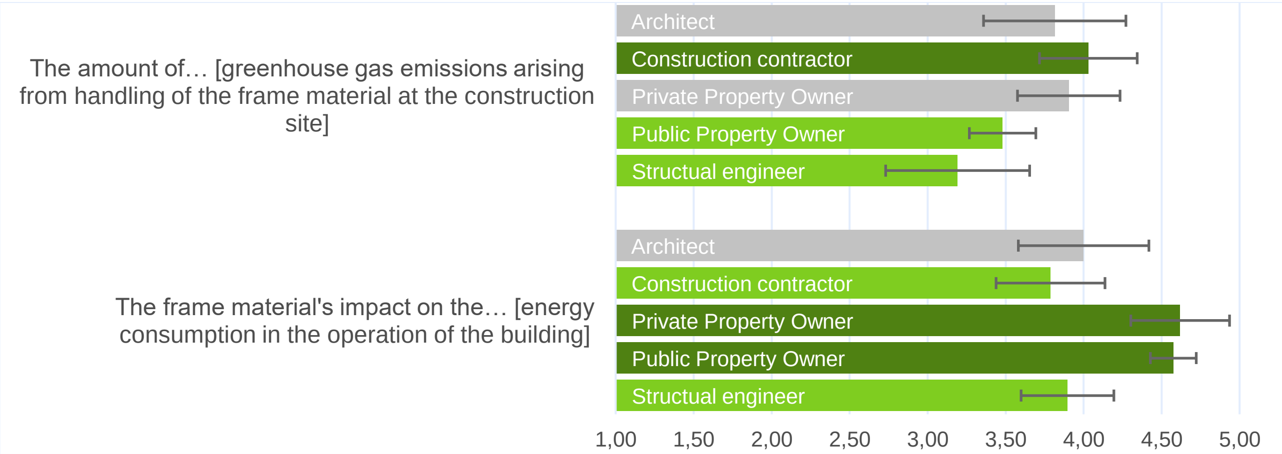

Figure 51: Comparison of how important some of the environmental factors are for the different actors.

Figure 50 and 51 above shows that the amount of *frame-material waste arising at the worksite* and the amount of *greenhouse gas emissions arising from handling of the frame material at the construction site* are more important for construction contractors than for public property owners and structural engineers. Further, that the frame material has *carbon storage properties* is more important for architects than for public property owners. Furthermore, that the frame material is *renewable* is more important for architects and private property owners than for structural engineers. Lastly, the frame material's impact on the *energy consumption in the operation of the building* is more important for property owners than for construction contractors and for structural engineers.

4.2.8 Summary of the Most Important Factors for each Actor to Prefer a Certain Frame Material

In this section, the most important factors for each actor to prefer a certain frame material are summarized and compared.

For private property owners, the frame material's impact on the *life span of the building*, *material costs in the project*, *indoor environment for the end user*, *energy consumption in the operation of the building* and *construction site's safety and* the frame material's *fire properties* are the most important factors in order for them to prefer a certain frame material.

For public property owners, the frame material's impact on the *life span of the building*, *stability of the construct, material costs in the project, construction time, indoor environment for the end user*, *energy consumption in the operation of the building* and *construction site's safety* and the impact on the frame material from *rain and moisture during construction* are included as the most important factors for them in order to prefer a certain frame material. Furthermore, the frame material's *fire properties*, *acoustic properties*, *heat and cold insulating properties* and *compatibility with other building materials/systems* are also included as the most important factors in order for public property owners to prefer a certain frame material.

For architects, the frame material's impact on the *life span of the building*, *stability of the construct* and *material costs in the project*, *indoor environment for the end user* and *appearance of the building* are the most important factors in order for them to prefer a certain frame material. Furthermore, no environmental factors are more or less important than any other environmental factors in order for architects to prefer a certain frame material.

For structural engineers, the frame material's impact on the *stability of the construct*, *construction time*, *life span of the building*, *material costs in the project*, *indoor environment for the end user*, *energy consumption in the operation of the building* and *construction site's safety* and the frame material's *fire properties*, *heat and cold insulating properties* and *modifiability* are the most important factors in order for structural engineers to prefer a certain frame material.

For construction contractors, the frame material's impact on the *construction time*, *stability of the construct, material costs in the* project, on the *construction site's safety* and *construction site's general working environment* and the impact on the frame material from *rain and moisture during construction* are included as the most important factors in order for construction contractors to prefer a certain frame material. Furthermore, the frame material's *fire properties*, *compatibility with other building materials/systems*, *modifiability*, *heat and cold insulating properties* and the amount of *frame-material waste arising at the worksite* are also included as the most important factors in order for construction contractors to prefer a certain frame material.

The results show that the frame material's impact on *the material costs in the project* is one of the most important economic factors for all actors in order for them to prefer a certain frame material. Three of four actors also see the frame material's impact on the stability of the construct as one of the most important economic factors. Furthermore, the frame material's impact on the *construction site's safety*, *indoor environment for the end user* and the frame material's *fire properties* are social factors which three of four actors view as some of the most important social factors in order for them to prefer a certain frame material. Three of four actors also see the frame material's impact on the *energy consumption in the operation of the building* and the frame material's *heat and cold insulating properties* as some of the most important environmental factors.

4.3 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material

In this section, the results from the survey and interviews regarding how different factors impact sustainable value creation for the actors in the construction value chain, regarding massive wood as frame material, are presented. The difference of how a factor is viewed based on experience of using massive wood as frame material can be found in *Appendix 6*. The data the figures presented in this section is based on can be found in *Appendix 5*. See figure 52 below for this section's relation to the other sections in the empirics.

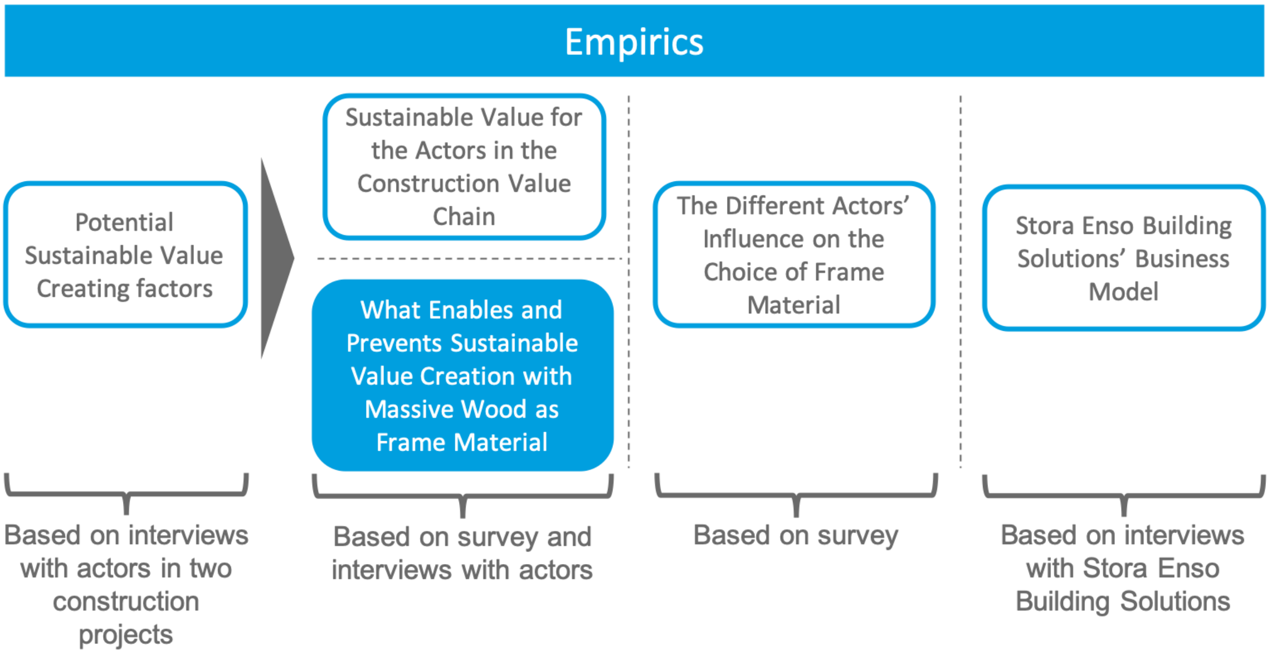

Figure 52: This section's relation to the other sections in the empirics.

The figures presented in the following sections show the distribution of answers of how the respondents view the different factors regarding massive wood as frame material, both generally and divided into each category of actors. The scale of the charts reaches from -2 to 2, where -2 represents that the factor is seen as a great disadvantage for the respondent to prefer massive wood as frame material and 2 represents that the factor is seen as a great advantage for the respondent to prefer massive wood as frame material. Thus, the longer the red part of the bar is, the larger number of respondents view the factor as a disadvantage, and the longer the green part of the bar is, the larger number of respondents view the factor as an advantage for them to prefer massive wood as frame material.

4.3.1 What Enables and Prevents Sustainable Value Creation Generally for the Actors in the Construction Value Chain

The results from the survey investigating if actors in the construction value chain generally see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 53, 54 and 55 below.

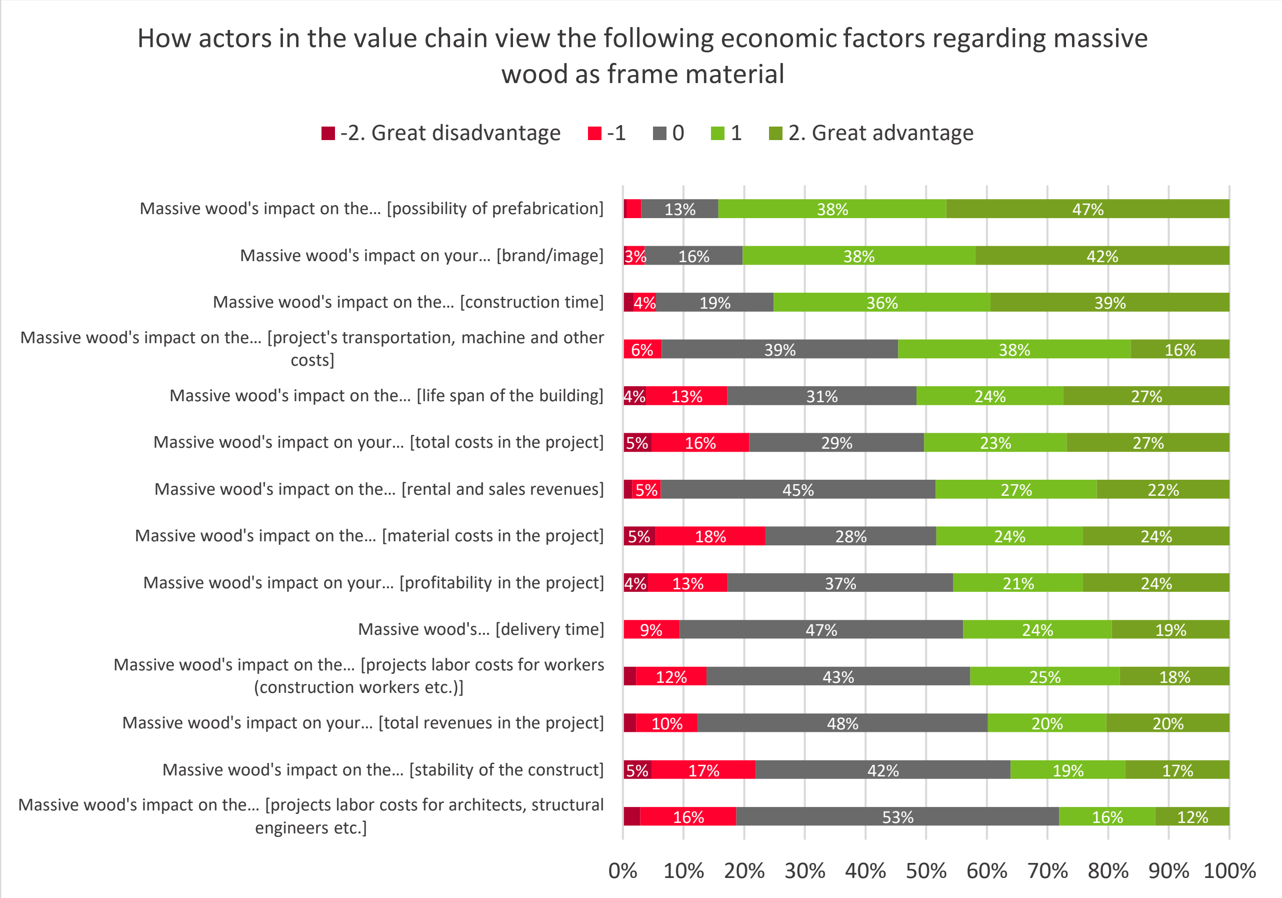

Figure 53: How actors in the construction value chain view these economic factors.

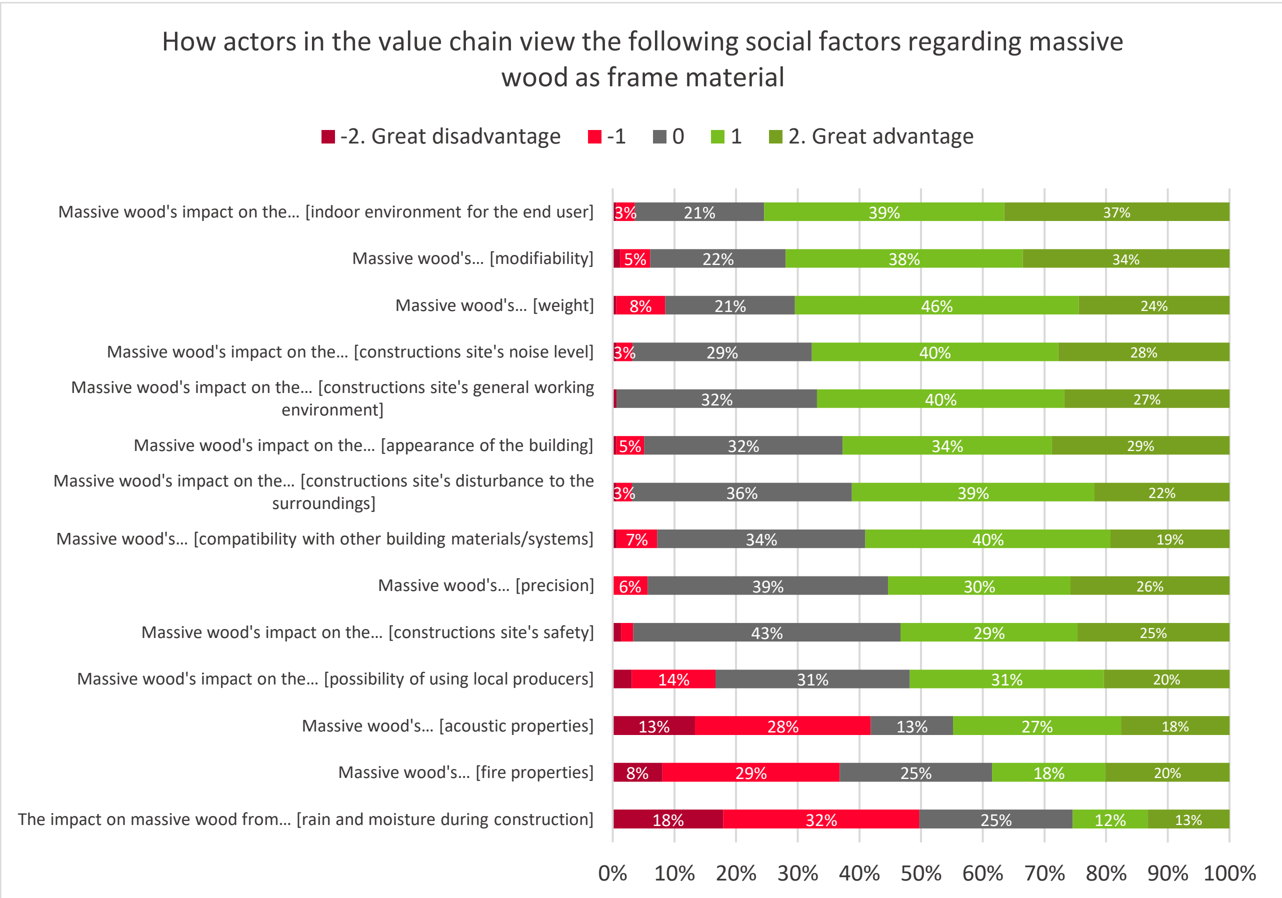

Figure 54: How actors in the construction value chain view these social factors.

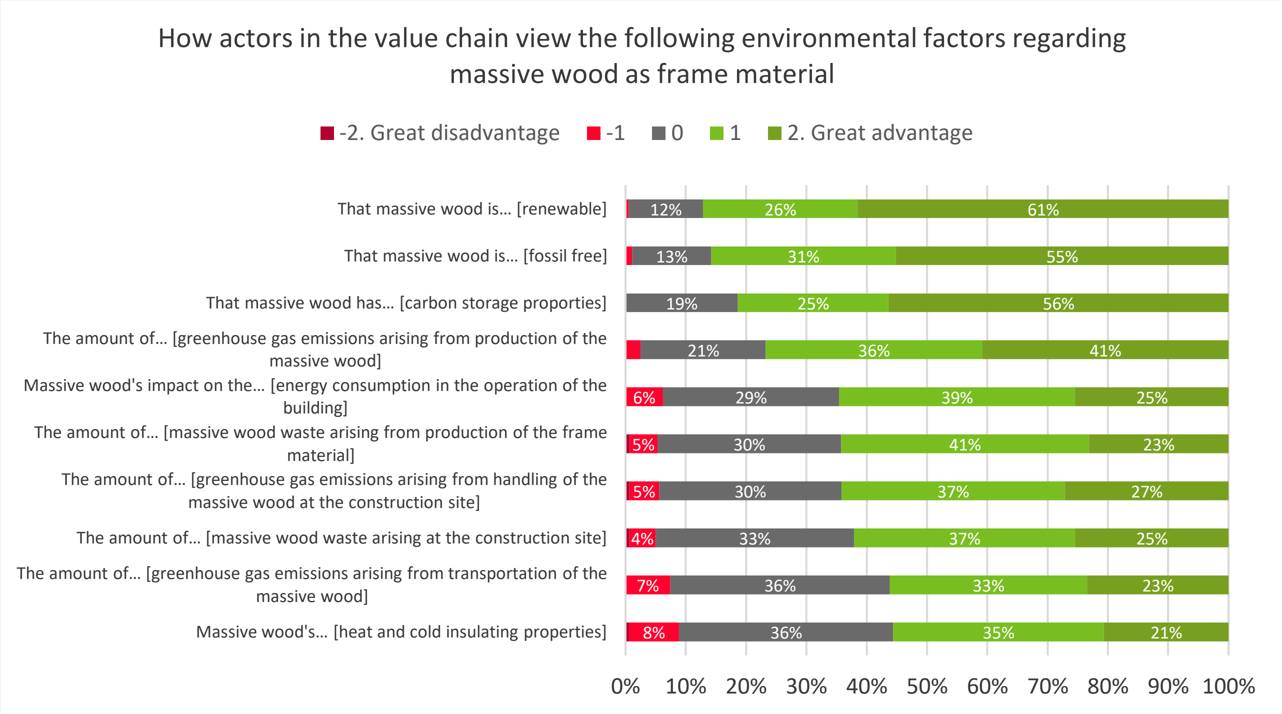

Figure 55: How actors in the construction value chain view these environmental factors.

As can be seen in the figures, many actors in the value chain generally see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many seen as great advantages. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication* and *construction time* and massive wood's impact on your *brand/image* as advantages with massive wood as frame material. Furthermore, massive wood's *acoustic properties*, *fire properties* and the impact on massive wood from *rain and moisture during construction* are by actors in the construction chain seen as the main disadvantages with massive wood as frame material.

4.3.2 What Enables and Prevents Sustainable Value Creation for Private Property Owners

The results from the survey investigating if private property owners see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 56, 57 and 58 below.

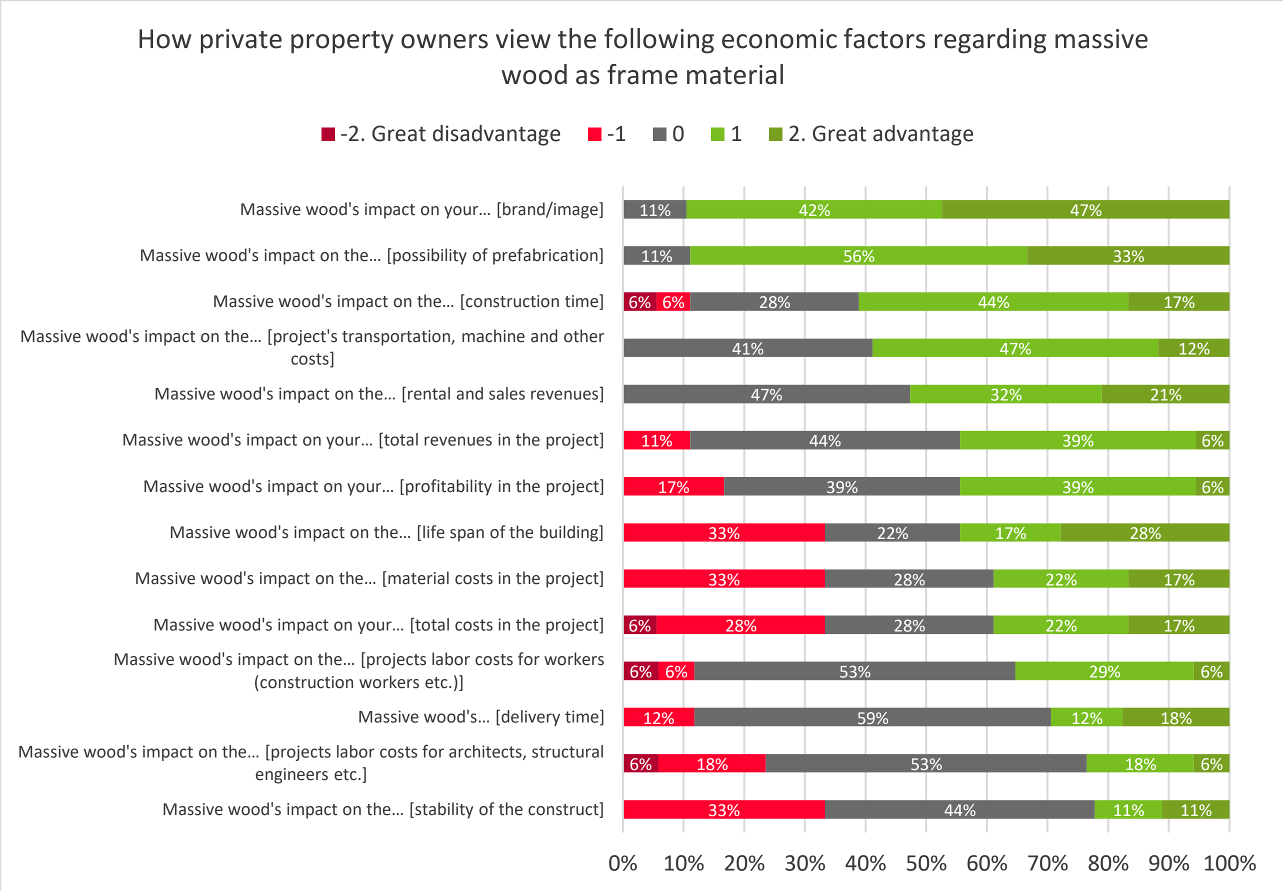

Figure 56: How private property owners view these economic factors.

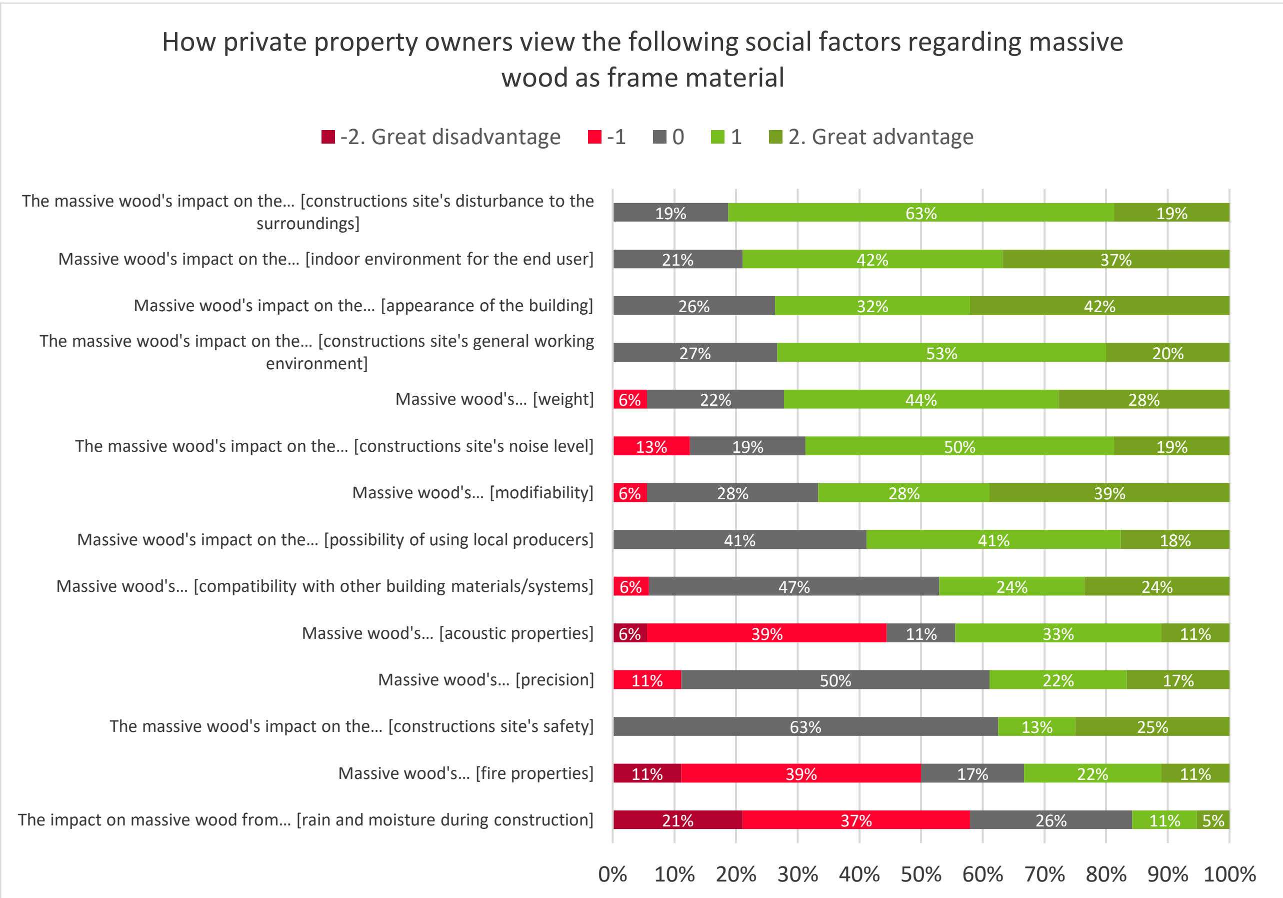

Figure 57: How private property owners view these social factors.

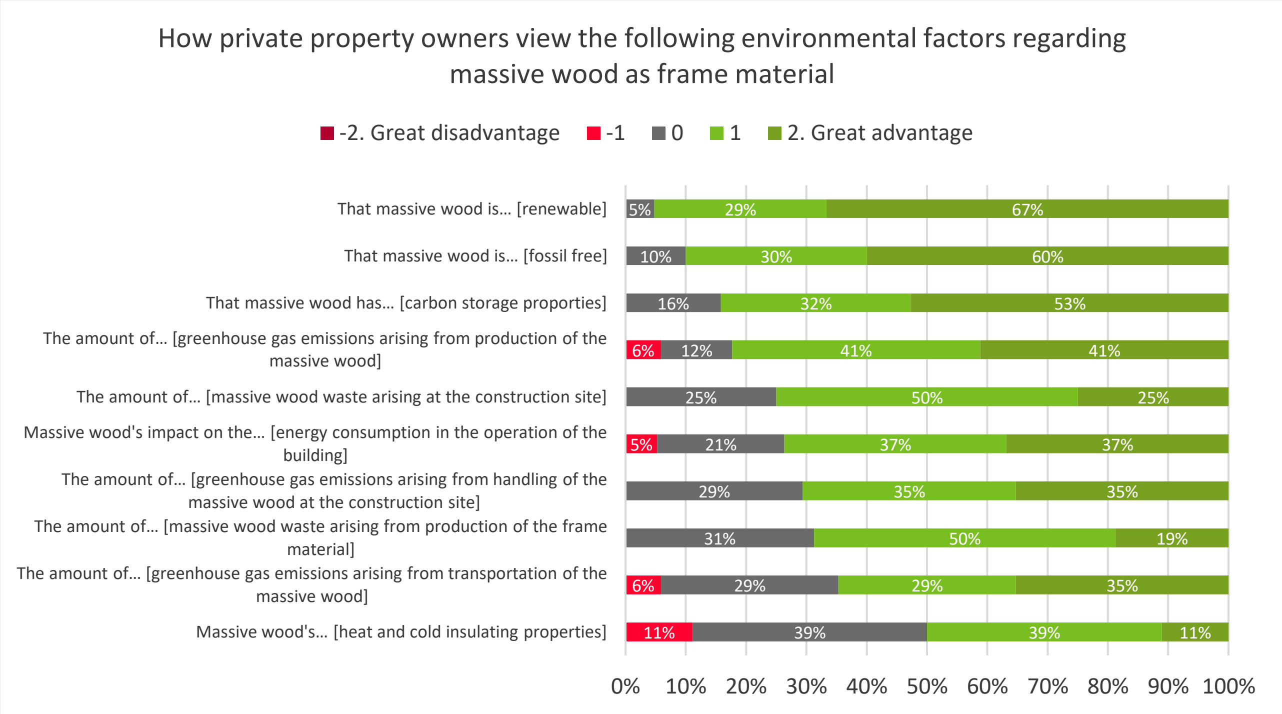

Figure 58: How private property owners view these environmental factors.

As can be seen in the figures, many private property owners see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many seen as great advantages. Also, the amount of *greenhouse gas emissions arising from production of massive wood* is by many private property owners seen as an advantage. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication* and massive wood's impact on your *brand/image* as advantages with massive wood as frame material. Moreover, massive wood's impact on the *construction site's disturbance to the surroundings* and *indoor environment for the end users* are seen as advantages with massive wood as frame material. Furthermore, massive wood's *acoustic properties*, *fire properties* and the impact on massive wood from *rain and moisture during construction* are by private property owners seen as the main disadvantages with massive wood as frame material.

4.3.3 What Enables and Prevents Sustainable Value Creation for Public Property Owners

The results from the survey investigating if public property owners see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 59, 60 and 61 below.

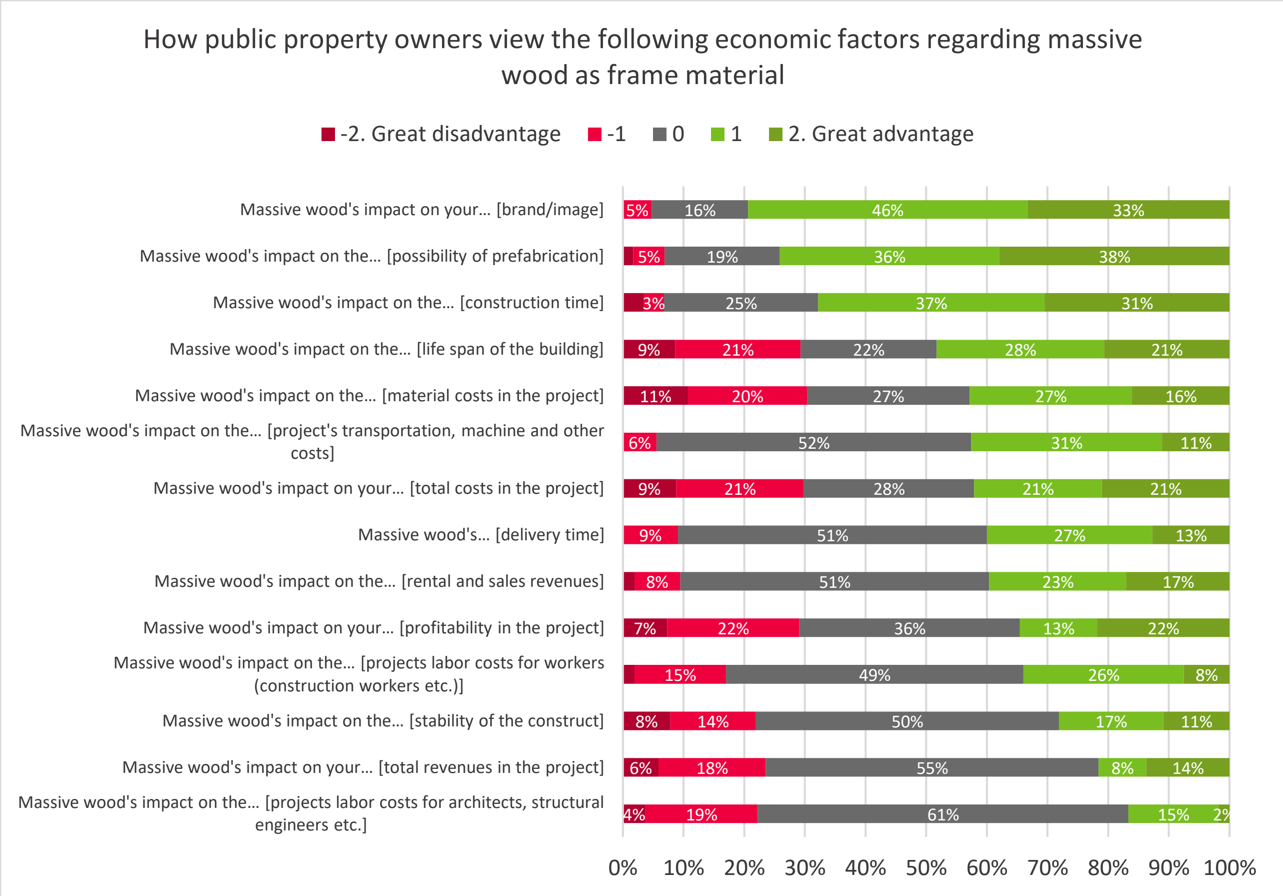

Figure 59: How public property owners view these economic factors.

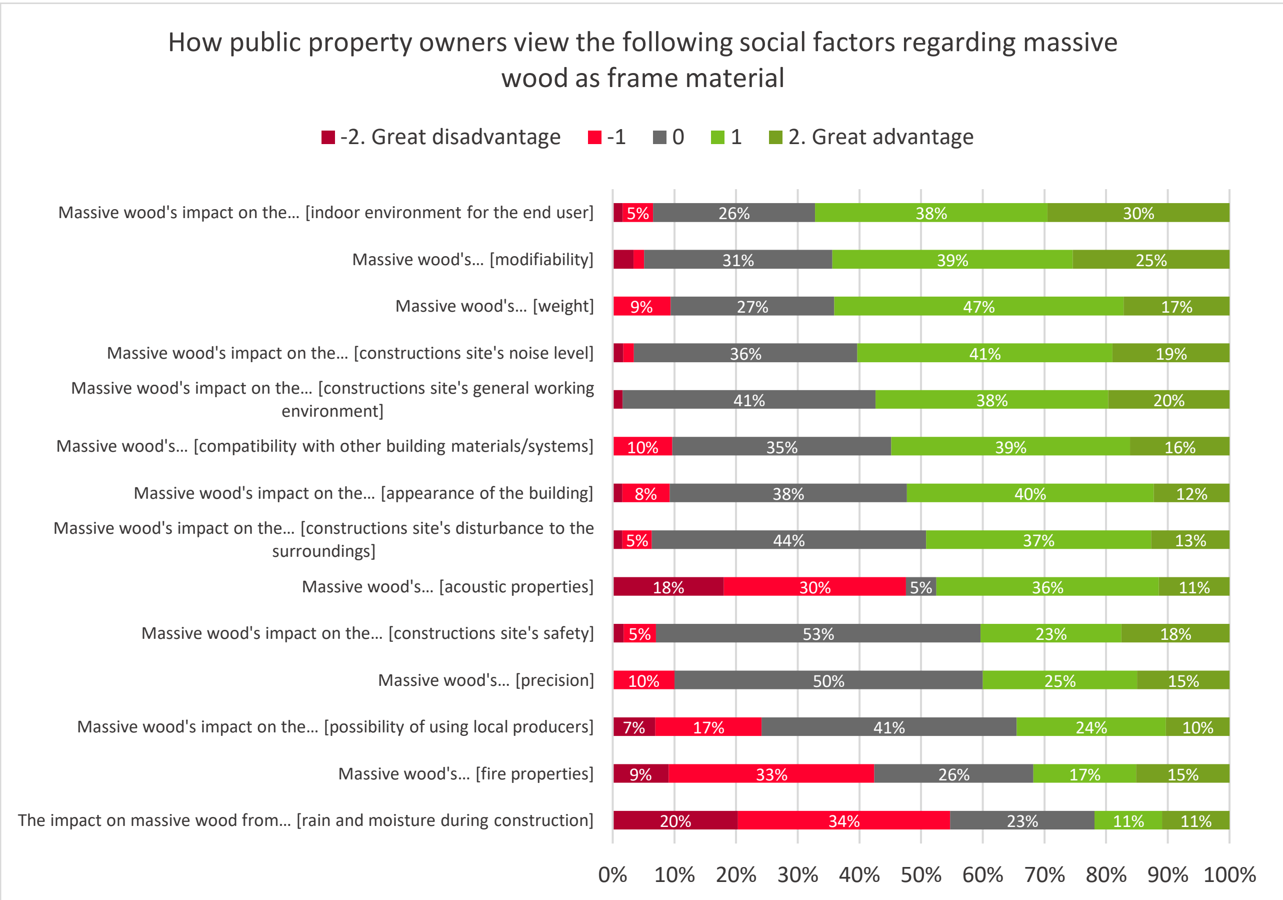

Figure 60: How public property owners view these social factors.

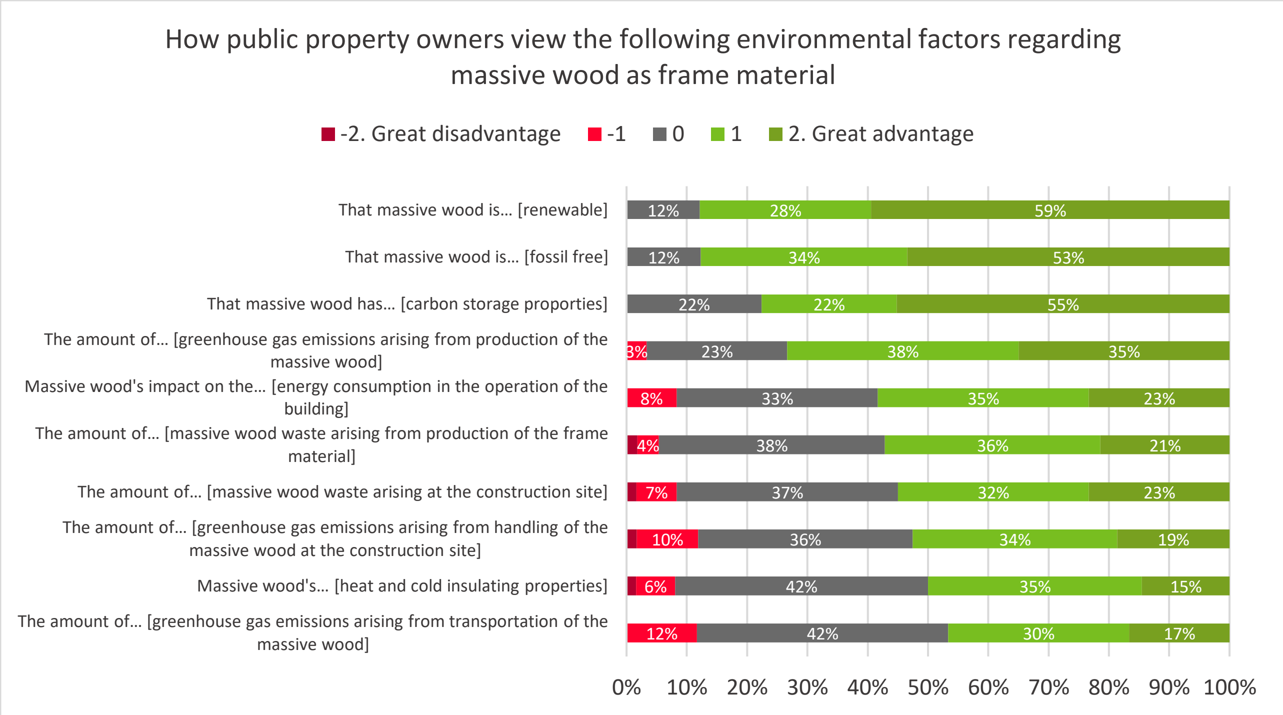

Figure 61: How public property owners view these environmental factors.

As can be seen in the figures, many public property owners see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable* and *fossil free* are by many seen as great advantages. Furthermore, *fire properties* and the impact on massive wood from *rain and moisture during construction* are by public property owners seen as the main disadvantages with massive wood as frame material. Regarding the impact on massive wood from *rain and moisture*, especially the public property owners with no experience of using massive wood as frame material see the factor as a disadvantage with massive wood as frame material. Regarding massive wood's *acoustic properties*, it seems that approximately half of the respondents see it as an advantage and the other half sees it as a disadvantage.

4.3.4 What Enables and Prevents Sustainable Value Creation for Architects

The results from the survey investigating if architects see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 62, 63 and 64 below.

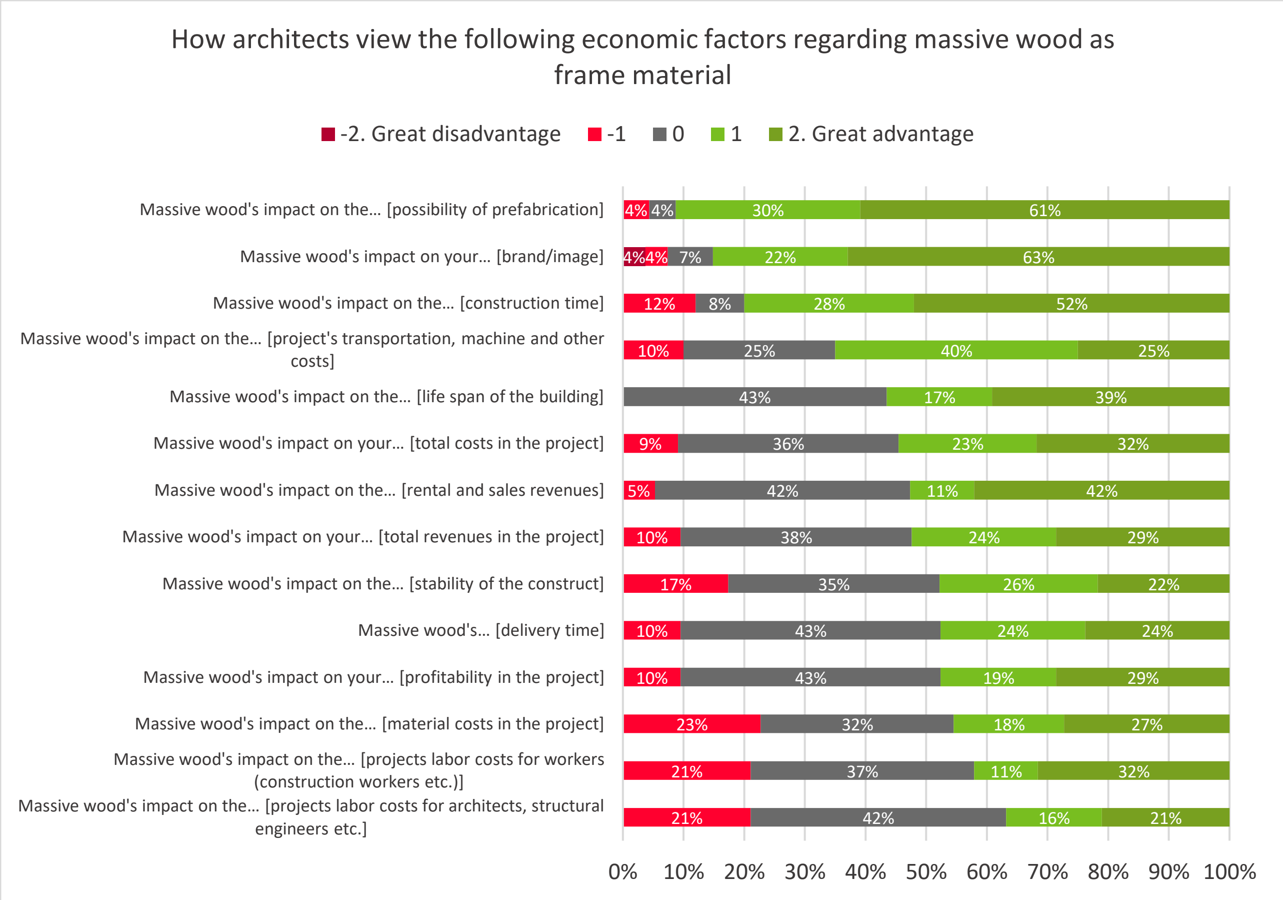

Figure 62: How architects view these economic factors.

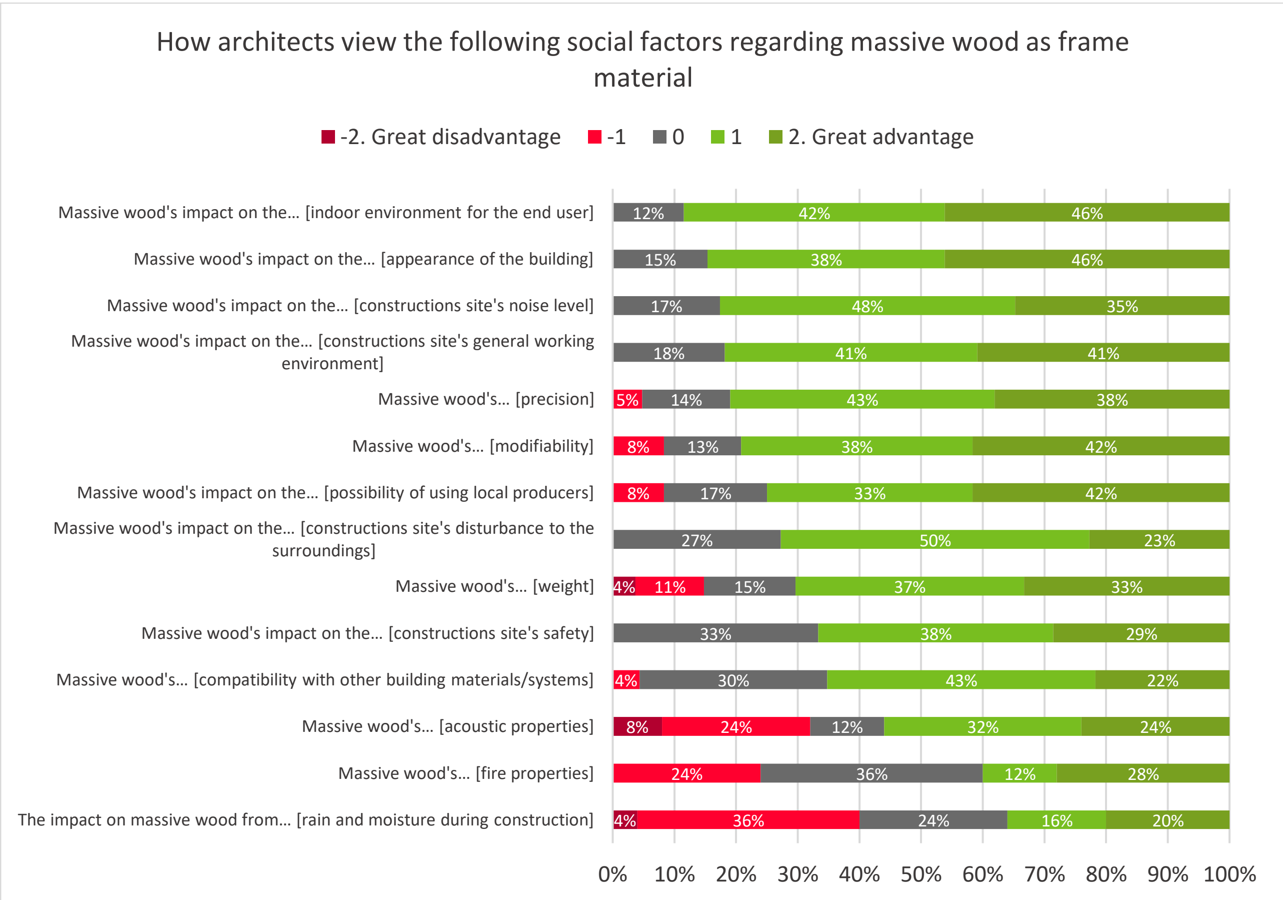

Figure 63: How architects view these social factors.

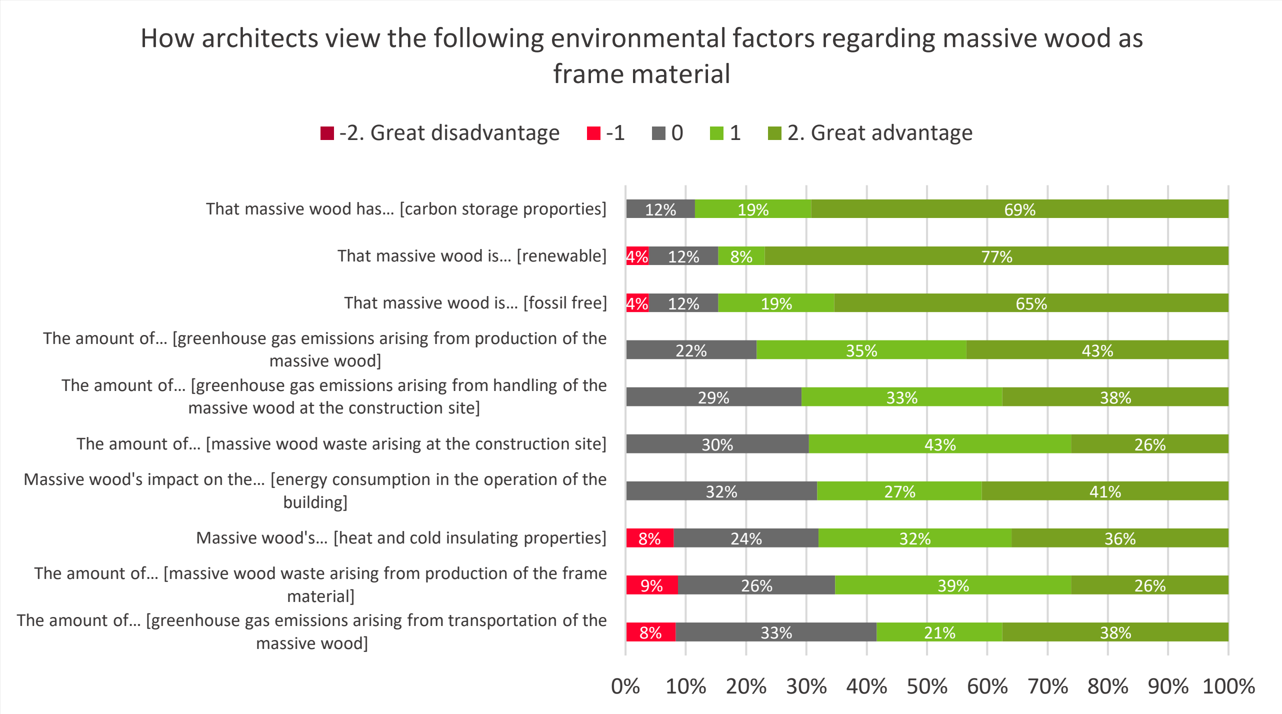

Figure 64: How architects view these environmental factors.

As can be seen in the figures, many architects see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many seen as great advantages. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication*, *construction time* and massive wood's impact on your *brand/image* as advantages with massive wood as frame material. Moreover, architects also see advantages with many social factors as massive wood's impact on the *indoor environment for the end users*, *appearance of the building*, *construction site's noise level* and *construction site's general working environment* and massive wood's precision and modifiability. Furthermore, massive wood's *acoustic properties*, *fire properties* and the impact on massive wood from *rain and moisture during construction* are by architects seen as the main disadvantages with massive wood as frame material. Regarding the impact on massive wood from *rain and moisture*, especially the property owners with no experience of using massive wood as frame material see the factor as a disadvantage.

4.3.5 What Enables and Prevents Sustainable Value Creation for Structural Engineers

The results from the survey investigating if structural engineers see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 65, 66 and 67 below.

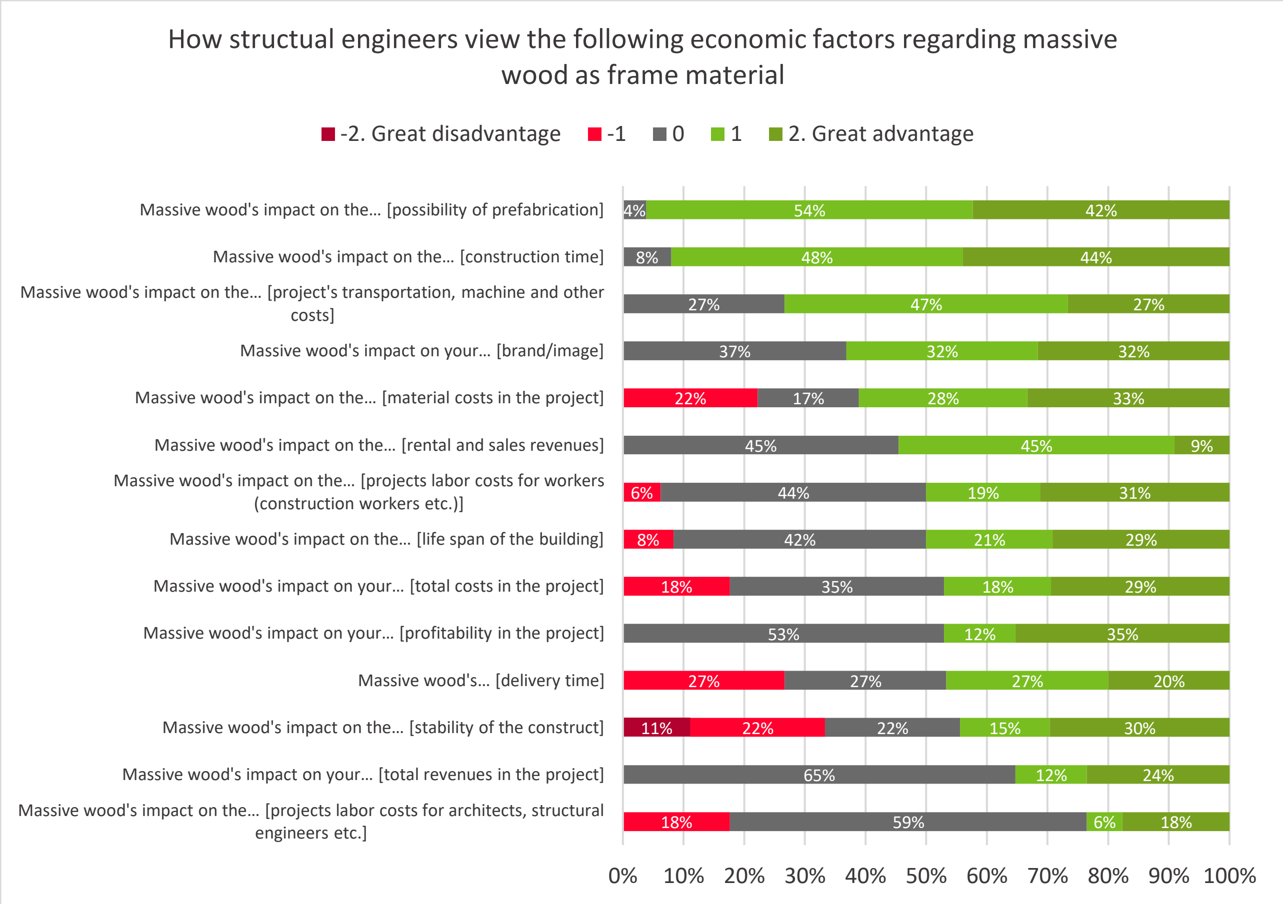

Figure 65: How structural engineers view these economic factors.

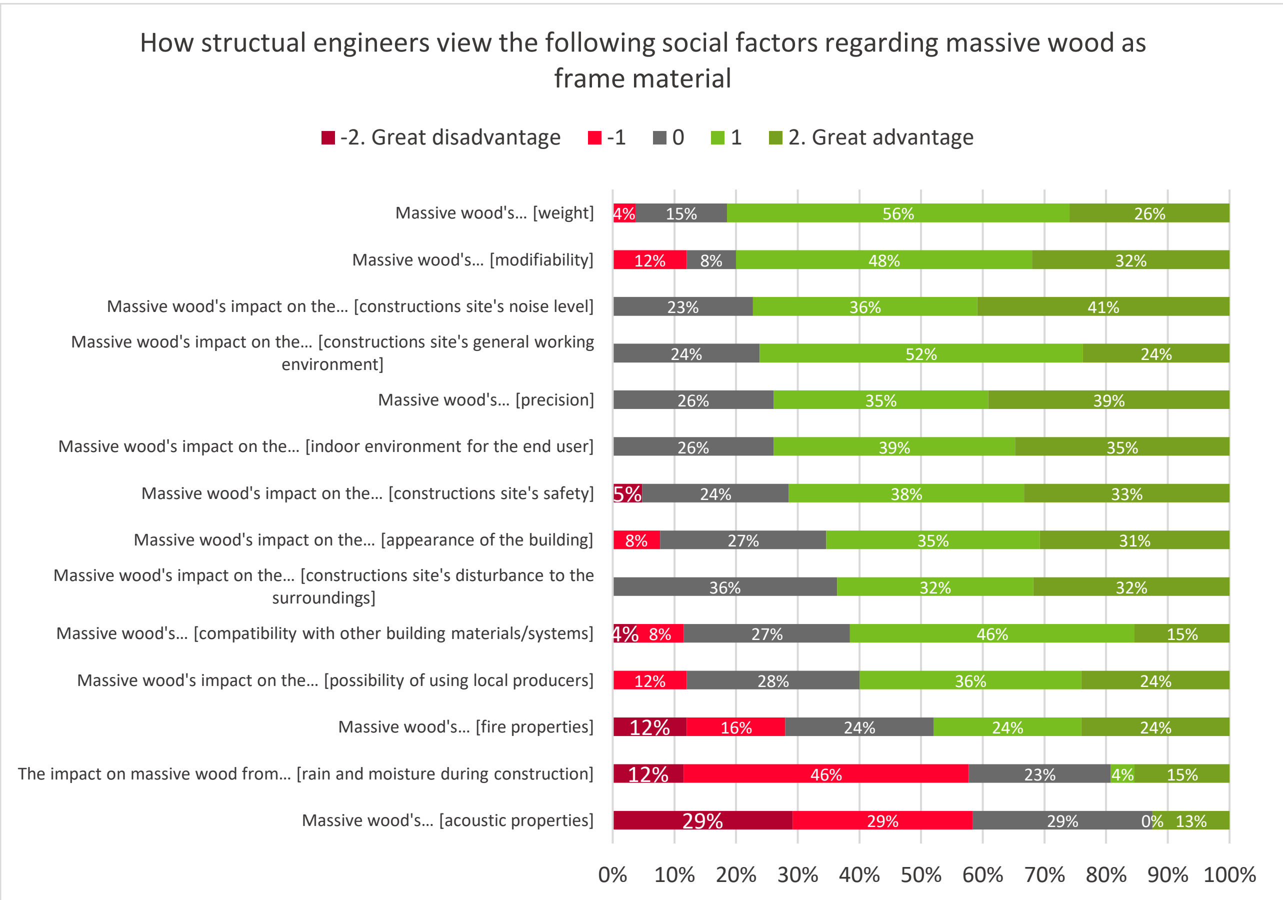

Figure 66: How structural engineers view these social factors.

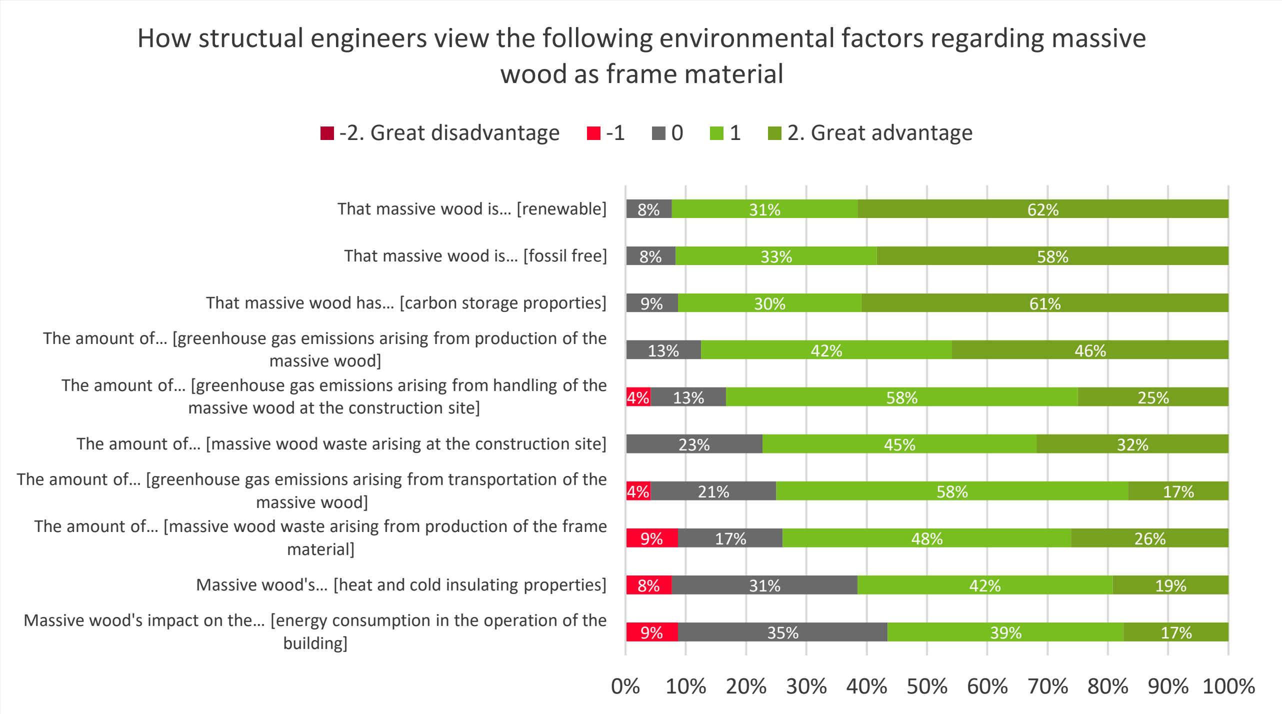

Figure 67: How structural engineers view these environmental factors.

As can be seen in the figures, many structural engineers see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many seen as great advantages. Also, the amount of *greenhouse gas emissions arising from production of the massive wood and from handling of the massive wood at the construction site* are by many structural engineers seen as advantages. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication* and *construction time* as advantages with massive wood as frame material. Moreover, massive wood's *weight* and *modifiability* are by many structural engineers seen as advantages with massive wood as frame material. Furthermore, massive wood's *acoustic properties*, massive wood's impact on the *stability of the construct* and the impact on massive wood from *rain and moisture during construction* are by structural engineers seen as the main disadvantages with massive wood as frame material.

4.3.6 What Enables and Prevents Sustainable Value Creation for Construction Contractors

The results from the survey investigating if construction contractors see different economic, social and environmental factors as advantages or disadvantages for them to prefer massive wood as frame material are presented in figure 68, 69 and 70 below.

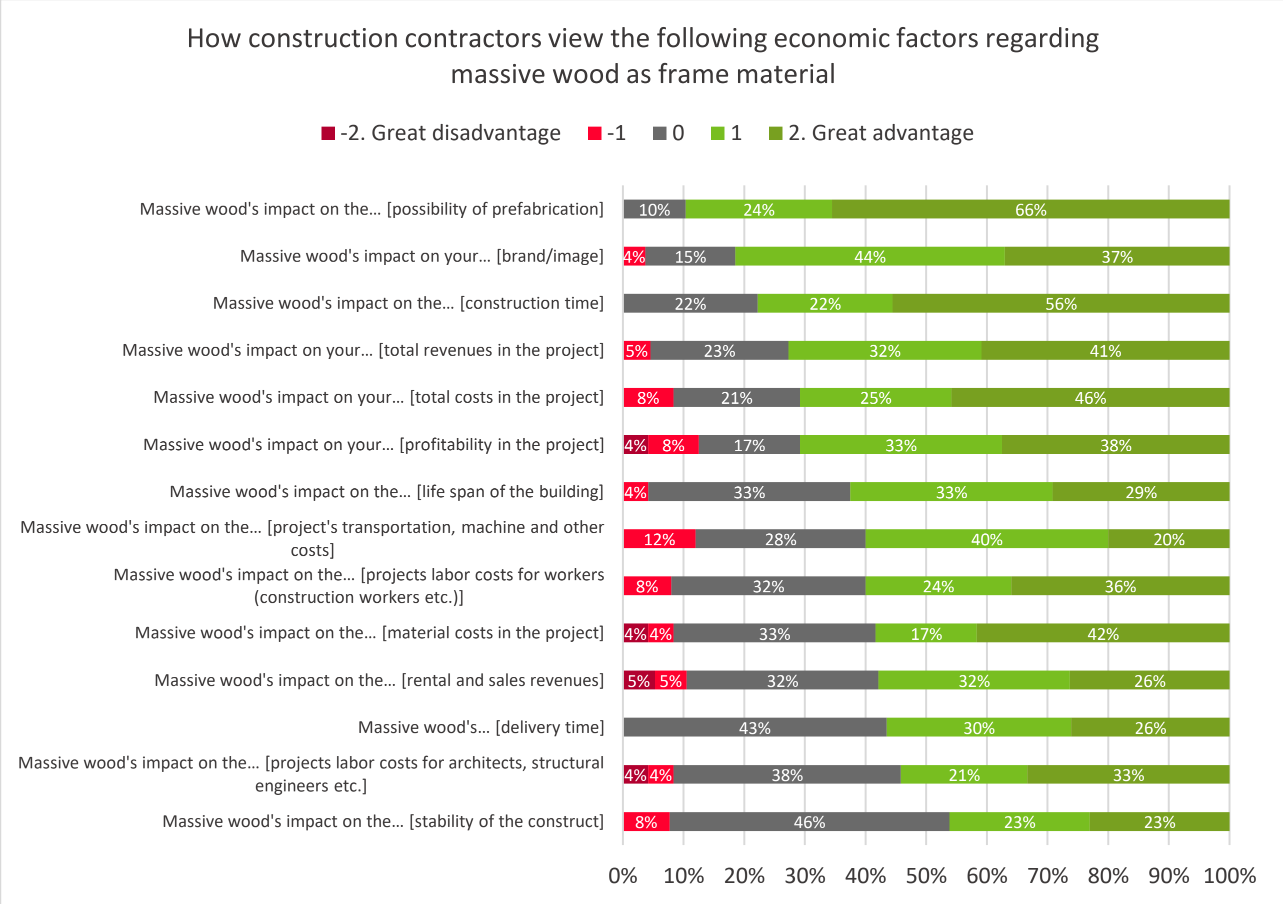

Figure 68: How construction contractors view these economic factors.

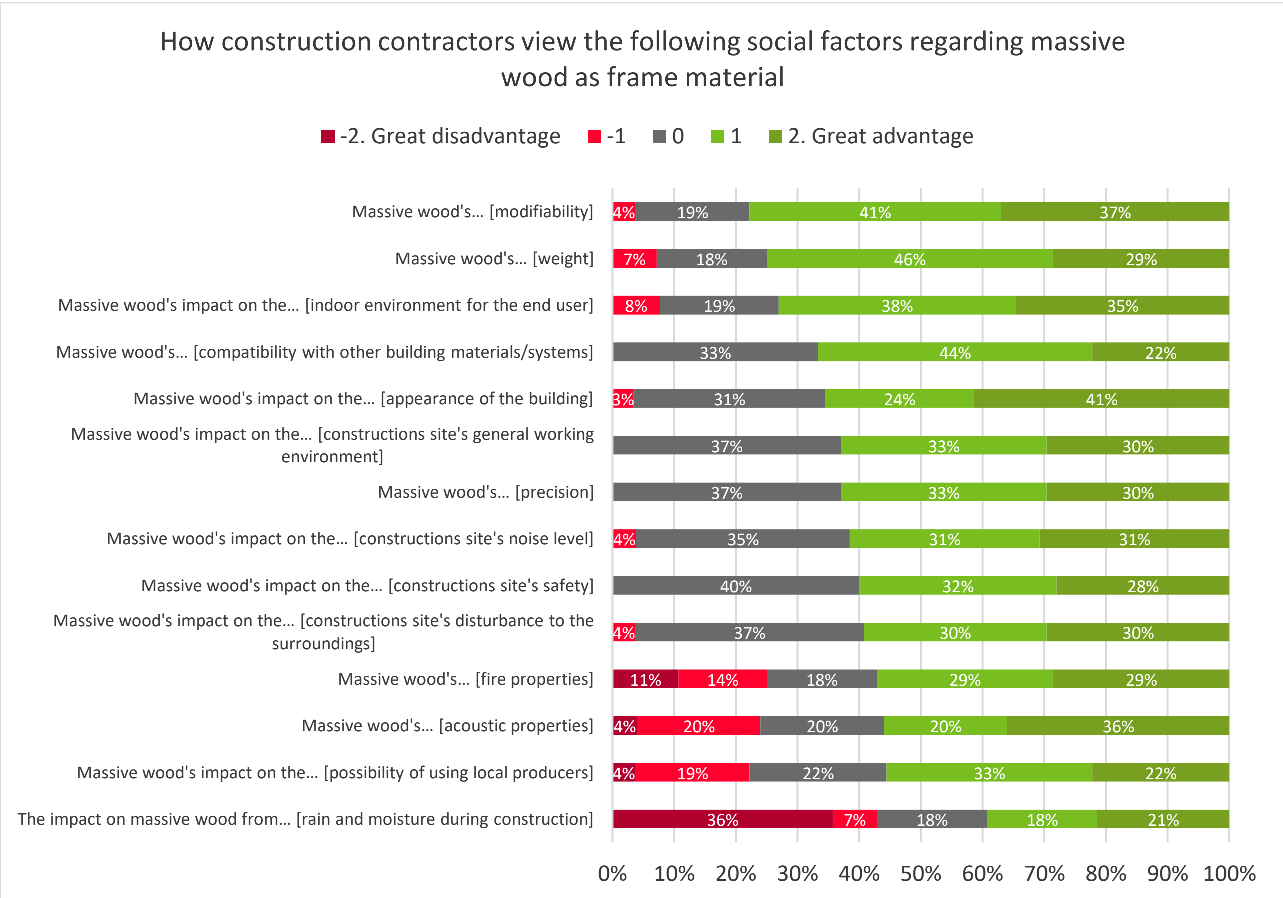

Figure 69: How construction contractors view these social factors.

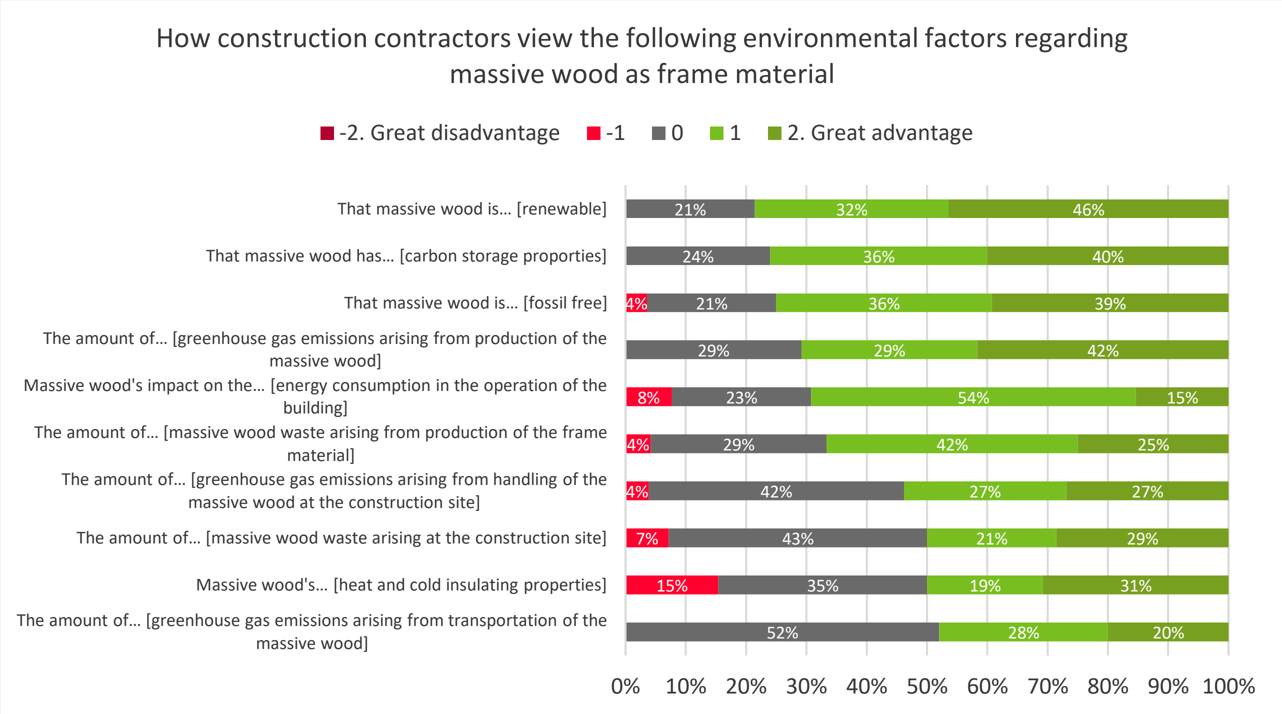

Figure 70: How construction contractors view these environmental factors.

As can be seen in the figures, many construction contractors see environmental factors regarding massive wood as frame material as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many seen as great advantages. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication* and *massive wood's impact on your brand/image* as advantages with massive wood as frame material. Moreover, massive wood's *modifiability* is seen as an advantage with massive wood as frame material for many construction contractors. Furthermore, massive wood's impact on massive wood from *rain and moisture during construction* is by structural engineers seen as the main disadvantage with massive wood as frame material, especially for construction contractors with no earlier experience of working with massive wood as frame material.

4.3.7 Summary of how Different Actors view Economic, Social and Environmental Factors Regarding Massive Wood as Frame Material

In this section, the results of how the different actors view economic, social and environmental factors regarding massive wood as frame material is summarized.

The respondents generally view environmental factors regarding massive wood as advantages, where that massive wood is *renewable*, *fossil free* and has *carbon storage properties* are by many respondents seen as great advantages. Many actors in the value chain also see economic factors as massive wood's impact on the *possibility of prefabrication* and *construction time* and massive wood's impact on your *brand/image* as advantages with massive wood as frame material. Furthermore, massive wood's *acoustic properties*, *fire properties* and the impact on massive wood from *rain and moisture during construction* are by actors in the construction chain seen as the main disadvantages with massive wood as frame material where property owners and structural engineers are the most negative. Economic factors such as massive wood's impact of the life span of the building, material costs in the project, total costs in the project and profitability in the project are seen as disadvantages for many property owners while many structural engineers instead see massive wood's impact on the stability of the construct as a disadvantage.

4.3.8 Why the Potential Sustainable Value Creating Factors are Viewed as Advantages or Disadvantages

In this section, the results from the complementary interviews with eleven different actors in the construction value chain, including two architects, two construction contractors, two structural engineers, two private property owners, two public property owners and one project developer, are synthesized. This, with the purpose to get a contextual understanding of the results of the survey. Thus, this synthesis gives possible explanations of why actors generally view different factors as advantages and disadvantages regarding massive wood as frame material. Since the purpose of these interviews are to get a contextual understanding of the results and not to compare differences between groups, our interpreted general view for all actors in the value chain based the interviews with all the different groups of actors, is presented. This further implies that the view of each actor and how the views between the different groups of actors differ are not presented. The factors discussed in the interviews are the factors which, in the survey, are identified as the most important factors, or the greatest advantages or disadvantages with massive wood, for the interviewed actor. The factors presented here, are these factors and factors which the interviewees, during the interviews, presented as important for them to prefer massive wood as frame material or factors which they view as great advantages or disadvantages regarding massive wood. A presentation of the interviewees and their organizations is given in *Appendix 4*.

4.3.8.1 *Massive Wood´s impact on the Stability of the Construct*

Some of the interviewees see the impact of massive wood on the stability of the construction as a disadvantage. It is primarily the low density of the frame material that is seen as a disadvantage when it comes to high buildings, high buildings are explained to require a high weight to be stable. For example, it is argued that CLT is a good choice for buildings up to around 8-10 floors but after that it could be viewed as a disadvantage. The larger volume of the frame elements, which in some cases is required for wood elements compared to other frame materials in order to result in a stable construct, is explained to be a disadvantage. Further, a wish for guidelines, of how to manage the lower density and stability, from material suppliers have been expressed in the interviews. A proposed potential solution of how to manage the challenge of lower density and stability is to use combinations of steel, wood and concrete, thus, hybrid solutions. According to some of the interviewees, hybrid solutions are argued to be good solutions not only to manage the challenge with lower density and stability but also to manage longer spans, meet acoustic and fire safety requirements, meet height limitations of the building and in order to visualize wood. It is argued that wood, concrete and steel all have their advantages and disadvantages and if all of these materials are used in a project, one can benefit from all of their different properties.

4.3.8.2 *Massive Wood´s impact on different Costs in a Construction Project*

Massive wood’s impact on the project’s transportation, machine and other costs is argued to be an advantage. This, because of the lower density of massive wood compared to other frame materials which results in the possibility to decrease the number of transports (you can transport a larger volume of wood on each truck) and the possibility to use smaller and less expensive machines with wood compared to other frame materials.

Massive wood’s impact on the material costs in the project are by some interviewees seen as an advantage and by others seen as a disadvantage. Some interviewees explain that a wood-frame construction costs a little bit more than a frame of concrete or steel. Others explain that a frame in massive wood is not more expensive, however, they argue that complementary work, for example installation of plasterboards, requires a lot of resources and that a larger volume of the frame material is required in a wood-frame construction compared to a construct in concrete or steel, and therefore the total cost will be higher.

Some interviewees also argue that the uncertainty of using a new material, which massive wood can be for some actors, and the risk associated with it, can result in a higher cost in the project. For example, it is explained that the construction contractors, which is usually invoiced for the material, might add the risk of using a new material to their financial calculation and therefore, massive wood as frame material can be viewed as a costly choice. Furthermore, both the design and construction phase are argued to be costly if the structural engineers and the workers on the construction site do not have sufficient knowledge and experience of working with massive wood. For example, it is explained that if structural engineers are worried about making errors in dimensioning, they will control the calculations more which will require more working hours. Moreover, if the workers on the construction site have to learn new methods for construction, it is also explained to require more working hours.

However, if the actors in a construction project have knowledge and experience of using massive wood as frame material, the potential higher material costs of massive wood compared to other frame materials is argued, by an actor with experience of using massive wood, to be compensated with a higher productivity. The interviewee argues that many actors think that using massive wood is not financially defensible but that this is not true if the higher productivity is included in the calculations. For example, the experienced actor argues that the construction time is shorter with massive wood as frame material, with the proposed approximation that it takes half the time to assemble a wood frame compared to a frame in concrete. This is further argued to result in earlier generated rental and sales revenues. Furthermore, the experienced actor argues that a wood frame requires fewer, around half of the, working hours compared to when concrete is used because it requires fewer number of workers on the construction site.

4.3.8.3 *Massive Wood´s Precision*

Massive wood’s precision compared to other frame materials are by many interviewees seen as an advantage. It is explained that wood has a very good precision, while concrete according to some of the interviewees, has less dimensional accuracy. However, other interviewees argue that their experience is that both prefabricated concrete and wood in general have high accuracy.

4.3.8.4 *Massive Wood´s impact on the Possibility of Prefabrication*

Massive wood’s impact of the possibility of prefabrication is generally seen as an advantage. It is explained that other frame materials can also be prefabricated but it has more disadvantages, for example, a proposed problem with prefabricated concrete is by some interviewees argued to be its limited precision. A high level of prefabricating is explained as an advantage because it moves resources from the construction site to the factory which, for example, results in easier coordination, shorter construction time, increased quality control, less disturbance on the surroundings and higher safety on the construction site. However, a high level of prefabrication is argued to be challenging for some projects. It is for example argued that the use of a prefabricated wood-frame is, according to one interviewees experience, challenging for round buildings. Limitations of the maximum volume possible for each element due to the transportation used and other limitation for the elements due to the cranes used are also examples of factors affecting the preferred level of prefabrication.

Even though the possibility of prefabrication is seen as an advantage regarding massive wood, some of the interviewees argue that massive wood is still behind the competition from other materials. They demand increased prefabrication level and a more active product development in order to increase productivity and decrease the activities performed on the construction site, thus, increase the safety. Furthermore, several of the interviewees express a need for a supplier that offers complete solutions; solutions including the design, manufacturing and assembly of the elements. A complete solution is explained to be easier to coordinate on the construction site.

4.3.8.5 *Massive Wood´s impact on the Construction Time*

The impact of massive wood on the construction time is by most of the interviewed actors seen as an advantage. From many of the interviewees’ experiences, the construction time when using massive wood as frame material is shorter compared to construction with concrete as frame material, at least for the construction time of the frame. Thus, massive wood is argued to result in a higher productivity. For example, an actor with experience of massive wood projects argues that the construction time is shorter with massive wood as frame material, with the proposed approximation that it takes half the time to assemble a wood frame compared to a frame in concrete. Furthermore, subcontractors are explained to be able to work faster with massive wood as frame material, this because complementary work such as electrical installations can quickly be installed. A short construction time implies short time until the workers on the construction site can work on another project and short time until the spaces of the building can generate rental incomes, which are two presented reasons why this is an important advantage.

However, some of the interviewees claim that if all complementary work, for example installation of plasterboards, are included in the construction time, the total construction time is more comparable with other materials. The construction time is argued to be longer if the workers on the construction site do not have sufficient knowledge and experience of working with massive wood. Thus, if the workers on the construction site have to learn new methods for construction it will require more working hours.

4.3.8.6 *Massive Wood´s Acoustic Properties*

The acoustic properties of massive wood are by some interviewees seen as an advantage. A wood house is by some interviewees argued to have a special acoustic ambiance, a soft acoustic ambiance which is appreciated by many people and thus contribute to a good indoor environment for the end-user.

The acoustic properties of massive wood as frame material are also by many interviewees mentioned as a disadvantage and one of the main challenges when using massive wood as frame material. To find the right solutions to meet the acoustics performance requirements are explained to take time both in the design phase and in the construction phase of a project. The low frequencies, mainly from step sounds, are presented as challenging while the high frequencies are not an issue. Solutions, or as one interviewee express it "maybe-solutions", to this challenge are presented in the interviews. For example, the use of thicker beams which is argued to be a common solution today or using hybrid materials where beams of massive wood are combined with a layer of concrete and/or other sound absorbing materials. It is explained that even if there are solutions to meet the acoustics requirements, these solutions are by some seen as costly. Furthermore, the building's height increases with thicker beams and if there are limitations for the building's height, to use thicker beams is not a possible solution in order to meet the acoustic properties.

It is by some interviewees argued that actors with experience of using massive wood as frame material see massive wood's acoustic properties as a challenge, but a manageable challenge and that the acoustics properties of massive wood are mostly seen as a critical disadvantage for those with less experience working with massive wood. Moreover, if to meet the acoustic requirements are a challenge or not is also argued to vary between projects and what the building will be used to. For example, the developer can have an opinion of the acoustics performance of the building. The acoustics requirements also differ based on the type of building, for example, the acoustics requirements differ between residential buildings and public buildings. Furthermore, what the building will be used for is explained to impact the wanted acoustics performance, for example, if the building will have a library, the acoustics performance is of great importance.

Many interviewees have expressed a wish for more guidance from the material suppliers of how to manage the challenges with massive wood's acoustics properties. A need for proven standard solutions how to manage acoustics are also expressed. Also, a wish that material suppliers will start to provide hybrid material solutions which can solve the challenge with acoustics is expressed.

4.3.8.7 *Massive Wood´s Fire Properties*

Generally, for the interviewees, the fire properties of massive wood are both seen as an advantage and a disadvantage. To meet the requirements for fire safety are by many explained as a manageable issue with massive wood if the building is designed properly. The requirements for fire safety are often managed through covering the surfaces with plasterboards, fire-resistant paint or sprinklers. Massive wood is also argued to have good fire characteristics; the fire is argued to be more predictable with massive wood compared to some other frame materials. Some interviewees claim that visually exposed wood can result in a challenge when it comes to fire safety but that this issue is manageable, for example through the use of fire-resistant paint. However, one actor expresses it to be challenging to find environmentally classified fire-resistant paint. The requirements for fire safety are also explained to differ between residential and public buildings, where the requirements for residential buildings are stricter. Furthermore, one interviewee claims that there is a lack of knowledge of how the glue in the massive wood products react to fire, which according to the interviewee results in uncertainty for the actors when it comes to fire safety.

A proposed reason that some interviewees see massive wood's fire properties as a disadvantage is the lack of knowledge. It is argued that in general, there is an uncertainty when it comes to fire safety and massive wood as frame material, especially for the end users who are mostly no technical experts. It is also argued that it can be difficult to get insurance companies to insure a building with massive wood as frame material because of their presumptions of limitations in fire safety with massive wood. A need for standard solutions for how to manage the fire safety requirements and a need to get the knowledge about the fire characteristics of massive wood spread, not only to the actors in the construction value chain but for the end users, insurance companies and society at large too, are expressed.

4.3.8.8 *Massive Wood´s Weight*

The weight of massive wood is both seen as an advantage and a disadvantage by the interviewees. It is argued that the weight is mostly seen as a disadvantage when it comes to the impact of massive wood on the stability of the construction and the way low-frequency sound is transferred in the structures, which is further explained above. The low density of massive wood compared to steel and concrete is also argued to be viewed as an advantage, for example, massive wood is explained as a suitable frame material for projects of addition of storeys or when the ground's carrying capacity is limited. Massive wood's weight is also seen as an advantage because it results in that smaller and less expensive cranes, compared to when other frame materials are used, are required. Furthermore, it is argued that fewer transports are needed which is seen as an advantage because it reduces the transportation costs, the greenhouse gas emissions and the disturbance on the surroundings.

4.3.8.9 *Massive Wood´s Modifiability*

It is by some interviewees argued that the modifiability of massive wood can be viewed as an advantage due to the simplicity of processing wood compared to for example concrete; it is easy to make adjustments and installations on the construction site if necessary. For example, installation of electricity and modifications of cut-outs for windows and doors can be performed on the working site. Furthermore, the adjustments can usually be performed fast and relatively quiet. A possible reason that some see the modifiability of massive wood as a disadvantage is argued to be because massive wood as frame material limits the possible forms of the building if it is compared to concrete. Furthermore, one interviewee claim that massive wood elements usually come in widths of approximately 3 meters which can be viewed as a disadvantage because it restricts the possible floor height. This is for example argued to be a possible issue for ground floors on public buildings. Moreover, it is argued that massive wood as frame material can limit the possibility to rebuild a building and move walls.

4.3.8.10 *Massive Wood´s Heat and Cold Insulating Properties*

Massive wood's heat and cold insulating properties are generally seen as an advantage. However, it is argued that it also could be viewed as a disadvantage, it depends on what it is compared to. If massive wood's heat and cold insulating properties are compared to isolation materials' heat and cold insulating properties, it would be viewed as a disadvantage. For example, one interviewee claim that wood has approximately ¼ of mineral wool's insulating properties. However, compared to other frame materials, as concrete or steal, the heat and cold insulating properties of massive wood are generally seen as an advantage. The reason that some see massive wood's heat and cold insulating properties as a disadvantage is also explained, by the interviewees, to be because of a lack of knowledge of massive wood's heat and cold insulating properties. The project *Strandparken* is presented as an example where it has been shown that massive wood has beneficial heat and cold insulating properties.

4.3.8.11 *The impact on Massive Wood from Rain and Moisture during Construction*

Some argue that rain's and moisture's impact on massive wood in construction is the main challenge when using massive wood as frame material. This, because rain and moisture are argued to have an impact on massive wood and could damage the construct which results in that costly solutions, either preventing damage or fixing the damage afterwards or both, are needed.

There are presented solutions for this challenge, solutions to prevent the damage, as for example using tents and fans, but these solutions are often argued to be costly. Tents are further argued to only be a reasonable solution for rectangular buildings, and not for round or square buildings, because of the required size of the tents. It is by one interviewee explained that some actors have managed the rain and moisture challenge with the use of embedded sensors inside the wood elements so that the moisture levels can be monitored, both during the assembly and operation phase. Furthermore, "vacuum cleaners" for water, to quickly cover the construct with a roof, protecting wall elements during construction, temporary pipe systems to remove water, to keep the wood elements in plastic as long as possible and covers in rubber are presented experimental solutions which have been used instead of tents in order to prevent damage.

Some interviewees claim that rain's and moisture's impact on massive wood in construction do not have to be viewed as a disadvantage when it comes to massive wood as frame material and that weather protection on the construction site is not necessary as long as the material is not built in before it is given sufficient time to dry out. Some even see the use of a massive wood frame as an advantage when it comes to the impact from rain and moisture because of the fast assembly of a massive wood frame. Thus, the time until the building is climate-proof is short.

A proposed explanation, presented by the interviewees, why some still see this factor as one of the main disadvantages with massive wood as frame material is argued to be the lack of knowledge and early construction errors where the wood-frame was built in before it was sufficiently dry. More knowledge and information of how to manage the challenge with rain and moisture in construction, spreading of this knowledge and information, guidance from the material suppliers, proven standard solutions and a tool calculating the required drying time are presented as possible and useful solutions for the challenge many actors see with rain's and moisture's impact on massive wood in construction. Proven standard solutions for, for example, how to cover joints is requested by multiple of the interviewees. Moreover, that the information is available not just in English, but also in Swedish, is argued to be important to decrease the language barriers making the information available for more people.

4.3.8.12 *Massive Wood´s impact on the Construction Site's Working Environment*

Massive wood's impact on the construction site's working environment is generally seen as an advantage. That it is easy to handle, has low weight and results in a relatively safe, dry, warm, quiet and nice working environment are presented as possible reasons for this. Especially, some interviewed construction contractors argue that massive wood's impact on the construction site's working environment is a great advantage compared to other frame materials. Wood dust is argued to be a disadvantage with massive wood, but compared to the alternative frame materials, massive wood is presented as a good choice. Some argue that massive wood's impact on the construction site's safety is an advantage, for example, because of higher level of prefabrication. Other argue that the construction site's safety is the same regardless of the material used.

4.3.8.13 *Massive Wood´s impact on the Energy Consumption in the Operation of the Building*

The impact of massive wood on the energy consumption in the operation of the building is generally seen as an advantage by the interviewed actors. It is argued that the use of a wood frame compared to the alternatives can lower the energy consumption and that this has been shown in finished construction projects with massive wood as the frame material. One proposed explanation for a lower energy consumption in buildings with massive wood as the frame material, presented by multiple interviewees, is that wood absorbs and emits moisture. One interviewer also proposes the explanation that massive wood decreases the effect of thermal bridges and contributes to a more efficient isolation. A public property owner, which have been interviewed, sees this factor as an important advantage in order to reach the environmental certification called *Miljöbyggnad*[3].

4.3.8.14 *The Amount of Massive Wood Waste*

Regarding the frame material waste arising at the construction site, massive wood is by the interviewees generally seen as an advantage. The precision and flexibility in production is seen as one explanation to this. Generally, frame material waste is mentioned in the interviews as an important aspect to consider and an interest in what happens with the frame material waste generated in a construction project is shown. The interest focuses on possible new or already practiced solutions in order to reduce the waste or reuse the waste. A proposed reason for the interest in waste is that no one is interested in paying for something which is not used. Many interviewees claim that, with waste, one think about the waste that is generated from the cutting in the elements to make space for windows and doors. It is argued that the architects and structural engineers have a responsibility when it comes to minimize the waste but that a material supplier could be a part of the solution by increasing the precision and the flexibility in the dimensions of the massive wood elements and find solutions to use the generated waste.

4.3.8.15 *Massive Wood´s impact on the Life Span of the Building*

The opinions of massive wood's impact on the life span of a building vary. Some propose that the technical life span of a building with massive wood as the frame material is shorter compared to concrete and steel as the frame material. It is also explained that if a wood-frame is built-in and properly built, there are no

[3] *Miljöbyggnad* is a Swedish environmental certification assigned by Sweden Green Building Council. The certification is divided in three different levels (Bronze, Silver and Gold) and is based on sixteen different indicators (Sweden Green Building Council, 2019).

disadvantages with massive wood as frame material when it comes to the life span of the building. If the wood-frame is visible, it is however argued that it is important that it is properly maintained for it to not impact the life span of the building.

4.3.8.16 *Massive Wood´s impact on the Appearance of the Building*

Massive wood's impact on the appearance of the building is generally seen as an advantage by the interviewees. For example, some of the interviewees explain how they like the appearance of visually exposed wood; massive wood is explained to be beautiful and its natural appearance and how it is a living material are argued to contribute to a living appearance of the building. However, that massive wood is a living material is also argued to be a possible disadvantage for the appearance of the building. This because wood can become yellow with age and also crack due to movements and tensions in the material.

It is explained that when using massive wood as frame material, usually you also want to visualize this either exterior or interior. An architect explained that it is important for them to visualize how the building is constructed and designed. For example, for schools, to visualize wood is explained to have an educational purpose showing the children and parents how the building is constructed and how to build for sustainability. Furthermore, a property owner explained that it is important for them to visualize the wood in order to visualize the building's environmental benefits. Moreover, to visualize wood is explained by the property owner to have a positive impact on their brand/image. To visualize wood is by some argued to be challenging regarding fire safety, acoustic properties and the impact from rain and moisture during construction. This, since some of the solutions regarding these challenges implies that the surface of the massive wood element is covered by other materials. However, regarding the challenge with fire safety and visually exposed wood, it is by some interviewees argued to be easy solved with transparent fire protection paint. What to do with, for example, electricity installations are also argued to be a challenge when the wood is visually exposed.

If massive wood is used as frame material, it is by one interviewee argued to be easier to create a special architectural design compared to concrete elements which are usually quite strict. This special architectural design is viewed as an advantage with massive wood because it is can result in an attractive appearance of the building. At the same time, to build a round house in massive wood is explained to be difficult. A private property owner which has built a round building in massive wood claimed that only one of the material suppliers they contacted could offer a solution with *CLT*.

4.3.8.17 *Massive Wood´s impact on the Indoor Environment for the End User*

Massive wood's impact on the indoor environment for the end user is generally seen as an advantage by the interviewees. It is argued that a building with massive wood as frame material creates a healthy indoor environment for the end user, both psychologically and physically. For example, the indoor environment is argued to be healthy physically because of healthier indoor air with massive wood. It is also argued that the indoor environment in a building with massive wood as frame material is considered healthy psychologically because it results in an indoor environment which give the end user an enjoyable feeling. It is argued that some end users are interested in living or working in a wood building because it provides a special and enjoyable feeling. To build with natural materials like massive wood is furthermore claimed to be a good choice for schools because the indoor environment is argued to be extra important for young children when their immune system is under development.

4.3.8.18 *Massive Wood´s impact on Brand/Image*

Massive wood's impact on brand/image is generally seen as an advantage. The use of massive wood as frame material is claimed to be trendy. An organization which for example use massive wood in their building project or rent their workspaces in a building with massive wood as frame material can argue that they are up-to-date, that they are progressive and act on the basis of their environmental policy. It is explained that it shows credibility; the organization does not just say that they are trying to be sustainable, they can show that they actually act upon it. It is argued that to visualize the wood is important in order to obtain the advantages with massive wood's impact on brand/image.

4.3.8.19 *That Massive Wood is Renewable, Fossil Free and has Carbon Storage Properties*

That massive wood is renewable, fossil free and has carbon storage properties are generally seen as the main environmental advantages, and in many cases the main advantages generally, with massive wood as frame material. A private property owner explains that these environmental factors are the reason that they have chosen massive wood as frame material in their project. Furthermore, the private property owner values that massive wood is renewable and has carbon storage properties because of the climate issue, with massive wood they explain that they can contribute to a more sustainable future.

4.3.8.20 *Massive Wood´s impact on the Possibility of using Local Producers*

That the frame material is locally produced is both seen as an environmental advantage and a social advantage by the interviewees. It is seen as an environmental aspect because locally produced is explained to often imply shorter transports and therefore lower greenhouse gas emissions. However, it is argued that longer transports by train are often more environmentally friendly than short transports by trucks and therefore, the way of transporting the material is also explained to be an important aspect. Locally produced is also seen as a social advantage because it is explained to benefit the Swedish industry and the Swedish countryside, and some interviewees also see an advantage with material from Sweden because of the local expertise, the possible opportunity to be a part of a material supplier's product development or just because it feels better.

4.3.8.21 *The Amount of Greenhouse Gas Emissions arising from Transportation of the Massive Wood*

The amount of greenhouse gas emissions arising from transportation of the massive wood is by the interviewees seen as an important advantage compared to the transportation of other frame materials. That the amount of greenhouse gas emissions arising from transportation are argued to be less for massive wood than other frame materials is explained to be because of massive wood's relatively light weight resulting in the possibility of a larger volume of frame material on each truck compared to the possible volume when using concrete or steel. Thus, it is argued that fewer transports are needed when using massive wood as frame material compared to concrete and steel which mean less greenhouse gas emissions.

4.3.8.22 *Massive Wood´s Compatibility with Other Building Materials/Systems*

Massive wood's compatibility with other building materials/systems are both seen as an advantage and a disadvantage for the interviewed actors. It is argued that it could be viewed as a disadvantage because massive wood is a living material, it moves when it dries and when it is exposed to heat. Therefore, to combine massive wood with other materials and systems is argued to be a potential challenge. However, some of the interviewees argue that it is the same issue regardless of what materials that is combined. *CLT* is also explained to be relatively predictable even though it is organic because it is cross laminated. Some interviewees further argue that massive wood's compatibility with other building materials/systems can be viewed as an advantage because it does not react with other materials.

Furthermore, how massive wood's compatibility with other building materials/systems is viewed is claimed to be impacted by the offering of the material suppliers, if they for example offer complete solutions or not. A challenge of using massive wood as frame material is argued to be the need of multiple suppliers in a project because the material suppliers of massive wood do not provide offerings with complete solution (with screws, windowsills etcetera.). If the different material suppliers do not collaborate, the massive wood's combability with other building materials/systems is argued to be a disadvantage because it is a challenge to put together a complete solution with all the different materials and products needed in a project. If the material suppliers do not provide complete solutions, that they at least can refer to other suitable suppliers and their materials and products in order to puzzle together a complete solution is argued to be important.

4.3.8.23 *Generally*

Many of the interviewed actors emphasize the lack of knowledge in the construction chain, of how to use massive wood as frame material, of the material's advantages and disadvantages and of how to manage potential challenges, as a disadvantage with massive wood as frame material. It is explained that some actors in the value chain see the risk of using a new, not well established, material as a barrier for them to use massive wood as frame material in their projects. Proposed solutions in order to increase the knowledge of massive wood are through collaboration with universities and the use of reference projects. Through collaboration with universities, knowledge of massive wood and how to use it can be learned by for example architects, structural engineers and construction contractors already at university, which will in the long-term perspective increase the knowledge of massive wood in the construction value chain. Furthermore, reference projects are explained to spread the knowledge of for example how to manage potential challenges which can reduce the risk of using a less well-established material as massive wood is.

4.4 The Different Actors' Influence on the Choice of Frame Material

In this section, the results from the survey regarding the different actors' impact on the choice of frame material are presented. This result is used to analyze which actors in the construction value chain a material supplier should create and deliver sustainable value to, and hopefully confirm what was concluded in section *1.4 Theoretical Starting Point*, that all actors in the construction value chain influence the choice of frame material. See figure 71 below for this section's relation to the other sections in the empirics.

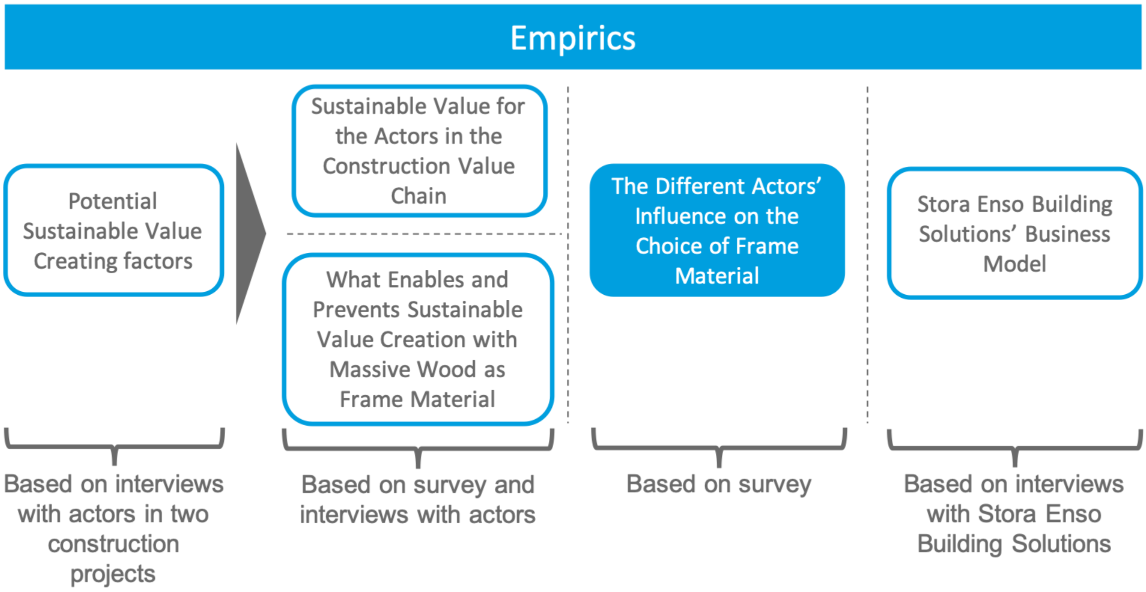

Figure 71: This sections relation to the other sections in the empirics.

Figure 72 below show the mean values of all the respondents' opinions of how much influence the different actors have on the choice of the frame material. The error bars represent a two-sided confidence interval (95 percent) for the sample mean. The scale of the charts reaches from 1 to 5, where 1 represents that the respondent views the actor to have no influence of the choice, and 5 represents that the respondent views the actor to have very high influence of the choice of the frame material. Thus, the higher mean value of an actor, the higher influence the respondents think that actor group has on the choice of the frame material. However, in order to interpret significant differences between factors, the confidence intervals of the groups of actors compared must not overlap. Further, the width of the confidence interval is interpreted as the consensus of the respondents regarding each factor, where a narrow interval represents a consensus in the answers and a wide interval indicates that the respondents' opinions of a question differs.

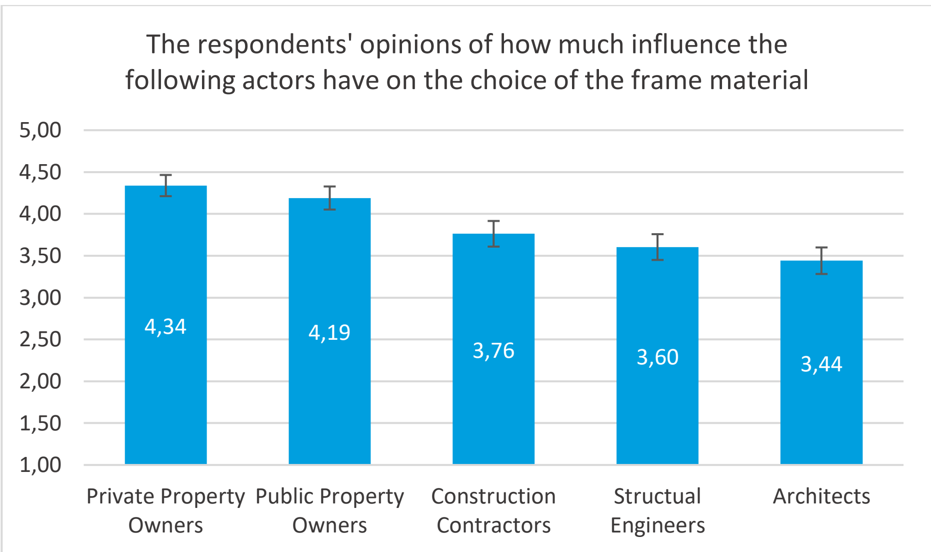

Figure 72: The different actors' impact on the choice of material according to all the respondents in total.

Figure 72 above shows that the respondents think the property owners have the significantly highest possibility to influence the choice of material. This is followed by the construction contractors, the structural engineers and the architects. The difference between the construction contractors and the architects are significant, thus, the respondents claim that the construction contractors influence the choice of frame material more than the architects. However, the differences between the structural engineers and the construction contractors respectively the architects are not significant. Furthermore, the results show that the respondents think that all actors influence the choice of frame material.

Table 6 below show, as figure 72 above, the respondents' opinions of how much influence the different actors have on the choice of the frame material, however, in this figure the mean values are separated by what group of actors the respondent belongs to, for the data with for example the standard deviations, see *Appendix 5*. Thus, by studying this figure an interpretation of how much influence each category of actors has, and how the opinions differ between the different categories of actors, could be made. If the mean value of a group of actors' are similar to the mean value of all respondents, thus, the color coding of the columns are similar to the color coding of the field in the last row, the interpretation is that there is more or less a consensus regarding that actors influence of the choice of frame material. However, if the mean values differ, thus there are larger differences between the color coding for different rows in a column, the opinions regarding the that actors influence of the choice of frame material are fragmented.

Table 6: The different actors' influence on the choice of material according to the different groups of actors.

		The respondent's view of the different actors' influence on the choice of material				
		Private Property Owners	Public Property Owners	Construction Contractors	Structural Engineers	Architects
Respondent	Private Property Owners	4,57	4,1	3,67	3,43	3,43
	Public Property Owners	4,35	4,27	3,63	3,54	3,18
	Construction Contractors	4,44	4,3	3,94	3,97	4,06
	Structural Engineers	4,31	4,18	3,79	3,55	3,76
	Architects	4,15	4,04	4,04	3,63	3,26
	All respondents	**4,34**	**4,19**	**3,76**	**3,60**	**3,44**

Table 6 above shows that for property owners there is a general agreement of how much influence they have, and that this influence is relatively large. However, for architects, the opinions are more fragmented. While architects and public property owners seem to claim that architects do have a relatively limited influence over the choice of frame material, construction contractors and structural engineers seem to claim that architects do have a relatively large influence.

In the open questions of the survey, the different actors' impact on the choice of frame material has also been discussed. It is explained that the impact of different actors on the choice of frame material vary from project to project and that there are other factors influencing the choice of material; each situation, project and client has its prerequisites. Furthermore, the developer, sometimes together with the architect, are explained to often have an initial idea about which alternative or alternatives of frame material they would prefer. Then structural engineers can assist with input on how these alternatives impact the construct and provide calculation for different constructions based on the different alternatives of frame material. Sometimes they can recommend a certain frame material. In the end, it is argued that the developer and the construction contractor have the largest impact on the final choice of frame material and that the architects and structural engineers almost do not have any impact at all.

4.5 Stora Enso Building Solutions' Business Model

In this section, the results from the interviews with Mikael Lindberg, *Head of Sales Scandinavia* at Stora Enso Wood Products, regarding their business model are presented. The results from the interviews are complemented with information from internal documentation and information available at their website. See figure 73 below for this section's relation to the other sections in the empirics.

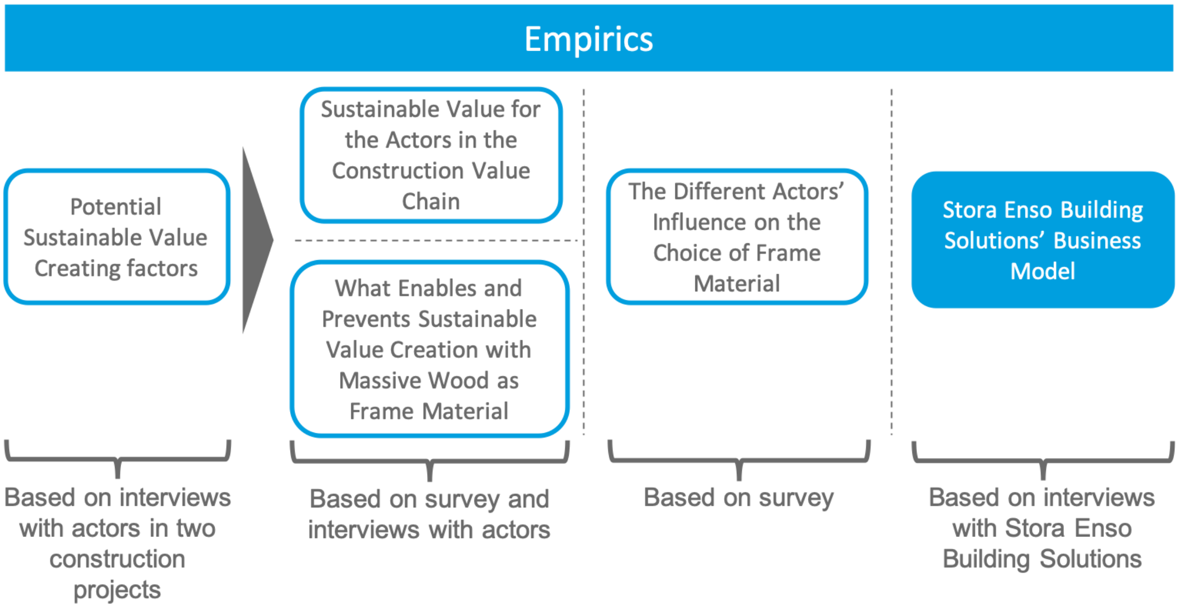

Figure 73: This section's relation to the other sections in the empirics.

4.5.1 The Products/Value Proposition

In this section, the *Value Proposition* of Stora Enso Building Solutions' *Business Model* is presented.

Stora Enso Building Solutions offer massive wood products for industrialized wood-frame construction. According to Lindberg (2019), their core offering includes massive wood elements of *Cross Laminated Timber (CLT)* and *Laminated Veener Lumber (LVL)*. Through partners, their offering also includes construction beams of *Glued Laminated Timber (Glulam)* (Lindberg, 2019).

CLT is an engineered wood construction product which consists of, at least, three layers of orthogonally arranged panels that are glued together (Stora Enso Wood Products, 2017). Stora Enso see many advantages with CLT compared to conventional construction materials. They emphasize advantages including a high level of prefabrication, high precision, a short set-up time and an easy assembling (Stora Enso Wood Products, 2017). Furthermore, they argue that with CLT, up to 10 percent more space for living can be gained based on a house with a 100 m^2 living space and it will create an indoor climate that is comfortable and healthy (Stora Enso Wood Products, 2017). They also claim that CLT has good insulating and structural properties and that, compared to concrete and brick, CLT is a light-weight material (Stora Enso Wood Products, 2017). Furthermore, they propose that CLT also has advantages when it comes to safety with good fire safety characteristics and that it is a construction method resistant to earthquakes (Stora Enso Wood Products, 2017). Moreover, CLT is a certified construction material and enables an eco-friendly and sustainable construction method which will result in a positive CO_2 balance (Stora Enso Wood Products, 2017).

LVL is an engineered wood construction product which consists of several layers of rotary-peeled spruce veneers (Stora Enso Wood Products, 2018). Stora Enso argues that LVL shares many of the advantages of CLT, such as its high level of prefabrication, workability, precision and that it is a renewable and carbon-neutral alternative because its storage of carbon (Stora Enso Wood Products, 2018). In comparison to CLT, LVL has according to Stora Enso even higher strength in relation to weight, twice as high as steel (Stora Enso Wood Products, 2018). It is according to Stora Enso one of the strongest wood-based construction materials in relation to its weight (Stora Enso Wood Products, 2018).

To complement their offering, Lindberg (2019) explains that Stora Enso Building Solutions also offer services. These services include Technical Support, Digital Services and Advanced Logistic Solutions (Lindberg, 2019). The Technical Support is internal resources with competences to support the customer in technical issues regarding for example acoustics and fire which is free of charge for all customers (Lindberg, 2019).

The Digital Services consists of instructions and digital tools which all are free of charge (Lindberg, 2019). One digital tool is CLT360 which is an app for Stora Enso Building Solutions' product CLT which can be used on the construction site (Stora Enso, 2019b). With this app, the user scans a QR code which is found on the CLT panel and where the panel should be assembled on the construction site will be displayed in a 3D model (Stora Enso, 2019b). Another digital tool is Calculatis, which is an online software tool to support engineers on the design of timber structures (Stora Enso, 2019b). It includes for example connection design, building physics (thermal analysis and condensation), fire design, design according to swiss building code (SIA) and design of laminated veneer lumber (LVL) (Stora Enso, 2019b). It is available in 6 languages, is based on Eurocode 5 and has been adapted to 9 national building rules, for example BBR (Stora Enso, 2019b).

The Advanced Logistic Solutions are services with the aim to deliver the products optimized based on the order they are to be assembled on the construction site and the products can be delivered by road, railroad or water (Lindberg, 2019).

4.5.2 The Customer Interface

In this section, the *Customer Interface* of Stora Enso Building Solutions' *Business Model*, including their *Customer Segments, Channels,* and *Customer Relationships*, are presented.

Lindberg (2019) claims that they want their offering to fit a wide range of purposes, from exclusive single-family homes to the world's largest offices, from buildings with simple standard to buildings with exclusive standard. Their flexibility is according Lindberg (2019) one of their strengths. What they actually deliver the most depends to some extent of the market. In Sweden, there has been a focus on apartments, school-buildings and commercial properties. Lindberg (2019) explains that they view the actors in the construction value chain as either buying customers or non-buying customers. The construction contractor, or sometimes the CLT-partner, is seen as the buying customer while architects, structural engineers and property owners are seen as non-buying customers. He emphasizes that they generally target a wide range of customers and that all customers are important for them. However, he also explains that they value customers that builds repetitively. Therefore, developers and larger construction contractors in specific might be the key customers for them.

Stora Enso Building Solutions use the traditional channels for marketing and communication, such as advertisement, social media and their own website (Lindberg, 2019). Beyond that, Lindberg (2019) emphasizes their network of reference projects as an important channel for marketing and communication with new customers. He explains that the reference projects are a tool for Stora Enso Building Solutions to show transparency and let their customers form their own opinions about their offering by gaining experiences from earlier similar projects. A digital site with reference projects is under development for their own website, with the aim of presenting easily accessible facts for their customers (Lindberg, 2019). Further, marketing and communication is performed through existing networks, seminars and fairs (Lindberg, 2019).

Lindberg (2019) explains that Stora Enso Building Solutions, in their communication, present their offering, show reference projects and if the potential customer demands solutions including for example assembly or calculations, they are able to meet these demands through their partners. Lindberg (2019) further explains how they use their own sales organization as a channel for distribution and sales directly to customers on all their markets around the world. They also use different partners as channels for sales for different markets (Lindberg, 2019). In Scandinavia, he presents Woodcon and Dala Massivträ as two examples. For after sales support, Stora Enso Building Solutions use their organization for supply chain and project management (Lindberg, 2019).

Lindberg (2019) emphasizes their focus on long-term relationships with their customers. He describes how they are constantly looking for new customers that fit them and their long-term ambitions and plans. At the same time, he explains that they also want to grow together with their existing customers and partners. He explains their customer relationships to be personally for the most part and when the projects are sold, the relationships can partly transition to a more automated relationship. Furthermore, Lindberg (2019) explains that they want to reach a high flexibility in meeting their customers' demands but that the production sets the limits of how flexible they can be. Collaboration with other actors in the construction value chain is performed through R&D projects, for example through networks such as *Svenskt Trä*[4] (Lindberg, 2019).

4.5.3 Infrastructure Management

In this section, the *Infrastructure Management* of Stora Enso Building Solutions' *Business Model*, including their *Key Resources, Key Activities*, and *Key Partners*, are presented.

The CLT which Stora Enso offers is produced in either Austria or Sweden (Stora Enso Wood Products, 2017). In Austria they have two different factories, one in in Ybbs an der Donau and one in Bad St. Leonhard (Stora Enso Wood Products, 2017). These factories have a total capacity of 140,000 m^3 each year (Stora Enso Wood Products, 2017). Lindberg (2019) explains that, in Sweden, a new factory for producing CLT has just started its production (in the beginning of 2019). The factory is placed in Gruvön, and the factory is according to Lindberg (2019) the largest and most modern factory of CLT production in Europe with a capacity of 100,000 m^3 CLT per year which makes Stora Enso one of the largest suppliers of CLT in the world. Stora Enso also have one factory producing LVL in Finland, with the capacity of producing 100,000 m^3 each year (Stora Enso Wood Products, 2018).

Lindberg (2019) emphasizes their production facilities with high capacity as a key resource for them. He argues that they are not more flexible than their competitors but that their capacity is higher. He explains how they rarely reach the upper limits of their production capacity and he argues that the modern machines imply an efficient production with short lead times which for the customer means a short delivery time of the ordered products. Moreover, Lindberg (2019) explain that another of their key resources is their integrated logistic network, which he argues results in good control over the raw material supply. The integrated logistic network also includes an integrated production, with the sawmill and the manufacturing of massive wood elements at the same location (Lindberg, 2019). Lindberg (2019) also emphasizes their R&D department and their technical excellence as key resources to deliver their value proposition. However, he also explains how their partners are still required in order to deliver solutions for their customers. Furthermore, their physical presence in more than 30 countries is according to themselves another of their key resource.

Lindberg (2019) mentions their production, marketing and sales activities generally as important activities for them. Specifically, he emphasizes their R&D and logistics as key activities. Lindberg (2019) argues how their size implies that they can offer a widely covering logistic network even though they do not own the logistic solutions by themselves. In Sweden, the raw material is primarily bought from private forest owners close to the production site and the distance from the raw material to the production site is generally less than 100 km (Lindberg, 2019). After the manufacturing, they, except for transportation by road, also have the possibility to transport the massive wood elements on either railroad or by water directly from the production site (Lindberg, 2019).

Lindberg (2019) explains how they use external resources, called CLT-Partner in order to enable complete solutions for their customers to build with massive wood, without having all the resources internally in their own organization. This allows Stora Enso Building Solutions to, according to Lindberg (2019), be both flexible in meeting the customer demands and to perform cost efficient processes.

The activities performed by their key partners are project management, assembly, project planning and optimized logistics with components from their partners, such as fasteners, included (Lindberg, 2019).

4.5.4 Financial Aspects

In this section, the *Financial Aspects* of Stora Enso Building Solutions' *Business Model*, including their *Revenue Streams* and *Cost Structure*, are presented.

[4] *Svenskt Trä* is an organization belonging to the trade association Skogsindustrierna, working for knowledge transfer, inspiration and development related to wood, wood products and wood construction (Svenskt Trä, 2019).

The revenue streams come from the products and services included in the offering (Lindberg, 2019). The paying customer, the construction contractor or sometimes from the CLT-partner of the project, gets the invoice when the products starts to be delivered (Lindberg, 2019). For the most part, the price is based on for example volume (Lindberg, 2019). The cost structure contains mainly of fixed costs, such as machinery and other production equipment, and variable costs such as labor and raw material (Lindberg, 2019). The cost structure is characterized by fixed costs and economies of scale (Lindberg, 2019).

5. Analysis

In this chapter, the empirics are analyzed based on the Model of Analysis in order to answer the research questions and thus, reach the purpose of the thesis. First, what creates sustainable value for the actors in the construction value chain regarding the frame material is analyzed. Second, what enables and prevents sustainable value creation with massive wood as frame material is analyzed. Third, what elements in a wood-frame material supplier's business model could be used to create and deliver this value is analyzed. The disposition of the analysis is summarized in figure 74 below.

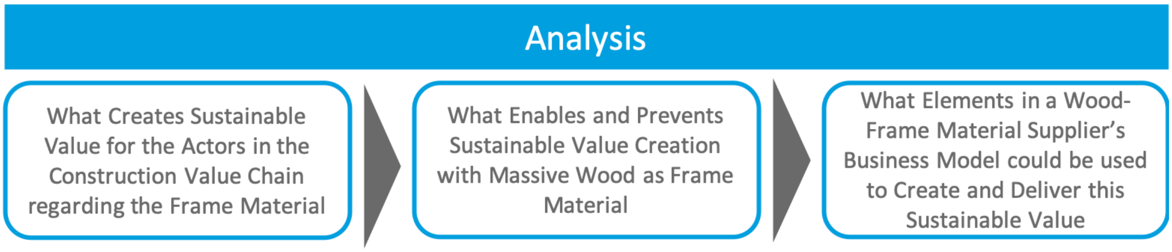

Figure 74: The disposition of the analysis.

5.1 What Creates Sustainable Value for the Actors in the Construction Value Chain regarding the Frame Material

In this section, research question 1, *what creates sustainable value for the actors in the construction value chain regarding the frame material,* is answered. First, how the different actors influence the choice of material is analyzed in order to confirm that a material supplier should create sustainable value for all actors in the construction value chain. Second, potential sustainable value creating factors for the different actors are analyzed. Lastly, a summary of what creates sustainable value for the actors in the construction value regarding the frame material is given. See figure 75 below for this section's relation to the other sections in the analysis and figure 76 below for an illustration of what is analyzed in the Model of Analysis.

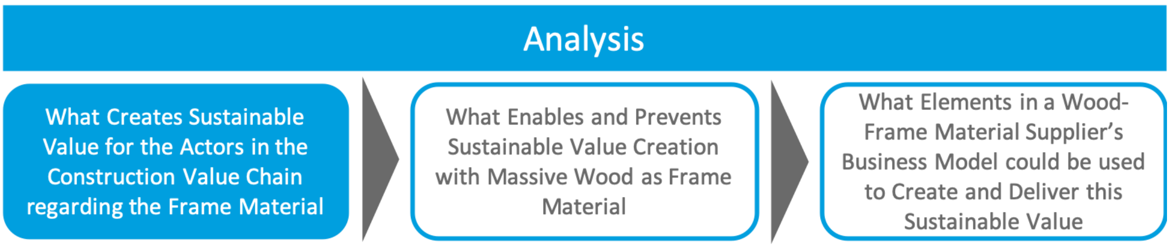

Figure 75: This section's relation to the other sections of the analysis.

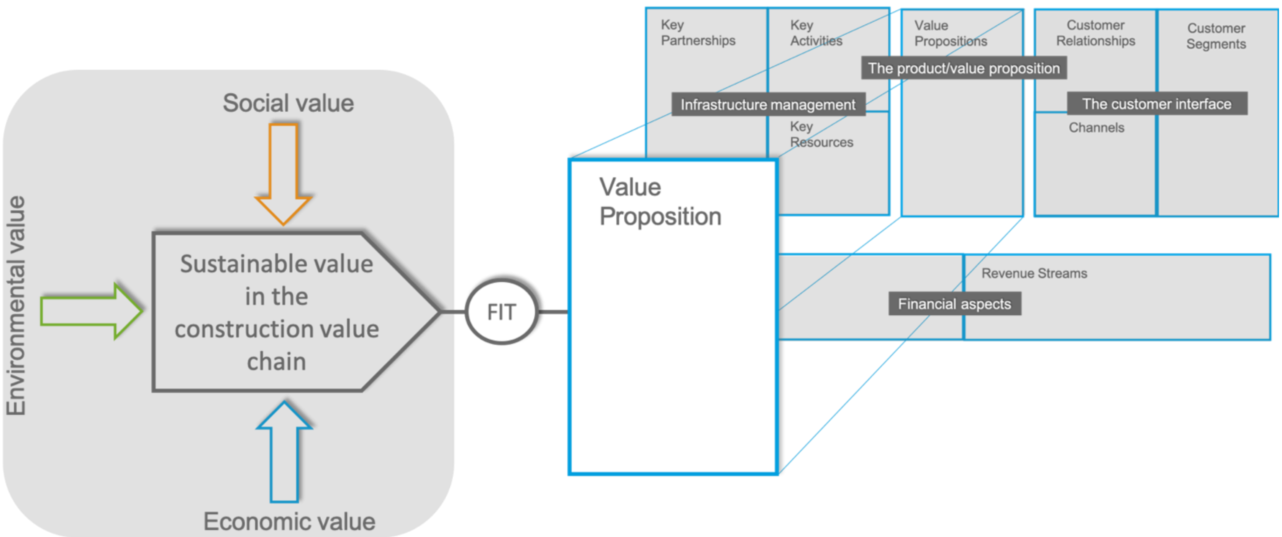

Figure 76: What is analyzed, illustrated in the Model of Analysis.

5.1.1 Which Actors a Material Supplier should Create and Deliver Sustainable Value to

In section *4.4 The Different Actors' Influence on the Choice of Frame Material,* the respondents' opinions of how much influence the different actors in the value chain have on the choice of the frame material are presented. It is observed that all the actors influence the choice of material where the property owners (often developers) have the significantly highest possibility to influence. This is followed by the construction contractors, the structural engineers and the architects. The difference between the construction contractor and the architect is significant, thus, the respondents claim that the construction contractor influence the choice of frame material more than the architects. However, the differences between the structural engineer and the construction contractor respectively the architect are not significant. Furthermore, from the open answered questions, the different actors seem to influence the choice of material in different phases of the project.

The results from the survey is basically in line with Roos, Woxblom and McCluskey (2009) who argue that the developer, followed by the construction contractor have the most power to affect the choice of the material in a construction project. Furthermore, architects and structural engineers have limited power and the end user has the lowest power to affect the choice of material (Roos, Woxblom & McCluskey, 2009). Further, based on the results, we emphasize that all of the actors in the value chain, the developer (private and public property owners), the construction contractor, the architects and the structural engineers, must be viewed as customers and key stakeholders for a material supplier in the construction industry, as stated in section *1.4 Theoretical Starting Point*. Therefore, because a sustainable business model needs to create and deliver sustainable value to the organization's customers and other main stakeholders, which is further stated in section *1.4 Theoretical Starting Point*, we argue that a material supplier in the wood-frame multi-storey construction industry needs to create and deliver sustainable value to the private or public property owners, the construction contractors, the architects and the structural engineers in the projects.

5.1.2 Potential Sustainable Value Creating Factors for the different Actors

From the data collected through the survey, presented in section *4.2 Sustainable Value for the Actors in the Construction Value Chain,* the most important economic, social and environmental factors for each group of actors are identified. As described in section *3.6.1 Analysis of the Survey,* a factor is interpreted as one of the most important factors for an actor if the mean value of the factor is significantly (α=0.05) higher than the total mean value of all the factors in that category (economic, social and environmental) for that actor. The result is presented in table 7 below. The economic, environmental and social factors that are the most important for different actors, in order for them to prefer a certain frame material, are marked in blue. The larger number of groups of actors who view the factor as one of the most important, the higher up in the table the factor is placed.

As shown in the frame of reference, see section *2.2.5 Summary of Value,* benefits and sacrifices that the customer also sees as important for them to prefer or not prefer the offering, create or prevent value for the customer. The factors, presented in table 7 below, are important for the actors to prefer a certain frame material, and therefore, they are potentially value creating factors depending on if they are seen as advantages, thus benefits, or disadvantages, thus sacrifices, for the specific frame material. Therefore, we argue that these factors are potential value creating factors that either contribute to, or prevent, value creation for the actors in the construction value chain for a specific frame material

Table 7: Summary of the most important potential value creating factors.

Aspect	The Most Important Potential Value Creating Factors	Private Property Owner	Public Property Owner	Architect	Structural Engineer	Construc-tion Contractor
Economic	The frame material's impact on the **[material costs in the project]**					
Social	The frame material's impact on the **[construction site's safety]**					
Environ-mental	The frame material's impact on the **[energy consumption in the operation of the building]**			*		
Social	The frame material's impact on the **[indoor environment for the end user]**					
Social	The frame material's **[fire properties]**					
Economic	The frame material's impact on the **[stability of the construct]**					
Environmental	The frame material's **[heat and cold insulating properties]**			*		
Economic	The frame material's impact on the **[life span of the building]**					
Economic	The frame material's impact on the **[construction time]**					
Environmental	The amount of **[frame material waste arising at the worksite]**			*		
Social	The frame material's **[modifiability]**					
Social	The frame material's **[compatibility with other building materials/systems]**					
Economic	The impact on the frame material from **[rain and moisture during construction]**					
Environmental	That the frame material is **[fossil free]**			*		
Environmental	That the frame material is **[renewable]**			*		
Environmental	That the frame material has **[carbon storage properties]**			*		
Environmental	The amount of **[frame material waste arising from production of the frame material]**			*		
Environmental	The amount of **[greenhouse gas emissions arising from handling of the frame material at the construction site]**			*		
Environmental	The amount of **[greenhouse gas emissions arising from production of the frame material]**			*		
Environmental	The amount of **[greenhouse gas emissions arising from transportation of the frame material]**			*		
Social	The frame material's impact on the [**construction site's general working environment]**					
Social	The frame material's impact on the [**appearance of the building]**					
Social	The frame material's **[acoustic properties]**					

**Not significantly more or less important than other factors of the same aspect of sustainability.*

When analyzing the most important potential sustainable value creating factors for architects, no environmental factor is significantly more or less important than the other environmental factors. Further, it seems like all environmental factors are relatively important for architects because the factors have relatively high mean values, compared to other groups. Therefore, all environmental factors are included as the most important potential sustainable value creating factor for architects.

From table 7 above, we observe that the factors which most, at least four out of the five types of actors, see as one of the most important economic, social or environmental factors for them to prefer a certain frame material, are the frame material's impact on the *material costs in the project*, *stability of the construct*, *construction site's safety*, *indoor environment for the end user*, *energy consumption in the operation of the building* and the frame material's *fire properties* and *heat and cold insulating properties*. If these are viewed as advantages with the specific frame material, they create sustainable value for most of the actors in the construction value chain and they could therefore be interpreted as the most important potential sustainable value creating factors.

We also observe that important for the actors generally are economic factors affecting the profitability, such as the frame material's impact on the *material costs in the project, construction time* and the impact on the frame material from *rain and moisture during construction.* Further, a factor affecting the return on investment, the frame material's impact on the *life span of the building* is also important. As Evans et al. (2016) claim, typical forms of economic value are traditional concepts such as profit and return on investment, but when adding sustainability, it also needs to generate a long-term liability and a stable business with financial resilience. This, we argue, the frame material's impact on the *construction time* contributes to. However, it seems like it is primarily the traditional concepts such as profitability and return on investment that are valued. Additionally, we observe that the frame material impact on the *stability of the construct* is an important factor that we argue could be interpreted as an economic factor.

Further, we observe that important social factors for the actors are primarily related to health and safety, such as the frame material's impact on the *construction site's general working environment, construction site´s safety* and the frame material´s *fire properties,* and *acoustic properties.* This is in line with Evans et al. (2016) who claim that social value forms include health and safety. Furthermore, we also observe that the frame material´s *modifiability* and *compatibility with other building materials/systems* are important factors. This is in line with Patala et al. (2016) who argue that labor practices and working conditions impact social sustainability. Additionally, we observe that the frame material´s impact on the *indoor environment for the end user* is an important factor that we argue could be interpreted as a social factor.

Furthermore, we also observe that for environmental factors there are two factors that stand out. The frame material´s impact on the *energy consumption in the operation of the building*, and the frame material´s *heat and cold insulating properties*. Important for the architects especially are also environmental factors regarding low emissions, such as the amount of *greenhouse gas emissions arising from production of the frame material, transportation of the frame material* and *handling of the frame material at the construction site* and also that the frame material is *fossil free* and *has carbon storage properties*. Further, that the frame material is *renewable* is also important. Moreover, the amount of frame material waste arising *from production* and *at the worksite* are also important. This is in line with Evans et al. (2016) who argue that the environmental value form typically includes the use of renewable resources, processes with low emissions and waste.

From table 7 above, it is observed that eight of our identified factors are related to functional demands and could therefore be categorized as factors affecting functional demands. These are the following.

- The frame material's impact on the energy consumption in the operation of the building.
- The frame material's impact on the indoor environment for the end user.
- The frame material's fire properties.
- The frame material's heat and cold insulating properties.
- The frame material's modifiability.
- The frame material's compatibility with other building materials/systems.
- The impact on the frame material from rain and moisture during construction.
- The frame material's acoustic properties.

Furthermore, two of the most important potential sustainable value creating factors could also be categorized into energy properties: These are the following:

- The frame material's impact on the energy consumption in the operation of the building.
- The frame material's heat and cold insulating properties.

Moreover, one of the most important potential sustainable value creating factors is about appearance. This is the factor:

- The frame material's impact on the appearance of the building.

Laslty, one of the most important potential sustainable value creating factors impact total cost of the investment. This is the factor:

- The frame material's impact on the material costs in the project.

From the perspective of architects and structural engineers, Roos, Woxblom and McCluskey (2009) have identified factors which they claim will influence the decision of material in a construction project. If a factor can influence the decision of material, we argue that the factor affect the value creation. The identified factors are for example functional demands, energy properties, appearance and the total cost of the investment (Roos, Woxblom & McCluskey, 2009). As presented above, some of our identified factors can be categorized to the categories of factors presented by Roos, Woxblom and McCluskey (2009). This, we argue, supports that these factors could create value, and therefore they are seen as some of the most important potential sustainable value creating factors for actors in the construction value chain.

Table 7 also shows that thirteen of our identified factors are regarding processes and activities or the frame material's impact on processes and activities. These factors can further be categorized to the production of the material, the construction phase of the project and the management phase of the project. These factors are the following:

- Production phase
  - The amount of frame material waste arising from production of the frame material.
  - The amount of greenhouse gas emissions arising from production of the frame material.
  - The amount of greenhouse gas emissions arising from transportation of the frame material.
- Construction phase
  - The frame material's impact on the construction site's safety.
  - The frame material's impact on the construction time.
  - The amount of frame material waste arising at the worksite.
  - The frame material's modifiability.
  - The frame material's compatibility with other building materials/systems.
  - The impact on the frame material from rain and moisture during construction.
  - The amount of greenhouse gas emissions arising from handling of the frame material at the construction site.
  - The amount of greenhouse gas emissions arising from transportation of the frame material.
  - The frame material's impact on the construction site's general working environment.
- Management phase
  - The frame material's impact on the energy consumption in the operation of the building.

Pan and Goodier (2012) argue that processes and activities capture and create value of house-building businesses. According to the authors, the value creating processes and activities can be performed pre-site, during production, and be performed on-site or post-site. This is in line with the results of the survey presented above, where some of the identified most important potential sustainable value creating factors are categorized as processes and activities and categorized into production phase, construction phase of the project and management phase of the project, thus pre-site, on-site and post-site. The categorization by Pan and Goodier (2012), do not take sustainability as the starting point, and therefore, are not fully applicable to our research question. However, it seems to support our arguments, that these factors could create value, and therefore they are interpreted as some of the most important potential sustainable value creating factors for actors in the construction value chain.

Furthermore, as can be seen in table 7 above, seven of the most important potential sustainable value creating factors are material properties. These factors are the following:

- The frame material's fire properties.
- The frame material's heat and cold insulating properties.
- The frame material's modifiability.
- That the frame material is fossil free.
- That the frame material is renewable.
- That the frame material has carbon storage properties.
- The frame material's acoustic properties.

5.1.3 Summary of what Creates Sustainable Value for the Actors in the Construction Value Chain regarding the Frame Material

We have confirmed what was proposed in section *1.4 Theoretical Starting Point*, thus, if a material supplier in the wood-frame multi-storey construction industry wants to develop a sustainable business model, they need to create and deliver sustainable value to the developers (for example private or public property owners), the construction contractors, the architects and the structural engineers in the projects. Thus, the most important factors for each of these actors need to be included in the most important potential sustainable value creating factors for the actors in the construction value chain.

To answer research question 1, *what creates sustainable value for the actors in the construction value chain regarding the frame material*, the factors identified to be the most important economic, social and environmental value creating factors for the actors in the construction value chain are shown in figure 77 below. The blue arrow includes the economic factors, the orange arrow includes the social factors and the green arrow includes the environmental factors. These factors can be categorized in other ways too, for example, the factors can be categorized to one or more of the following categories of factors: material properties, factors which impact functional demand, energy properties, appearance, factors which impact total cost of the investment and activities and processes. However, because sustainable value is studied, the factors are categorized into economic, social and environmental factors. If these factors are viewed as advantages for a certain frame material, we argue that they are value creating and therefore creates sustainable value in the construction value chain.

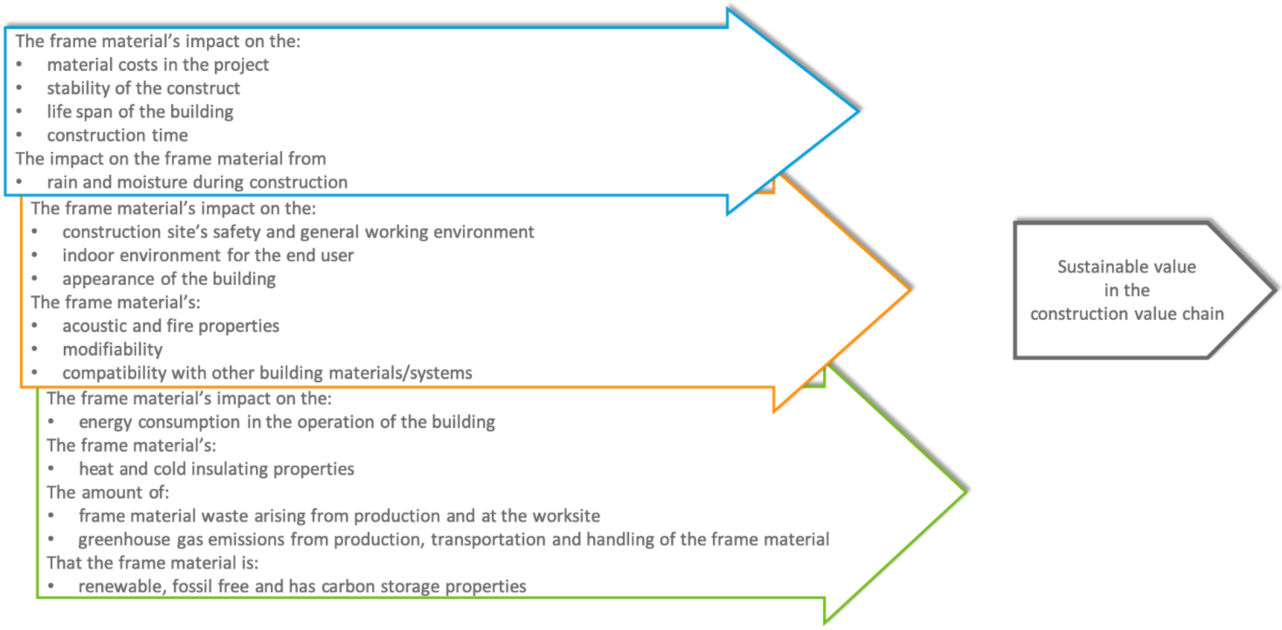

Figure 77: The most important potential sustainable value creating factors in the construction value chain regarding the frame material.

The factors which most, at least four out of the five types of actors, see as one of the most important economic, social or environmental factors for them to prefer a certain frame material are the frame material's impact on the *material costs in the project*, *stability of the construct*, *construction site's safety*, *indoor environment for* *the end user*, *energy consumption in the operation of the building* and the frame material's *fire properties* and *heat and cold insulating properties*. If these are seen as advantages with the specific frame material, they create sustainable value for most of the actors in the construction value chain and are therefore important potential value creating factors.

5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material

In this section, research question 2, *what enables and prevents sustainable value creation with massive wood as frame material*, is answered. It is analyzed if using massive wood as frame material is seen as an advantage or disadvantage for the identified potential value creating factors in section 5.*1.2 Potential Sustainable Value Creating Factors for the different Actors* above. This, to understand what enables and prevents sustainable value creation for a material supplier in industrial wood-frame multi-storey construction.

See figure 78 below for this section's relation to the other sections in the analysis and figure 79 below for an illustration of what is analyzed in the Model of Analysis.

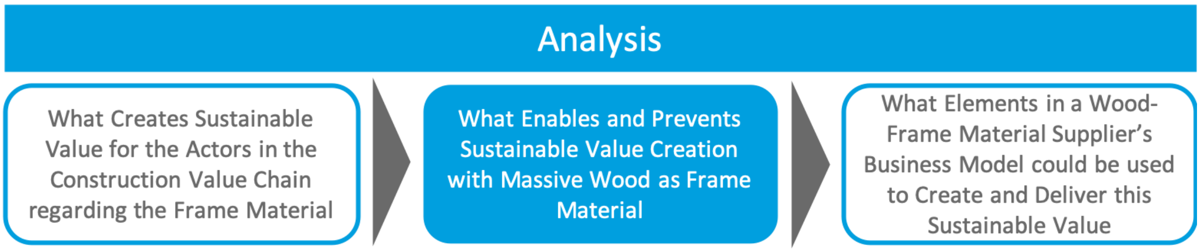

Figure 78: This section's relation to the other sections of the analysis.

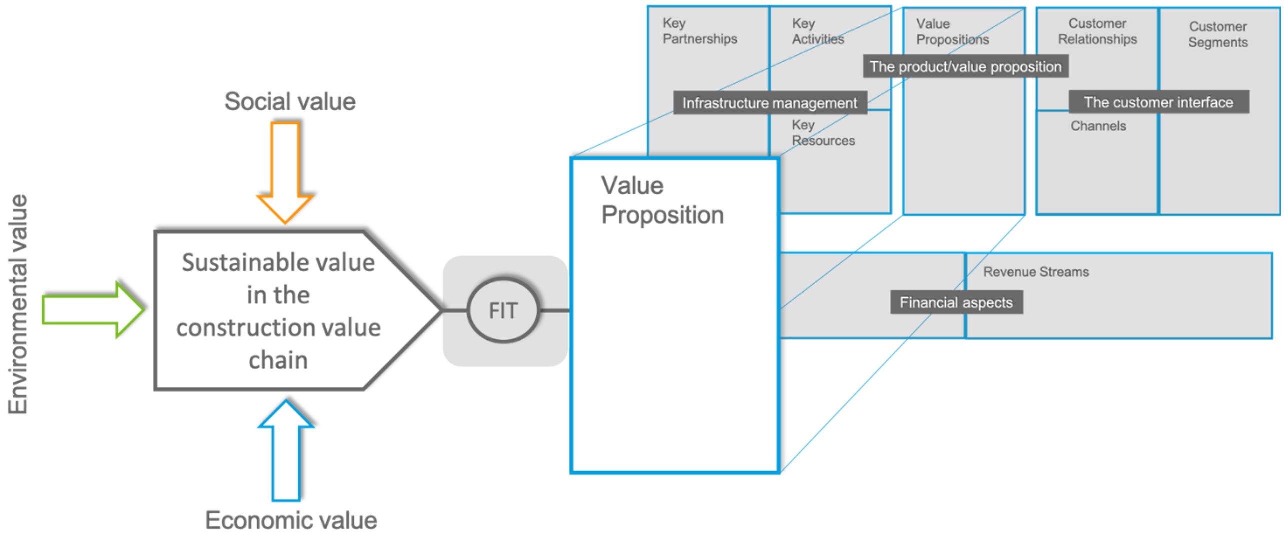

Figure 79: What is analyzed, illustrated in the Model of Analysis.

Based on the results from the survey presented in section *4.3 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material* and in *Appendix 5*, if the mean value of the factor is significantly higher than 0 the factor is viewed as an *advantage* for that actor in order to prefer massive wood as the frame material. This is presented as a "+" in table 8 below. In the same way, a factor with mean value significantly lower than 0 is viewed as a *disadvantage* for that actors in order to prefer massive wood as frame material. This is presented as a "-" in table 8 below. If the mean value is not significantly higher, or lower, than 0 it is viewed as *both an advantage and a disadvantage*, because then the respondents have seen it both as an advantage and a disadvantage. This is presented as a "+/-" in table 8 below. This is explained in more detail in the methodology chapter, section *3.6.1 Analysis of the Survey*.

As argued in the frame of reference, see section *2.2.5 Summary of Value*, benefits and sacrifices that the customer also sees as important for them to prefer, or not prefer, the offering create, or prevent, value for the customer. The factors, presented in table 8 below, are (1) important for the actors to prefer a certain frame material and (2) seen as either advantages, or disadvantages, when it comes to massive wood as frame material, for the actors regarding each factor. Therefore, our logical argument is that those factors are potential value creating factors that either contribute to, or prevent, value creation for the actors in the construction value chain.

The most important potential sustainable value creating factors in the construction industry and if these factors are seen as advantages and therefore create value (+), are seen as disadvantages and therefore prevent value to be created (-) or both (+/-), regarding massive wood as frame material, is presented in table 8 below. The numbering of the factors is used in order to facilitate referencing to the different factors.

Table 8: The most important potential sustainable value creating factors and if these factors create value, prevent value creation or both for different actors when it comes to massive wood as frame material.

Nr	The Most Important Potential Sustainable Value Creating Factors	Private Property Owner	Public Property Owner	Architect	Structural Engineer	Construction Contractor
1	Massive wood's impact on the… **[material costs in the project]**	+/-	+/-	+/-	+	+
2	Massive wood's impact on the… **[construction site's safety]**	+	+		+	+
3	Massive wood's impact on the… **[energy consumption in the operation of the building]**	+	+	+	+	
4	Massive wood's impact on the… **[indoor environment for the end user]**	+	+	+	+	
5	Massive wood's… **[fire properties]**	+/-	+/-		+/-	+
6	Massive wood's impact on the… **[stability of the construct]**		+/-	+	+/-	+
7	Massive wood's… **[heat and cold insulating properties]**		+	+	+	+
8	Massive wood's impact on the… **[life span of the building]**	+/-	+/-		+	
9	Massive wood's impact on the… **[construction time]**		+		+	+
10	The amount of… **[massive wood waste arising at the worksite]**			+		+
11	Massive wood's… **[modifiability]**				+	+
12	Massive wood's… **[compatibility with other building materials/systems]**		+			+
13	The impact on massive wood from… **[rain and moisture during construction]**		-			+/-
14	That massive wood is… **[fossil free]**			+		
15	That massive wood is… **[renewable]**			+		
16	That massive wood has… **[carbon storage properties]**			+		
17	The amount of… **[massive wood waste arising from production of the frame material]**			+		
18	The amount of… **[greenhouse gas emissions arising from handling of massive wood at the construction site]**			+		
19	The amount of… **[greenhouse gas emissions arising from production of massive wood]**			+		
20	The amount of… **[greenhouse gas emissions arising from transportation of massive wood]**			+		
21	Massive wood's impact on the… **[construction site's general working environment]**					+
22	Massive wood's impact on the… **[appearance of the building]**			+		
23	Massive wood's… **[acoustic properties]**		+/-			

The factor 1, *massive wood's impact on the material costs in the project*, is one of the most important economic factors for all actors. The group of structural engineers and construction contractors seems to view massive wood's impact on the material costs in the project as a value creating factor. However, for the other groups, the factor is seen as a factor that both enables and prevents value creation. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, the reason the factor can prevent value creation might be due to the view that massive wood as frame material costs a little bit more than a frame of concrete or steel, and if the uncertainty and risk of using massive wood as frame material impact the financial calculation and therefore, it seems like a more costly choice. At the same time, that some interviewees claim that that a massive wood frame does not cost more than a frame in another material can explain why massive wood's impact on the material costs in the project creates value for some actors. Our result that the material costs are an important factor is consistent with earlier research of Pan and Goodier (2012), who explain that financial factors are important regarding the value creation. The result from the study performed by Espinoza et al. (2016), indicating that costs is a barrier for CLT adoption in Europe and the argument by Hurmekoski (2017), that wood construction will become economic competitive in the future is interesting to put in relation to our result. In contrast to Espinoza et al. (2016) our result does not indicate that the material costs would be viewed as a disadvantage regarding massive wood. Possibly, wood construction has started to be more economic competitive. Or else, the divergence might be due to geographical differences in competitiveness regarding the costs. Another indication that massive wood has started to be more economic competitive might be that the construction contractors, that is directly invoiced for the costs of the frame material, see the factor as a value creator, but property owners, downstream the value chain, have a more negative view of the factor. Perhaps it rather is the increased perceived uncertainty and risk of using massive wood that is the underlying explanation why this factor prevents value creation for some respondents. Since construction contractors primarily are the actors that are directly invoiced for the cost of the frame material, they might also be the most up to date regarding the economic competitiveness of different materials. To summarize, factor 1 is an important potential sustainable value creating factor for all actors which both creates value and prevents value creation in the construction value chain.

The factor 2 and 21, *massive wood's impact on the construction site's safety* and *massive wood's impact on the construction site's general working environment*, are two of the most important social factors for some of the actors in the construction value chain. For all types of actors except architects, factor 2 is an important value creator, and for construction contractors, both factor 2 and factor 21 are important value creators. These two factors are similar to each other and the correlation is significant. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood's impact on the construction site's general working environment creates value because massive wood is viewed as a material with low weight that is easy to handle and results in a relatively safe, warm, dry, quiet and nice working environment. Based on the interviews, factor 2 might be value creating because of the high level of prefabrication possible with massive wood as frame material, which implies a working environment with increased safety. This is consistent with Hurmekoski, Jonsson and Nord (2015), who argue that architects and engineers see an advantage with the safety through industrial prefabrication in wood-frame multi-storey construction. In addition to their study, our result seems to broaden this view to also cover the other actors in the value chain. However, based on our result, architects do not see either of these two factors as the most important social factors, but they still see them as advantages regarding massive wood. To sum up, factor 2 and 21 are sustainable value creating factors for actors in the construction value chain.

The factor 3 and 7, *massive wood's impact on the energy consumption in the operation of the building* and *massive wood's heat and cold insulating properties*, are two of the most important environmental factors for most of the actors the construction value chain. For factor 3, all actor groups except construction contractors see the factor as one of the most important environmental factors and for factor 7, all groups except private property owners see the factor as one of the most important environmental factors. Factor 3 and factor 7 are similar to each other, and the correlation is significant. In section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, it is observed that the reason why these factors are value creating might be due to the perception that wood absorbs and emits moisture and therefore contributes to a more stable indoor environment and that it reduces the effect of thermal bridges compared to many other frame materials. Especially, public property owners that demands the certification called *Miljöbyggnad* seems to value wood regarding these factors. We have not been able to find clear explanations why construction contractors might not see factor 3 as important and why private property owners might not see factor 7 as important, neither in the literature, nor in the empirical data gained from the interviews. However, as presented in chapter *4. Empirics* above, those two factors are the most important environmental factors for the actors generally and are also seen as advantages by the actors in the construction value chain generally. This is consistent with earlier research by Roos, Woxblom and McCluskey (2009), that functional demands and energy properties are value creating regarding a frame material. Therefore, we view these factors as value creating. To summarize, factor 3 and 7 are sustainable value creating factors for most actors in the construction value chain.

The factor 4 and 22, *massive wood's impact on the indoor environment for the end user,* and *massive wood's impact on the appearance of the building* are two of the most important social factors for some of the actors in the construction value chain. For factor 4, all groups except construction contractors see the factor as important. For architects, factor 22 is also an important value creator. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood as frame material is perceived to create a healthy indoor environment for the end user. Furthermore, the appearance of visually exposed wood and the special architectural design which is possible with massive wood is valued. Thus, wood seems to be value creating both psychologically, through its internal, and external, appearance and physically, through its impact on the physical indoor environment. This is consistent with earlier research by Muilu-Mäkelä et al. (2014) in Hurmekoski, Jonsson and Nord (2015), Hurmekoski (2017) and Markström et al. (2018) regarding the impact wood has on the indoor environment, and that architects and engineers see the natural and warm appearance with massive wood as advantages with wood-frame multi-storey construction. Furthermore, the complementary interviews also indicate that the value creation of those factors are tightly connected to factor 5, *massive wood´s fire properties,* factor 23, *massive wood's acoustic properties* and factor 13, *the impact on massive wood from rain and moisture during construction,* this since some of the solutions regarding those factors implies that the surface of the massive wood element is covered by other materials. To sum up, factor 4 and 22 are sustainable value creating factors for the actors in the construction value chain.

The factor 5, *massive wood's fire properties,* is one of the most important social factors for most of the actors in the construction value chain, however it is not one of the most important social factors for the responding architects. Even if the responding construction contractors seems to see it as an advantage, factor 5 is one of the main perceived disadvantages actors in the value chain see with massive wood as frame material. 37 percent of the respondents see massive wood's fire properties as a disadvantage where the property owners are the most critical. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, the reason this factor creates value is because of its fire characteristics resulting in a more predictable fire compared to other frame materials. Furthermore, massive wood's fire properties prevent value because of lack of knowledge and uncertainty regarding fire safety and massive wood as frame material, especially for end users and insurance companies. This is consistent with the results of the study conducted by Espinoza et al. (2016) indicating that fire resistance is an important topic for further research and the arguments presented by Roos, Woxblom and McCluskey (2009), that the opinions of wood's fire resistance properties are fragmented, with some that emphasize the lower resistance to fire while other emphasize the increased predictability of the fire with wood and how that simplifies the design phase of a construction project. To summarize, factor 5 is an important potential sustainable value creation factor for most of the actors in the construction value chain and it both creates value and prevents value creation.

The factor 6, *massive wood's impact on the stability of the construct*, is one of the most important economic factors for the actors in the construction value chain. Only private property owners do not see it as one of the most important economic factors. Factor 6 is seen as both an advantage and a disadvantage for public property owners and for structural engineers, however, for architects and construction contractors, the factor is mainly seen as an advantage. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood's impact on the stability of the construct creates value if the buildings are not too high, because of its high strength to weight ratio. This is in line with Hurmekoski, Jonsson and Nord (2015), who argue that actors in the construction value chain see that wood-frame multi-storey construction meet structural strength requirements as an advantage, and Roos, Woxblom and McCluskey (2009), arguing that architects and structural engineers see advantages with wood as frame material because of its strength in relation to weight. However, based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood's impact on the stability of the construct prevents value creation in construction projects of high buildings, because high buildings require more weight to be stable and massive wood has a relatively low density. This is consistent with Roos, Woxblom and McCluskey (2009), who argue that structural engineers and architects see the lower stability of a building with massive wood as frame material as a disadvantage. To sum up, factor 6 is an important potential sustainable value creation factor for most of the actors in the construction value chain and it both creates value and prevents value creation.

The factor 8, *massive wood's impact on the life span of the building,* is one of the most important economic factors for most of the actors in the construction value chain. For property owners it both creates value and prevents value creation, for structural engineers the factor seems to create value. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, the reason it both creates value and prevents value creation might be that the opinions of massive wood's impact on the life span of the building are fragmented. It might prevent value if the technical life span of a building with massive wood as the frame material is presumed to be shorter compared to concrete and steel as the frame material, which is explained to possibly be the case if, for example, the wood-frame is visible and not properly designed and maintained. Furthermore, a possible explanation of why it for some respondents creates value is if the life span of the building is presumed to be comparable with a building in another frame material, for example when the wood-frame is built-in and properly built. As Ramage et al. (2017), who claim that the durability of structural wood elements is equivalent to other materials, if this is the view of the respondents, it should at least not prevent value to be created. Instead, in line with the results presented by Espinoza et al. (2016), that the availability of technical information is a barrier for CLT adoption and that there is a need for future research about the durability of wooden buildings, we argue that this is an indication that it is a need for the information, knowledge and the experience to be strengthened in the industry. To sum up, factor 8 is an important potential sustainable value creation factor for most of the actors in the construction value chain and it both creates value and prevents value creation.

The factor 9, *massive wood's impact on the construction time,* is an important economic factor in the construction value chain, especially for public property owners, structural engineers and construction contractors. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood's impact on the construction time creates value since the construction time of using massive wood as frame material often is viewed as shorter compared to the construction time with other frame materials. A short construction time creates value because it for examples results in a shorter time until the workers on the construction site can work on another project, thus, increases the productivity of the construction process. A shorter construction time also results in a shorter time until rental revenues are generated. Tightly connected to factor 9 is the factor: *massive wood's impact on the possibility of prefabrication*. The connection between these two factors are consistent with the arguments by Brege, Nord and Stehn (2017) and Hurmekoski (2017), who argue that the level of prefabrication impacts the construction time where a higher level of prefabrication usually implies a shorter construction time. As can be seen in section *4.3 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material*, *massive wood's impact on the possibility of prefabrication* is seen as an advantage by all actors in the construction value chain, thus, massive wood is perceived to be suitable for prefabrication. Even though *massive wood's impact on the possibility of prefabrication* is not one of the most important factors for actors in the construction value chain, if a high level of prefabrication enables shorter construction times, the factor enables value creating for the actors through the contribution to short construction times. Thus, factor 9 creates sustainable value in the construction value chain.

The factor 10 and 17, *the amount of massive wood waste arising at the worksite* and *from production of the frame material*, are two of the most important environmental factors for architects, which view both factors as important value creators. Furthermore, construction contractors view factor 10 as an important value creator. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, value is created when the waste generated is minimized by high precision of the products, in high flexibility in possible dimensions of the products and when there are solutions in order to reduce the waste or reuse the waste. This, because it is explained that no one is interested in paying for material which is not used. This explanation might be an argument for the factor to be viewed as an economic factor instead of an environmental factor. The view that this factor is value creating is consistent with Hurmekoski (2017), who argue that construction with wood can reduce the total material use, and thus, the waste amount. Thus, factor 10 and 17 create sustainable value for actors in the construction value chain.

The factor 11, *massive wood's modifiability*, is one of the most important social factors in the construction value chain, especially for structural engineers and construction contractors which both view this factor as an important value creator. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, it is the simplicity and low noise level of processing wood compared to for example concrete, thus, that it is easy and pleasant to make adjustments and installations on the construction site while necessary, that creates value. Thus, this factor might be connected to factor 2 and 21, regarding safety and working environment since the modifiability of the material enables the requirements of those factors to be fulfilled. Modifiability is also something actors in the construction value chain, more specifically architects and engineers, see as an advantage with wood-frame multi-storey construction according to Hurmekoski, Jonsson and Nord (2015). To summarize, factor 11 is an important factor that creates sustainable value in the construction value chain.

The factor 12, *massive wood's compatibility with other building materials/systems*, is one of the most important social factors for public property owners and construction contractors who view this factor as a value creator. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, *massive wood's compatibility with other building materials/systems* is value creating because massive wood products like CLT are viewed as relatively predictable even though they are organic, this because CLT is cross laminated. Furthermore, *massive wood's compatibility with other building materials/systems* might be value creating because massive wood does not react with other materials, for example, it does not rust in contact with other materials which can be a challenge with alternative frame materials. That multiple material suppliers are needed in a project because the material suppliers of massive wood do not provide complete solutions in their offerings can, according to the interviews, impact massive wood's compatibility with other building materials/systems negatively and therefore prevent value creation. This, because to put together a complete solution with different materials and products from different suppliers is explained to be challenging. To sum up, factor 12 seems to be an important factor for creating sustainable value in the construction value chain.

The factor 13, *the impact on massive wood from rain and moisture during construction*, is one of the most important factors in the construction value chain, especially for public developers for who this factor is preventing value creation and for construction contractors for who this factor both creates value and prevents value creation. It can further be seen that respondents with no experience of using massive wood as frame material are more likely to view this factor as a disadvantage than respondents with experience. For example, if dividing construction contractors based on level of experience, this is a factor preventing value to be created for the respondents with no earlier experience while it both creates value and prevents value creation for the construction contractors with earlier experience. Further, *the impact on massive wood from rain and moisture during construction* is the main disadvantage actors in the value chain generally see with massive wood as frame material. 50 percent of all the respondents see the impact on massive wood from rain and moisture during construction as a disadvantage where the property owners, structural engineers and construction contractors are the most critical. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, *the impact on massive wood from rain and moisture during construction*, prevents value if how to manage this becomes a challenge in a project, and if the used solutions do not work or are costly. That the impact on massive wood from rain and moisture is seen as a disadvantage for the actors in the construction value chain is well known, and the result is consistent with Roos, Woxblom and McCluskey (2009), who argue that the lower moisture resistance of wood is seen as a disadvantage of the material. However, beyond architects and structural engineers, this factor seems to be important for property owners and construction contractors as well. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, *the impact on massive wood from rain and moisture during construction* can also create value for actors if the actors view the use of a massive wood frame as an advantage when it comes to the impact from rain and moisture because of the fast assembly of a massive wood frame. Thus, the time until the building is climate-proof is short. To summarize, factor 13 is an important factor that both creates sustainable value and prevents sustainable value creation in the construction value chain.

The factors 14, 15 and 16, that *massive wood is fossil free, renewable and has carbon storage properties*, are material properties which basically all the respondents of the survey and all the interviewed actors see as advantages, and many see them as great advantages regarding massive wood as frame material. However, it is only the architects that view these factors as the most important environmental factors for them to prefer a certain frame material generally. Based on the interviews, presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, these factors create value because they contribute to a better environment and a more sustainable future. Less impact on the environment and sustainability are also things developers and commissioners and architects and engineers see as advantages with wood-frame multi-storey construction according to Hurmekoski, Jonsson and Nord (2015), and it is also consistent with Roos, Woxblom and McCluskey (2009) arguing that architects and structural engineers see advantages with wood's positive climate properties regarding carbon storage. However, those factors are not always demanded, but when they are, when environmental sustainability of the construction is demanded by the customer, they seem to be some of the main value creators of massive wood as construction material, and massive wood seems to have a competitive advantage over other materials. To sum up, factor 14, 15 and 16 are important factors that creates sustainable value in the construction value chain.

The factors 18, 19 and 20, *the amount of greenhouse gas emissions arising from handling of massive wood at the construction site, from production* and *from transportation of the massive wood*, are, as for factor 14, 15, and 16 above, seen as advantages by basically all the respondents, but only the responding architects see them as important environmental factors for them to prefer a certain frame material generally. Based on the interviews, presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, the lower the amount of greenhouse gases emitted, the more value seems to be created. The amount of greenhouse gas emissions from transporting massive wood seems to create value because it is lower in comparison to when concrete or steel is used. This, because of massive wood's relatively light weight, resulting in the possibility of transporting a larger volume and therefore fewer transports are needed. That these factors are value creating is in line with the earlier consensus in the research, for example Sathre and O'Connor (2010), Mahapatra et al. (2012) and Hurmekoski (2017), who argue that the total emissions of the production, as well as over the life cycle, in almost all cases are lower for wood-frame building materials compared to the use of other building materials. To summarize, these factors, as factor 14, 15 and 16 above, seem to be important sustainable value creators when environmental sustainability is demanded by the customer.

The factor 23, massive wood's *acoustic properties*, seems to be one of the most important social factors for public property owners. According to the results from the survey, it is one of the main disadvantages the actors in the value chain generally see with massive wood as frame material. 41 percent of the respondents see massive wood's acoustic properties as a disadvantage where the property owners and the structural engineers are the most critical. This is in line with Hurmekoski, Jonsson and Nord (2015), who argue that developers and commissioners, architects and engineers and builders and contractors all see acoustic properties/acoustic performance as disadvantages of wood-frame multi-storey construction. Based on the interviews presented in section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages* above, massive wood's acoustic properties prevent value creation because of the challenge of meeting the wanted acoustics requirements where low frequencies like step sounds are the main challenge and the need for increased dimensions in beams to meet the requirements. This is in line with Roos, Woxblom and McCluskey (2009), who argue that architects and structural engineers see a disadvantage with massive wood as frame material regarding the demand for increased dimensions in beams and walls in order to fulfill the acoustic demands. On the other hand, massive wood's acoustic properties also seem to create value because of what some interviewees explain as a special, soft, acoustic feeling in a room of a building in massive wood, appreciated by many people and thus is connected to the indoor environment for the end-user. To sum up, factor 23 is an important factor that both creates sustainable value and prevents sustainable value creation in the construction value chain.

5.2.1 Summary of how Massive Wood Enables or Prevents Value to be Created

To answer research question 2, *what enables and prevents sustainable value creation with massive wood as frame material*, the factors identified to be the most important potential economic, social and environmental value creating factors for the actors in the construction value chain, and if these factors are viewed as advantages and thus creating value or disadvantages and thus preventing value creation is presented in table 9 below.

Table 9: The most important potential sustainable value creating factors in the construction industry and if value is created, prevented or both for these factors when it comes to massive wood as frame material.

Nr	Potential Value Creating Factor	Creates/ prevents value
1	Massive wood's impact on the **[material costs in the project]**	+/-
2	Massive wood's impact on the **[construction site's safety]**	+
3	Massive wood's impact on the **[energy consumption in the operation of the building]**	+
4	Massive wood's impact on the **[indoor environment for the end user]**	+
5	Massive wood's **[fire properties]**	+/-
6	Massive wood's impact on the **[stability of the construct]**	+/-
7	Massive wood's **[heat and cold insulating properties]**	+
8	Massive wood's impact on the **[life span of the building]**	+/-
9	Massive wood's impact on the **[construction time]**	+
10	The amount of **[massive wood waste arising at the worksite]**	+
11	Massive wood's **[modifiability]**	+
12	Massive wood's **[compatibility with other building materials/systems]**	+
13	The impact on massive wood from **[rain and moisture during construction]**	+/-
14	That massive wood is **[fossil free]**	+
15	That massive wood is **[renewable]**	+
16	That massive wood has **[carbon storage properties]**	+
17	The amount of **[massive wood waste arising from production of the frame material]**	+
18	The amount of **[greenhouse gas emissions arising from handling of massive wood at the construction site]**	+
19	The amount of **[greenhouse gas emissions arising from production of massive wood]**	+
20	The amount of [**greenhouse gas emissions arising from transportation of massive wood]**	+
21	Massive wood's impact on the **[construction site's general working environment]**	+
22	Massive wood's impact on the **[appearance of the building]**	+
23	Massive wood's **[acoustic properties]**	+/-

Thus, for the factors that creates value, presented in table 9 above, there is a coherence (fit) between what is valued in the construction value chain and the respondents' view of a material supplier's value proposition. However, for the other factors, there is less coherence (fit), and those factors prevents value to be created. Therefore, a material supplier needs to develop a business model with a value proposition that both generates this sustainable value, and manages the factors preventing the sustainable value to be created.

Generally, for the factors, massive wood is more likely to be viewed as an advantage for the respondents with experience of using massive wood as frame material and more likely to be viewed as a disadvantage for the respondents with no experience of using massive wood as frame material. Thus, the knowledge and experience of using massive wood impact if the factor creates value or prevents value creation and more knowledge and experience will increase the value creation. This is in line with Hurmekoski, Jonsson and Nord (2015) who argue that the less experienced of working with massive wood as frame material, which is the majority of the actors, tend to be more skeptical and the skepticism is explained to be based on perceptions of costs, fire safety, stability and durability. Furthermore, Lessing (2010) claims that information deliveries regarding massive wood are not produced in the needed rate, which further strengthens this view.

5.3 What Elements in a Wood-Frame Material Supplier's Business Model could be used to Create and Deliver this Sustainable Value?

In this section, research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value*, is answered. See figure 80 below for this section's relation to the other sections in the analysis and figure 81 below for an illustration of what is analyzed in the Model of Analysis.

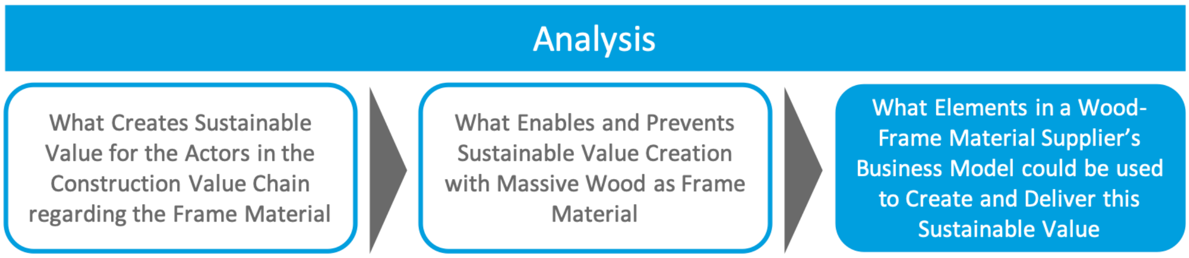

Figure 80: This section's relation to the other sections of the analysis.

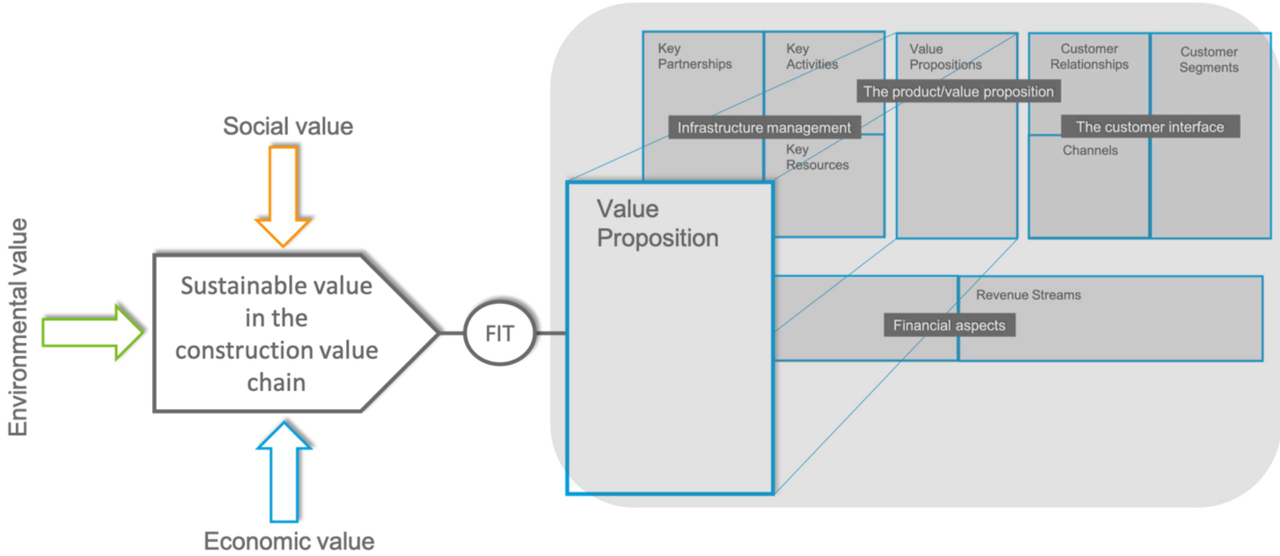

Figure 81: What is analyzed, illustrated in the Model of Analysis.

To understand how a material supplier, in the wood-frame multi-storey construction industry, can create and deliver this value through their business model, what elements in the business model that can contribute to sustainable value creation are analyzed. Elements which can be used to create and deliver sustainable value are identified based on what creates sustainable value for the actors in the construction value chain, see section *5.1 What Creates Sustainable Value for the Actors in the Construction Value Chain regarding the Frame Material*, what enables and prevents sustainable value creation, see the analysis in section *5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material* and what the actors in the value chain have explained as important elements for increasing the value creation for them, see section *4.3.8 Why the Potential Sustainable Value Creating Factors are viewed as Advantages or Disadvantages*.

5.3.1 The Products/Value Proposition

Factor 14, 15 and 16, *that massive wood is fossil free, renewable* and *has carbon storage properties* and factor 11, *massive wood's modifiability*, factor 7, *massive wood's heat and cold insulation properties,* and factor 12, *massive wood's compatibility with other building materials/systems* are material properties which creates value for the actors in the construction value chain. Because the value is due to material properties, the value is created through what the material supplier offers, thus, that they offer modifiable, renewable, fossil free products which have carbon storage properties, good heat and cold insulating properties and compatible with other building materials and systems. Therefore, to offer products with valued material properties seems to be important for a material supplier to create sustainable value for the actors in the value chain. In Stora Enso Building Solutions' case, they offer products of *CLT*, *LVL* and *Glulam*, products which have these material properties and therefore they create and deliver sustainable value. However, Müller (2012) explains how all customers may not value or understand the value of sustainability. This seems to be in line with the results of the survey; all the respondents do not see these factors as advantages and thus, all the respondents do not value these material properties. Müller (2012) further explains that a sustainable value proposition usually describes activities with the purpose to inform and explain the sustainable value to the customer. Therefore, a material supplier could go beyond just offering these material properties and also inform and explain their sustainable value to the customer.

Factor 2 and 9, *massive wood's impact on the construction site's safety* and *impact on the construction time,* both are connected to the prefabrication level of the products. A higher prefabrication level implies both higher safety on the construction site and shorter construction times, which creates value for the actors in the value chain. Hurmekoski (2017) and Brege, Stehn and Nord (2014) argue that massive wood is well suited for prefabrication. Therefore, to offer solutions for a high prefabrication level seems to be important for a material supplier in order to create sustainable value for the actors in the value chain. However, Brege, Stehn and Nord (2014) also explain that a high prefabrication level implies challenges when it comes to the coordination of subcontractors and the adaptation to varying client conditions. Therefore, the material supplier needs to take their ability to coordinate subcontractors and their goal regarding flexibility in meeting customer demands and building specifications into consideration when they decide their prefabrication level. A high prefabrication level could be reached either by providing resources internally, or externally through collaboration with partners, based on what's the most suitable with the strategy of the material supplier.

Factor 12, *massive wood's compatibility with other building materials/systems* are connected to the need of multiple material suppliers and actors in a project because the material suppliers do not provide complete solutions of products and services in their offerings, which seems to prevent value creation. According to the interviews with the actors, there is a demand for complete solutions; solutions including all the products and services needed in the project and design, manufacturing and assembly of the elements. In line with this, Brege, Stehn and Nord (2014) also explains how the customers may request the producer to provide onsite assembly capacities and coordination with technical sub-consultants such as architects and structural engineers during the design phase. Therefore, to offer complete solutions seems to important for a material supplier in order to create sustainable value for the actors in the value chain. However, Brege, Stehn and Nord (2014) argue that the offering of more complete solutions, for example by providing onsite assembly capacities, implies a degree of risk-taking for the material supplier and therefore, we argue that this higher risk has to be taken into consideration. Meeting the demand of more complete solutions could be done either by providing resources internally, or externally through collaboration with partners which is further analyzed in section *5.3.3 Infrastructure Management below.*

Regarding some of the factors that prevent value to be created, such as factor 5, *fire properties*, factor 6, *the stability of the construct,* factor 13, *the impact from rain and moisture* and factor 23, *acoustic properties,* there is still clearly a lack of knowledge and experience in the construction value chain. In some cases, the value prevention might even be due to misconceptions from the actors in the value chain and not due to actual limitations of the material or offering. As explained, Hurmekoski, Jonsson and Nord (2015) argue that the less experienced of working with massive wood as frame material tend to be more skeptical and the skepticism is explained to be based on perceptions of costs, fire safety, stability and durability. According to the interviews with the actors, the development and communication of clear standard solutions and to offer services for guidance might be value creating because it simplifies the knowledge transfer to the actors and decrease misconceptions. Lessing (2010) also claims that information deliveries regarding massive wood are not produced in the needed rate, which further strengthens this view. Therefore, in order to create and deliver value for the actors in the construction value chain, to offer standard solutions and services for guidance of how to manage some of the main challenges actors in the value chain see with massive wood as frame material, for example, how meet the acoustics requirements and fire safety requirements, how to manage the lower density of massive wood regarding stability and how to manage the impact on massive wood from rain and moisture, can be used. Furthermore, that the standard solutions and the services for guidance are available in multiple languages might, according to the interviews with the actors, be important to decrease the language barriers, thus increase value creation for more people.

From the interviews with the actors, practical examples of value creating standard solutions were identified. For example, standard solutions for how to cover joints and a tool calculating the required drying time for massive wood can be standard solutions to manage factor 13, *the impact on massive wood from rain and moisture in the construction phase*. Stora Enso Building Solutions have for example the service *Technical Support,* with internal resources with competences to support the customer in technical issues regarding for example acoustics and fire which is free of charge for all customers.

Sustainability is a strong market trend and, according to the interviews with the actors, to visualize wood can therefore be used as a tool to strengthen brand/image and as a statement of sustainable responsibility from a firm or an individual. Therefore, enabling visually exposed wood in a building seems to be value creating in some cases. At the same time, it is viewed as a challenge to have visually exposed wood in the building. Factors which can be viewed as challenges when the wood is visually exposed and need to be managed in order to be able to visualize the wood is factor 5, *massive wood's fire properties*, factor 8, *massive woods impact on the life span of the building* and factor 13, *the impact from rain and moisture during the construction phase* and factor 23, *massive wood's acoustic properties*. For example, if the massive wood is visually exposed, it is also more important to cover it from rain and moisture during the construction phase, fire-resistant paint might be needed due to regulations and to have an awareness of the ageing of the visually exposed is critical. Therefore, to offer solutions to enable visually exposed wood in the building seems to a way for a material supplier to create sustainable value for the actors in the value chain. To spread knowledge and offer standard solutions of how to enable visually exposed wood in a building and manage the explained challenges would also help creating and delivering value of factor 4 and 22, *massive wood's impact on the indoor environment for the end user* and *massive wood's impact on the appearance of the building.*

To reduce the amount of frame material waste at the construction site, thus, creating value for factor 10, *the amount of massive wood waste arising at the worksite* is value creating. Based in the interviews with actors, if the products have the high precision when they arrive at the construction site, the frame material waste can be reduced. Therefore, to offer flexibility and precision in products, for example, by providing products with high precision and with a wide range of dimension options seems to be important for a material supplier to create sustainable value for the actors in the value chain.

Based on the interviews with actors, hybrid materials and/or hybrid systems, with a combination of steel, wood and concrete, could be solutions to some of the main challenges actors in the construction value chain see with massive wood as frame material and therefore help create and deliver value for the potential value creation factors 5, *massive wood's impact on the fire properties*, factor 23, *massive wood's acoustic properties* and factor 6, *massive wood's impact on the stability of the construct*. In the interviews with the actors, the different materials are argued to have their own advantages and disadvantages and if they are combined in a project, one might benefit from all of their different properties. Therefore, to offer hybrid materials and/or hybrid systems seem to be important for a material supplier to create sustainable value for the actors in the value chain.

To sum up, we propose that a material supplier can offer the following products, services and solutions in order to create and deliver sustainable value:

- *products with valued material properties,*
- *solutions for a high prefabrication level,*
- *complete solutions,*
- *standard solutions and services for guidance,*
- *solutions to enable visually exposed wood,*
- *products with high precision and with wide range of dimension,* and lastly
- *hybrid materials and/or hybrid systems*.

Osterwalder (2004) describes the *Product*/*Value Proposition* pillar of the business model as an overall view of an organization's bundle of products and services which provide value to the organization's customers. Furthermore, Osterwalder and Pigneur (2010) emphasize that the *value proposition* block of the business model defines the value proposition, the products and/or services which solves customer problems or satisfy customer needs and therefore create value for a customer segment. Therefore, to offer the products, services and solutions we propose in order to create and deliver sustainable value can be categorized to the *Product/Value Proposition* pillar and the *value proposition* block of the business model.

These value proposition elements, we argue, should be developed in line with what Anderson, Narus and van Rossum (2006) argue is the best kind of value proposition, the *resonating focus* proposition, which focuses on the points of difference which deliver the greatest value to the customers. For a material supplier, in the wood-frame multi-storey construction industry, to be able to create and deliver sustainable value to their customers they therefore have to develop different value propositions for each customer segment, see section *5.3.2 The Customer Interface* below for an analysis of different customer segments, where they focus on the sustainable value creating factors, or points of difference, which deliver the greatest value to that specific customer segment. According to Anderson, Narus and van Rossum (2006), to be able to provide a resonating focus proposition, knowledge about how the organization delivers superior value compared to the competitors is also required. Therefore, material suppliers need to understand how the other material suppliers in the wood-frame multi-storey construction industry deliver sustainable value and based on that knowledge develop a resonating focus value proposition which offers superior sustainable value.

Furthermore, it is not enough to create and deliver what actors in the value chain view as sustainable value. The customer might value things which do not fit with sustainability and therefore Müller (2012) argues that a distinction between needs and satisfiers are needed. The author claim that the sustainable value proposition needs to explain how the customers' needs can be satisfied in a sustainable way. Therefore, in order for a material supplier to develop a sustainable value proposition they need to create and deliver sustainable value and do this in a sustainable way.

5.3.2 The Customer Interface

As discussed in section *5.1.1 Which Actors a Material Supplier should Create and Deliver Sustainable Value to*, a material supplier in the wood-frame multi-storey construction industry needs to create and deliver sustainable value to all the actors in the construction value chain. Therefore, all actors in the construction value chain could be viewed as customers. This is in line with how Stora Enso Building Solutions view the actors in the value chain; they view all the actors in the value chain as their customers, either paying or non-paying customers.

The analysis of the survey indicates differences between what creates sustainable value for the different actors in the value chain, thus, segmentation by actors, and therefore segmentation based on common needs and behaviors, seems to be viable. This is in line with Osterwalder and Pigneur (2010), who argue that customers should be grouped into segments with common needs or behaviors because it makes it easier to satisfy their needs and wants. To further segment the customers by the level of experience seems to be viable since the view of massive wood sometimes differs with different level of experience. As described in section *5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material*, massive wood is more likely to be viewed as an advantage for the actors in the value chain with experience of using massive wood as frame material and more likely to be viewed as a disadvantage for the actors with no experience of using massive wood as frame material. Thus, the level of experience impact if the factor creates value or prevents value creation where more experience increases the value creation.

To sum up, we argue that a way for a material supplier to facilitate better satisfying of customers' needs and wants, and thus to be able to create and deliver sustainable value, is:

- *segmenting customers by type of actor* and
- *level of experience.*

This segmentation must not be interpreted as exhaustive, multiple other possible segmenting dimensions, both wider and more detailed, not investigated in this thesis probably exists.

Osterwalder (2004) describes that the *customer interface* pillar of the business model includes the segment of customers the organization wants to create and deliver value to. Furthermore, Osterwalder and Pigneur (2010) explain that the *customer segments* block of the business model defines the different customer segments the organization wants to reach and serve. Therefore, the way we argue a material supplier can use to facilitate better satisfying of customers' needs and wants, and thus to be able to create and deliver sustainable value, can be categorized to the customer interface pillar and customer segments block of the business model.

As described in *5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material*, there is still is a lack of knowledge regarding massive wood in the industry which prevent value creation. Section *5.3.1 The Products/Value Proposition* is a clear indication of this, where standard solutions and guidelines of how to manage practical issues are identified as factors which can create sustainable value. Furthermore, Lessing (2010) claims that information deliveries regarding massive wood are not produced in the needed rate. Thus, efforts to get the knowledge of massive wood spread is needed. For example, based on the interviews with actors, to get the knowledge about the fire characteristics of massive wood spread, not only to the actors in the construction value chain but to the end users, insurance companies and society at large too, are important in order for massive wood's perceived fire properties not to be a factor preventing value creation.

Stora Enso Building Solutions emphasize reference projects as an important channel for marketing and communication with new customers, see section *4.5.2 The Customer Interface*. Reference projects are also proposed as a good channel that material suppliers can use in order to spread knowledge, according to the interviews with actors. In line with this, Anderson et al. (2006) argue that the cost saving or added value of a value proposition can be demonstrated by using value case histories. With value case histories, the cost saving or added value reference customers have received from the organization's offering are documented and presented to potential new customers. The description of value case histories is in line with the reference projects used by Stora Enso Building Solutions and we therefore argue that the use of these reference projects could be a way to communicate with new customers. Another way to manage the lack of knowledge of using massive wood as frame material is, based on the interviews with actors, collaboration with universities. Based on the interviews with actors, through collaboration with universities, knowledge of massive wood and how to use it can be learned by students in architecture, structural engineering and construction at universities which will then increase the knowledge in the value chain in a long-term perspective.

To sum up, we argue that a way for material suppliers to increase the total knowledge in the value chain, and therefore increase sustainable value creation, are channels such as:

- *the use of reference projects* and
- *collaborations with universities*.

Osterwalder (2004) includes an organization's means of getting in touch with their customers to the *customer interface* pillar of the business model. Furthermore, Osterwalder and Pigneur (2010) emphasize that the *channels* block of the business model explains the channels the organization uses; the way the organization reaches and communicates with their customer segments to be able bring their value proposition to market. Therefore, the channels we argue a material supplier can use to reach the actors in the value chain and spread the knowledge about massive wood, and therefore increase sustainable value creation, can be categorized to the customer interface pillar and the channels block of the business model.

Based on the interviews with actors, actors in the construction value chain have a demand for more knowledge and information of how to, for example, manage challenges with massive wood. The interviewees explain that they want the material supplier to offer this through for example services for guidance. Based on the interviews, there is also a demand for more complete solutions, solutions including all the needed products in the project and design, manufacturing and assembly, from the material supplier. Therefore, it looks like the customers want a relationship which extends beyond the role of just delivering the material. As earlier presented, Osterwalder and Pigneur (2010) argue that customers should be grouped into segments with common needs or behaviors because it makes it easier to satisfy their needs and wants. Therefore, we argued that a viable way of segmenting a material supplier's customers is by actor and level of experience. This also implies that the material supplier needs to treat their customers different, thus, have different customer relationships with each customer segment, in order to satisfy each customer segment's needs and wants. This, because the different customer segments have different factors which provide value and prevent value creation.

Therefore, we argue that a way for a material supplier to facilitate better satisfying of customers' needs and wants, and thus to be able to create and deliver sustainable value, is to develop customer relationships which are:

- *customized in order to create as much value for each segment as possible* and
- *extended beyond the role of just delivering the material.*

Osterwalder (2004) describes the type of link the organization establishes between themselves and their customers as a part of the *customer interface* pillar of a business model. Moreover, Osterwalder and Pigneur (2010) emphasize that the *customer relationship* block of the business model describes the different relationships the organization has with their customer segments. Therefore, the types of customer relationships we argue can be categorized to the customer interface pillar and customer relationships block of a business model.

5.3.3 Infrastructure Management

As described in *5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material* factor 1, *massive wood's impact on the projects' material costs*, factor 19 and 20, *the amount of greenhouse gas emissions arising from production* and *transportation of the massive wood* and for factor 17, *the amount of massive wood waste arising from production of the frame material* are creating sustainable value**.** The value creation of those factors is linked to the infrastructure management of the material supplier. Further, as described in section *4.5.3 Infrastructure Management*, Stora Enso Building Solutions emphasize that important resources in order to deliver their value proposition is their production facilities, with high production capacity, and their integrated logistic network. Thus, Stora Enso Building Solutions core competencies seems to be their production and supply chain management, in line with what Lessing and Brege (2015) claim is typical for a production-oriented house-building company. A high production capacity enables cost-efficiency, and if an integrated logistic network leads to an efficient production regarding costs, waste and greenhouse gas emissions, it can contribute to create sustainable value for all factors mentioned in the section above. Further, that the production facilities are located so that the *amount of greenhouse gas emissions arising from transportation of the massive wood* is minimized, does create sustainable value. In other words, the factors creating sustainable value for the actors in the value chain, and the production-orientation of Stora Enso Building Solutions, regarding the above-mentioned resources, seems to cohere.

Brege, Stehn and Nord (2014) claim that delivering of floor/wall elements might require resources such as onsite assembly capacities and coordination with technical sub-consultants such as architects and structural engineers during design phase, but that it at the same time implies a degree of risk-taking that is affecting the business model of the producer. Stora Enso Building Solutions seems to have managed this issue by using a strategy with intellectual and human resources such as R&D and technical excellence offered internally, but the main part of the resources offered externally, through partnerships. These intellectual and human resources can be used to deliver services and complete solutions, thus, to create sustainable value.

Therefore, we argue that the following elements of a material supplier business model can be used to deliver a value proposition which creates sustainable value:

- *Production facilities that enables large volumes, short delivery times and generates low amounts of greenhouse gas emissions and waste.*
- *Intellectual and human resources to deliver the services and complete solutions required by the customers.*

Osterwalder (2004) includes the resources that are necessary for an organization in order to create value for a customer to the *infrastructure management* pillar of a business model. Furthermore, Osterwalder and Pigneur (2010) emphasize that the *key resources* block of the Business Model Canvas presents the organization's key assets the organization needs in order to deliver their value proposition and enable the rest of the business model. Therefore, the resources we argue a material supplier can use to deliver a value proposition which creates sustainable value can be categorized to the infrastructure management pillar and the key resources block of a business model.

As described in section *5.2 What Enables and Prevents Sustainable Value Creation with Massive Wood as Frame Material,* a production with high cost-efficiency, low greenhouse gas emissions and capabilities to meet flexible customer demands would contribute to the value creation regarding factor 1, *massive wood's impact on the project's material costs,* factor 10 and 17*, the amount of massive wood waste arising from production* and *at the worksite* and also factor 19, *the amount of greenhouse gas emissions arising from production of massive wood*. Thus, a production with high cost-efficiency, low greenhouse gas emissions and high capacity to meet flexible customer demands is an important key activity in order to create sustainable value.

Furthermore, efficient transportation is a key activity in order to create and deliver value for the factor 20, *the amount of greenhouse gas emissions arising from transportation of the massive wood.* This factor creates value if the amount of greenhouse gas emissions is low, thus, it is critical to transport as short distances as possible, optimize the amount of wood on each transport in order to reduce the number of required transports and use environmentally friendly transport options.

We have already seen that the knowledge of massive wood impact if the factor creates value or prevents value creation and more knowledge and experience will increase the value creation. This is in line with Hurmekoski, Jonsson and Nord (2015) who argue that an actor less experienced of working with massive wood as frame material, who therefore has less knowledge of massive wood, tend to be more skeptical. Furthermore, Lessing (2010) claims that information deliveries regarding massive wood are not produced in the needed rate and Müller (2012) explains how all customers may not value or understand the value of sustainability and that the sustainable value therefore have to be informed and explained to the customer. Thus, in order to increase the knowledge, communication is an important activity for material suppliers in order to create sustainable value. For the factors which are viewed as advantages, these factors should be communicated to increase the value. For the factors which are viewed as disadvantages, communication in order to spread knowledge of how to manage possible challenges and counteract misconceptions seems to be central.

Generally, some of the main disadvantages the actors see with massive wood, and therefore factors which prevent value creation, are massive wood's *acoustic properties*, massive wood's *fire properties* and the *impact on massive wood from rain and moisture.* Communication regarding how to manage these challenges with standard solutions and guidance are important. The increased productivity with using massive wood as frame material is also something which is important to communicate, this, because it can create value for the factor 9, *massive wood's impact on the construction time*, and therefore compensate financially for an eventual higher cost of the frame material. Furthermore, in order to create value, the material supplier can communicate how the life span of the building is affected by the choice of massive wood as frame material. This, since value is prevented from being created if one believes that the life span is reduced. Moreover, in order to create value for factor 10 and 17, the amount of *massive wood waste arising at the worksite and from production of the frame material* have to be minimized. Therefore, a material supplier of massive wood can communicate how they minimize the waste in production, if they for example use the waste for something else, and they can also communicate how to minimize the waste on the worksite.

To sum up, we argue that the following elements in a material supplier's business model can be used to deliver a value proposition which creates sustainable value:

- *A production with high cost-efficiency, low greenhouse gas emissions and capabilities to meet flexible customer demands.*
- *An efficient transportation that decreases the amount of greenhouse gas emissions.*
- *Communication of the sustainable value creating factors to each customer segment. Communication of how to manage the factors preventing value creation for each customer segment.*

According to Osterwalder (2004), the arrangements of activities which are necessary for the organization to create value to their customers are included in the *infrastructure management* pillar of the business model. Moreover, according to Osterwalder and Pigneur (2010), the *key activities* block of the business model presents the key activities, the most important activities the organization have to perform in order to deliver the value proposition and enable the rest of the business model. Therefore, the activities which we argue are important in order to deliver the value proposition needed to deliver sustainable value to the actors in the value chain can be categorized to the infrastructure management pillar and key activities block of a business model.

As described in *5.3.1 The Products/Value Proposition* above, in order to offer some of the proposed products and services, external partners can be used. For example, to offer complete solutions and hybrid solutions seem to be a way for a material supplier in order to create sustainable value for the actors in the value chain. Meeting this demand could be done either by providing resources internally, or externally, through collaboration with partners. Additionally, a higher prefabrication level implies both higher safety on the construction site and shorter construction times, which creates value for the actors in the value chain. Furthermore, a high prefabrication level could be reached either by providing resources internally, or externally through collaboration with partners.

Payne, Frow and Eggert (2017) explain that some researchers argue how organizations have to engage with other actors in the value chain to be able to deliver an appropriate value proposition and engage and interact with a broad range of stakeholders to enable resource integration. Additionally, Brege, Stehn and Nord (2014) argue that to provide for example onsite assembly capacities can imply a degree of risk-taking for the material supplier which affect their business model. If looking at Stora Enso Building Solutions, they use external resources in order to enable more complete solutions for their customers to build with massive wood, without having all the resources internally in their own organization. According to themselves, the partnerships allow them to be flexible in meeting the customers' demands and to perform cost efficient processes. Thus, it seems like partnerships can be used in order for a material supplier, which does not have all the resources needed to offer complete and hybrid solutions with a high level of prefabrication internally, to be flexible in meeting their customers' demands and therefore, create value for the actors in the construction value chain. This without increasing their risk-taking.

Osterwalder and Pigneur (2010) distinguish different motivators for creating partnerships: economy of scale, optimization, risk and uncertainty reduction, resource and activity acquisition. According to this, Stora Enso Building Solutions key partnerships and the proposed solutions above with key partnerships with actors in the value chain and key partnerships with suppliers of other materials/products in order to offer complete and hybrid solutions can be motivated by at least economy of scale, risk and uncertainty reduction and activity acquisition.

To sum up, we propose that the following elements in a material supplier's business model can be used to deliver a value proposition which creates sustainable value:

- *Partnerships with actors in the value chain to be able to offer complete solutions and high level of prefabrication.*
- *Partnerships with other suppliers of materials and products to offer hybrid solutions.*

Osterwalder (2004) includes the voluntarily initiated cooperative agreement between the organization and other organizations in order to create value to the organization's customers in the *infrastructure management* pillar of the business model. Furthermore, according to Osterwalder and Pigneur (2010), the *key partnerships* block of the business model explains the organization's supplier and partner networks. Therefore, the partnerships which are important in order to deliver the value proposition needed to deliver sustainable value to the actors in the value chain can be categorized to the infrastructure management pillar and key partnerships block of the business model.

5.3.4 Financial Aspects

Factor 1, *massive wood's impact on the material costs in the project,* is a factor that both creates value and prevents value creation in the construction value chain. Based on Stora Enso Building Solution's described revenue streams and based on the interviews with the actors, a material supplier in the wood-frame multi-storey construction industry normally receive their revenues from only the customer segment construction contractors. Interestingly, the construction contractors, that is directly invoiced for the costs of the frame material, see the factor as a value creator. Osterwalder and Pigneur (2010) argue that there are two types of revenue streams: transaction revenues and recurring revenues, and two types of pricing mechanisms: fixed or dynamic pricing. Based on the revenue streams for Stora Enso Building Solutions and based on the interviews with different actors, the revenue streams for material suppliers in the wood-frame multi-storey construction industry come from the products and services included in the offering when they are delivered, and the price depends on volume. Thus, at least this material supplier, seems to use transaction revenues and dynamic pricing. From the interviews with the actors, no one has proposed these types of revenue streams as a problem or something preventing value creation.

Furthermore, as Brege, Nord and Stehn (2017) argue, industrial wood construction has the potential to increase the productivity and reduce the overall cost. This since wood construction has benefits when it comes to industrial prefabrication (Hurmekoski, 2017). A higher prefabrication level offered by the material supplier should imply that the material supplier could receive a larger proportion of the revenues, thus capture more value, in a construction project and at the same time, increase the total sustainable value delivered.

Thus, we propose that a material supplier can create sustainable value through:

- *revenue streams from construction contractors based on the delivered products and services.*

According to Osterwalder (2004), the way the organization makes money is included in the *financial aspects* pillar of the business model. Furthermore, according to Osterwalder and Pigneur (2010), the *revenue streams* block of the business model describes the revenue streams generated from the organization's different customer segments. Therefore, the proposed revenue streams a material supplier can use to create sustainable value through can be categorized to the financial aspects pillar and revenue streams block of the business model.

A business model with production facilities with high capacity and key activities as cost-efficient production and a lot of transportation imply a cost structure with high fixed costs. If looking at Stora Enso Building Solution's cost structure, they have a large proportion of fixed costs, such as machinery and other production equipment. The business model can have either a cost-driven or a value driven cost structure or have a cost structure somewhere in between these two extremes (Osterwalder & Pigneur, 2010). Therefore, for a material supplier in the wood-frame multi-storey construction industry, the resources and activities which we have proposed for a material supplier in order for them to create and provide sustainable value results in high fixed costs, and thus a cost driven cost structure.

Thus, we propose that a material supplier can create sustainable value through a:

- *cost driven cost structure.*

According to Osterwalder (2004), the representation in money of all the means which are used in the business model is included in the *financial aspects* pillar of the business model. Moreover, according to Osterwalder and Pigneur (2010), the *cost structure* block of the Business Model Canvas presents the costs the organization generates when operating their business model. Therefore, the proposed cost structure a material supplier can use to create sustainable value through can be categorized to the financial aspects pillar and the cost structure block of the business model.

5.3.5 Summary of What Elements in a Wood-Frame Material Supplier's Business Model could be used to Create and Deliver this Sustainable Value

To answer the research question 3, *what elements in a wood-frame material supplier's business model could be used to create and deliver this sustainable value*, the identified key elements are summarized in figure 82 below.

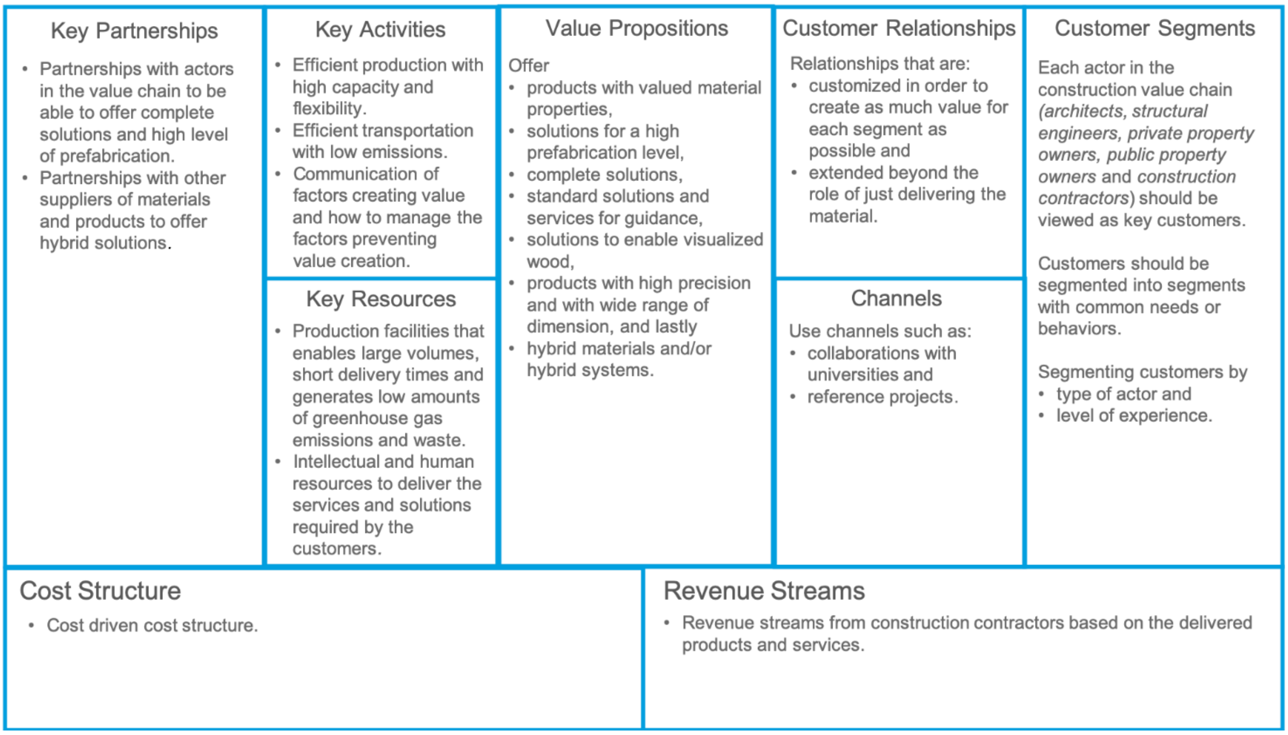

Figure 82: Elements in a wood-frame material supplier's business model which could be used to create and deliver sustainable value.

According to Brege, Stehn and Nord (2014), the business model should have a good external fit between the environment and the configuration of the different design parameters. In this case, the presented business model elements are identified as having a good external fit because they are identified based on what the customers value. However, Brege, Stehn and Nord (2014) also emphasize that a business model should have a good internal fit among the design parameters themselves. In our case, the internal fit among the presented business model elements has not been in focus and therefore, the presented business model in figure 82 above should not be viewed as a viable business model configuration but as elements which separate from each other can create sustainable value to the actors in the value chain.

6. Conclusions, Discussion and Future Research

In this chapter, a conclusion is presented followed with a discussion and future research.

6.1 Conclusions

The purpose of this thesis was to investigate how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.

First of all, we have concluded that a material supplier in the wood-frame multi-storey construction industry, who wants to develop a sustainable business model, needs to create and deliver sustainable value, not only to their main customers, but to all the actors in the value chain. Further, we have concluded that a material supplier in the wood-frame multi-storey construction industry, who wants to develop a sustainable business model, needs to create and deliver value of all aspects of sustainability, thus, economic, social and environmental value. Moreover, we have concluded that an economic, social or environmental factor creates value for a specific actor if that actor (1) view it as an important factor for them to prefer a certain frame material, and (2) view the frame material as advantageous.

In the analysis of this thesis, we have concluded what creates sustainable value for the actors in the construction value chain, see section *5.1.3 Summary of what Creates Sustainable Value for the Actors in the Construction Value Chain regarding the Frame Material.* We have also concluded whereas the actors in the construction value chain see the factors as advantages, disadvantages or both with massive wood as frame material, thus, if the factors with massive wood enable value creation or prevent value creation for the actors in the value chain, see section *5.2.1 Summary of how Massive Wood Enables or Prevents Value to be Created*. Lastly, to reach the purpose of this study, we have identified value creating business model elements that a material supplier, in the wood-frame multi-storey construction industry, can use to configure a business model that creates and delivers sustainable value to the actors in the construction value chain. Thus, we have concluded how a material supplier in the wood-frame multi-storey construction industry can create and deliver sustainable value through their business model, to the actors in the construction value chain.

Which the products, services and solutions included in the value proposition are, is concluded to be important in order for a material supplier to create and deliver sustainable value to the actors. Also, which the key activities of the business model are and how they are performed are important in order to create and deliver sustainable value to the actors. Furthermore, other parts of the business model are important in order to provide the products and services of the value proposition which creates this sustainable value, for example, key resources, different partnerships and the revenue streams and cost structures of the business model. Moreover, a material supplier's customer relationships and channels can be used as tools in order to increase the knowledge of massive wood, thus increase sustainable value creation. Table 10 below summarizes the identified elements in a material supplier's business model which we propose could be used to create and deliver sustainable value to the actors in the construction value chain.

Table 10: Elements in a material supplier's business model that could be used to create and deliver sustainable value.

Important elements in the Business Model	
The Products/Value Proposition	
Value proposition	Offer products with valued material properties (renewable, fossil free, modifiable, carbon storage properties, good heat and cold insulating properties and compatible with other building materials/systems).
	Offer solutions for a high prefabrication level to enable high safety on the construction site and short construction times.
	Offer complete solutions of the materials/products and services needed in a construction project.
	Offer standard solutions and services for guidance of how to manage the challenges the different actors see with massive wood as frame material, for example regarding fire-safety, stability, impact from rain and moisture and acoustics. Offer standard solutions of how to visualize wood and how to manage the consequences it can have regarding challenges with fire-safety, durability, impact from rain and moisture and acoustics.
	Offer products with high precision and with a wide range of dimensions in order to reduce the waste on the worksite.
	Offer hybrid materials and/or hybrid systems as a possible solution for how to manage some of the challenges the different actors see with massive wood as frame material, for example fire-safety, stability and acoustics.
The Customer Interface	
Customer Segments	View each actor in the construction value chain (architects, structural engineers, property owners and construction contractors) as key customers.
	Segment customers based on common needs or behaviors, for example by type of actor and level of experience.
Channels	Use channels such as collaborations with universities to increase the total knowledge of massive wood in the value chain.
	Use reference projects as a channel for marketing and communication with new customers who do not have experience of working with massive wood as frame material.
Customer Relationships	Create customized customer relationships with the different customer segments (different actors and different level of experience of using massive wood). Each relationship is important in order to understand what creates value and prevents value for different customer segments.
	Create customer relationships which are extended beyond the role of just delivering the material in order to reduce barriers and increase the knowledge about construction with massive wood in the value chain.
Infrastructure Management	
Key Resources	Use production facilities that enables large volumes, short delivery times and generates low amounts of greenhouse gas emissions and waste.
	Use intellectual/human resources to deliver the services required by the customers.
Key Activities	Use efficient production with high capacity and flexibility to meet customer demands, therefore, contribute to low amount of emissions and waste.
	Use efficient transportation with low greenhouse gas emissions.
	Communicate the sustainable value creating factors to each customer segment. Communicate how to manage the factors preventing value creation for each customer segment.
Key Partnerships	Use partnerships with actors in the value chain to offer complete solutions and high level of prefabrication.
	Use partnerships with other suppliers of materials and products to offer hybrid solutions.
Financial Aspects	
Revenue Streams	Have revenue streams from construction contractors based on the delivered products and services.
Cost Structure	Have a cost driven cost structure to be able to operationalize the business model.

Additionally, we have seen that there is still a lack of knowledge regarding massive wood as frame material in the construction value chain. First, massive wood seems more likely to be viewed as an advantage for actors in the value chain with experience of using massive wood as frame material and more likely to be viewed as a disadvantage for the respondents with no experience of using massive wood as frame material. Second, in the construction value chain, there are many perceptions of challenges when using massive wood as frame material which experienced actors and the material suppliers do not see as challenges with massive wood. Thus, the knowledge and experience of using massive wood impact if the factor creates value or prevents value creation and more knowledge and experience will increase the value creation. Therefore, we argue that it is critical that a material supplier, in order to increase sustainable value creation in the construction value chain, focuses on communication activities with the purpose of spreading knowledge and to explain the sustainable value of their value proposition to the customers.

6.2 Discussion

Through this thesis, with the identification of what creates sustainable value for the actors in the value chain and the identification of what enables and prevents value creation regarding massive wood, we have applied what de Wit and Meyer (2017) explain is a market-based outside-in perspective in the identification of key elements in the business model. Brege, Stehn and Nord (2014) argue that the business model should have a good external fit between the environment and the configuration of the different design parameters. By our approach, we argue that prerequisites for a business model configuration with good external fit between the environment and the business model is created. In line with Lessing and Brege (2015), we argue that an increased emphasis on the outside-in perspective should be a successful approach for the business model construct of a material supplier. However, an insight from our case study of Stora Enso Building Solutions is that they seem to follow the production-oriented business model that Lessing and Brege (2015) claim are typical for material suppliers in this industry. Therefore, the adoption of the market-based approach might imply a need for a shift in focus from the traditional production-oriented business models of a material supplier more towards a product-orientation. The key, according to Lessing and Brege (2015), is to find the right balance between production- and product-orientation and this is according to the authors done by a deep customer knowledge and creation of offerings that meet, or exceed, the expectations of the customers and we claim that the insights of this thesis will contribute to find this balance.

Brege, Stehn and Nord (2014) further argue that a business model should have a good internal fit among the design parameters. We emphasize that the elements described in table 10 above are elements which can be used to create and deliver sustainable value to the actors in the construction value chain. Different configurations of these elements, in order to generate a good internal fit between the elements themselves, is thereby possible. Thus, even though these elements could be used to create and deliver sustainable value, it does not necessarily imply that they are the needed elements in order to develop an optimal business model for a material supplier generally. For example, it does not necessarily imply that these elements will help a material supplier increase their sales or their profit or that these elements fit together. However, if a material supplier in the wood-frame multi-storey construction industry want to develop a sustainable business model they need to create sustainable value for the actors in the construction value chain, thus, considering these elements in their business model. Kumar and Reinartz (2016, p. 36) argue that the purpose of a sustainable business is "first, to create value for customers and, second, to extract some of that customer value in the form of profit, thereby creating value for the firm". Thus, if a material supplier first creates value for the customers, we claim they would also be able to capture some of that value, thus create value for the firm.

As stated in section *1.4 Theoretical Starting Point*, the research on sustainability have traditionally focused mainly on sustainable innovations without expanding the view to cover a broader business model perspective. Research points out that there is a considerable amount of knowledge on what drives sustainable innovation at a firm level, but less knowledge on how these innovations can be realized and how to enable sustainability on a higher and more systemic level. Further, as stated in section *2.3.5 Business Models in the Construction Industry*, the knowledge and research connecting building and construction with business models is limited.
We claim that this thesis contributes to the earlier knowledge of what the different actors in the construction value chain see as advantages and disadvantages with massive wood as frame material and with industrialized wood-frame multi-storey construction in general. This thesis further contributes to the knowledge of sustainable value in the construction industry with a link between the identified advantages and disadvantages, which the actors see with massive wood as frame material, and sustainable value creation for the actors in the

construction value chain. Furthermore, we claim that this thesis contributes to the research of how a material supplier in the wood-frame multi-storey construction industry can use a market-based approach to create sustainable value through their business model, which is a step in developing a sustainable business model. Thereby, our study contributes to the knowledge of how a material supplier in industrialized wood-frame multi-storey construction could work towards a climate-neutral and competitive construction industry in year 2045.

6.3 Future Research

This thesis has been conducted with an explorative approach, and with a broad focus where potential sustainable value creating factors have been identified. The combination of the quantitative and qualitative sections enabled us to identify differences between groups regarding the factors, with an additional contextual understanding of the factors. However, we suggest future studies to specifically test our identified value creating factors statistically on representative samples in order to verify our results.

We have identified some potential underlying explanations of why different factors are seen as advantages and disadvantages with massive wood as frame material. This is performed qualitatively through our complementary interviews. However, other underlying explanations, that we have not been able to identify probably exists, and therefore, we also suggest future studies to focus on the underlying explanations of why those factors might be value creating or preventing value creation. As a suggestion, this could be done through statistical methods such as factor analysis, and through more comprehensive qualitative studies.

Further, in this thesis we used primarily an outside-in perspective when identifying key elements to create and deliver sustainable value through a business model. How these elements could be configurated has not been the focus. Therefore, future studies could also take more of an inside-out perspective and focus on the configuration of our identified key elements into sustainable business models constructs that are viable.

Lastly, an initial aim was to understand how a material supplier in industrialized wood-frame multi-storey construction could work towards a climate-neutral and competitive construction industry in year 2045. This was then limited to look at how a material supplier in the wood-frame multi-storey construction industry could develop a sustainable business model and then further limited to how a material supplier in the wood-frame multi-storey construction industry could create and deliver sustainable value through their business model to the actors in the construction value chain, as an important part of a sustainable business model. The understanding of how a material supplier in the wood-frame multi-storey construction industry could create and deliver the sustainable value through their business model was studied through a single case, Stora Enso Building Solutions. Therefore, we suggest that future studies specifically focus on sustainable business models, through multiple case studies of material suppliers as well as of other actors in the value chain. By increasing the knowledge of sustainable business models, for all the actors in the construction value chain, it should result in a better understanding of how sustainable value could be co-created and how the industry should work together towards a climate-neutral and competitive construction industry in year 2045.

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Appendix

Appendix 1

The table below is a summary of typical sustainability impact categories in the sustainability literature (Jorgensen et al. (2008); Soukka (2007); VROM (2000); Fuller & Petersen (1995) in Patala et al., (2016, p, 146)).

Economic impact categories	Environmental impact categories	Social impact categories
• Availability of production • Performance of production • Quality of production • Residual value • Investment costs • Input costs ○ Material ○ Energy ○ Water • Maintenance costs • Man-hour costs • Material costs • Costs of externalities ○ Environmental costs ○ Social costs	• Damage to resources ○ Minerals ○ Fossil fuels • Damage to ecosystems ○ Biodiversity ○ Land use • Damage to human health ○ Radiation ○ Respiratory effects ○ Depletion of ozone layer ○ Climate change effects	• Human rights ○ Non-discrimination ○ Child labor ○ Forced labor • Labor practices and decent working conditions ○ Wages ○ Benefits ○ Safety ○ Satisfaction • Society ○ Job creation ○ Corruption ○ Support of local suppliers • Product responsibility ○ Safety ○ Labeling ○ Ethical marketing communications

Appendix 2

The table below presents identified factors which can potentially affect environmental, social and economic value creation for actors in the construction value chain. These are identified in the literature presented in the frame of reference, and in the pre-survey interviews with actors from two construction projects.

Factors affecting sustainable value creation

Appearance
• Appearance of the building
    ○ Suitability with local history and traditions
• Esthetically appealing for
    ○ end-consumer
    ○ the surrounding
• Possibility to visually expose the wood
• The design's and material's impact on the well-being of end-consumer

Branding and image
Delivery time of the material
Demand
Economic risk level
Economic competitiveness

Environmental impact
• Amount of emissions from
    ○ operation
    ○ the construction process
    ○ the material manufacturing process
    ○ transportation
• Amount of waste from
    ○ production
    ○ worksite
• How waste and by products are handled
• The amount of material used
• Energy consumption and energy mix used in manufacturing
• Fossil-free processes
• Sustainable forestry

Functional properties • Acoustics • Durability • Resistance to rain and moisture • Fire safety • Stability • Structural strength • Flexibility • How easy it is to handle • Dimensioning

Knowledge, experience and education
• Amount and availability of information about the material, products and processes
    ○ Environmental Product Declaration (EPD)
    ○ Forest Stewardship Council (FSC)
• Education
• Experience and confidence of using the material
• Knowledge of the material and how to use it
    ○ Sustainability aspects
    ○ Technological aspects

Material properties • Biomaterial • Carbon storage • Fossil-free • Modifiable • Non-toxic • Renewable • Visual aging • Weight

Number of suppliers
Number of working hours required
Productivity
Residential environment/Indoor air quality
Suitability for industrial processes / industrial prefabricationn
Time of the construction phase

Total cost of the project
• Construction phase
  ○ Cost of material
• Management phase
  ○ Façade maintenance cost
• Planning phase

Tradition of established practices
Use of local producers
Workplace environment • Dryness • Noise level • Disturbance on the surroundings • Dust • Safety for workers

Appendix 3

In the table below, the questions used in the survey are presented.

The Questions in the Survey
What is your main actor role?
In which county are you mainly active?
For you to prefer a certain frame material, what do you think of the following factors? • The frame material's impact on the… [material costs in the project] • The frame material's impact on the… [projects labor costs for architects, structural engineers etc.] • The frame material's impact on the… [projects labor costs for workers (construction workers etc.)] • The frame material's impact on the… [project's transportation, machine and other costs] • The frame material's impact on the… [rental and sales revenues] • The frame material's impact on your… [brand/image] • The frame material's impact on the… [possibility of prefabrication] • The frame material's impact on the… [construction time] • The frame material's impact on the… [energy consumption in the operation of the building] • The frame material's impact on the… [indoor environment for the end user] • The frame material's impact on the… [appearance of the building] • The frame material's impact on the… [life span of the building] • That the frame material is… [fossil free] • That the frame material is… [renewable] • That the frame material has… [carbon storage properties] • That the frame material is… [locally produced] • The frame material's… [acoustic properties] • The frame material's… [fire properties] • The frame material's… [heat and cold insulating properties] • The frame material's… [weight] • The impact on the frame material from… [rain and moisture during construction] • The frame material's impact on the… [stability of the construct] • The frame material's… [delivery time] • The frame material's… [precision] • The frame material's… [compatibility with other building materials/systems] • The frame material's… [modifiability] • The amount of… [greenhouse gas emissions arising from production of the frame material] • The amount of… [greenhouse gas emissions arising from transportation of the frame material] • The amount of… [greenhouse gas emissions arising from handling of the frame material at the construction site] • The amount of… [frame material waste arising from production of the frame material] • The amount of… [frame material waste arising at the worksite] • The frame material's impact on the... [construction site's safety] • The frame material's impact on the… [construction site's noise level] • The frame material's impact on the… [construction site's general working environment] • The frame material's impact on the… [construction site's disturbance to the surroundings]
Do you have any other opinions about what impact you to prefer a certain frame material?
How many projects where massive wood is used as frame material have you participated in?

For you to prefer massive wood as frame material, what do you think of the following factors?

- Massive wood's impact on your… [total costs in the project]
- Massive wood's impact on your… [total revenues in the project]
- Massive wood's impact on your… [profitability in the project]
- Massive wood's impact on the… [material costs in the project]
- Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]
- Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]
- Massive wood's impact on the… [project's transportation, machine and other costs]
- Massive wood's impact on the… [rental and sales revenues]
- Massive wood's impact on your… [brand/image]
- Massive wood's impact on the… [possibility of prefabrication]
- Massive wood's impact on the… [construction time]
- Massive wood's impact on the… [possibility of using local producers]
- Massive wood's impact on the… [energy consumption in the operation of the building]
- Massive wood's impact on the… [indoor environment for the end user]
- Massive wood's impact on the… [appearance of the building]
- Massive wood's impact on the… [life span of the building]
- That massive wood is… [fossil free]
- That massive wood is… [renewable]
- That massive wood has… [carbon storage properties]
- Massive wood's… [acoustic properties]
- Massive wood's… [fire properties]
- Massive wood's… [heat and cold insulating properties]
- Massive wood's… [weight]
- The impact on massive wood from… [rain and moisture during construction]
- Massive wood's impact on the… [stability of the construct]
- Massive wood's… [delivery time]
- Massive wood's… [precision]
- Massive wood's… [compatibility with other building materials/systems]
- Massive wood's… [modifiability]
- The amount of… [greenhouse gas emissions arising from production of the massive wood]
- The amount of… [greenhouse gas emissions arising from transportation of the massive wood]
- The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]
- The amount of… [massive wood waste arising from production of the frame material]
- The amount of… [massive wood waste arising at the construction site]
- Massive wood's impact on the… [construction site's safety]
- Massive wood's impact on the… [construction site's noise level]
- Massive wood's impact on the… [construction site's general working environment]
- Massive wood's impact on the… [construction site's disturbance to the surroundings]
- [The amount of information available on massive wood]
- [How much experience I have of using massive wood]
- [How much knowledge I have about massive wood]

Do you have any other opinions regarding massive wood as frame material?

In general, how much influence do you think the following actors have over the choice of a frame material?

- Architects
- Structural Engineers
- Construction Contractors
- Private Property Owners
- Public Property Owners

In the construction industry, how do you think massive wood as frame material contributes to ...

- Environmental sustainability
- Economic sustainability
- Social sustainability

What is your general attitude towards massive wood as frame material?

Appendix 4

In the table below, a presentation of the interviewees is made.

Presentation of Interviewed Persons and their Organizations	
Private Property Owners	
Lindsténs Fastigheter Peter Lindstén, *Owner*	Lindstén Fastigheter AB manages properties. Today, their property portfolio is concentrated in Linköping's city center and consists of around 25.000 m^2 distributed among stores, office spaces and residential buildings. They are involved in the construction project Valla Berså in Linköping, a circular building with 69 apartments and a couple of stores at the ground level, with massive wood as both frame and façade material.
Vasakronan Torbjörn Zettergren, *Project Leader*	Vasakronan is a Swedish real estate company focusing on buildings for office spaces and stores. Torbjörn Zettergren has experience of projects with massive wood as frame material.
Public Property Owners	
Karlstad Municipality Sixten Westlund, *Project Leader at the Engineering and Property Management of Karlstad Municipality*	The Engineering and Property Management of the municipality of Karlstad is responsible for the municipality's streets, nature, buildings and water and sewage. Karlstad Municipality and Sixten Westlund have been involved in building a preschool (Lotsen) with massive wood as frame material.
Akademiska Hus Anders Berg, *Project Manager*	Akademiska Hus builds, develops and manages buildings for education, research and innovation. Akademiska Hus is a state-owned property company which have around 65 percent of the market share for universities and colleges. Anders Berg is the Project Manager of the project *Studenthus Valla* in Linköping, a project with high sustainability focus.
Architects	
Arkitema Kristina Peters, *Partner/Business Manager*	Arkitema is one of Scandinavia's largest architectural organization with around 550 employees divided into five offices located in Copenhagen, Aarhus, Oslo, Stockholm and Malmö. Arkitema and Kristina Peters have experience of working with massive wood as frame material.
Sweco Architects AB Sebastian Fors, *Arkitekt SAR/MSA*	Sweco is the leading technology and architecture consulting company in Europe. Architects at Sweco work with for example residential buildings, health care buildings, schools and office spaces. Sweco Architects and Sebastian Fors have for example been involved in the project with the preschool Lotsen in Karlstad, where the frame material is massive wood.
Structural Engineers	
Bjerking Eric Borgström, *Structural Engineer and Contract Manager*	Bjerking an employee-owned technology consulting company with offices located in Uppsala, Stockholm and Enköping. They provide services within the building sector. Eric Borgström has experience of working in projects with massive wood as frame material.
Byggnadstekniska Byrån Elzbieta Lukaszewska, *Structural Engineer and Contract Manager*	Byggnadstekniska Byrån is a consulting firm in the building sector. They have experience of project areas including for example new construction and extensions and their projects comprise for example structural engineering, design of structures, building technology and foundation engineering. Elzbieta Lukaszewska has experience of projects where massive wood is used as frame material.
Construction Contractors	
Stångebro Bygg Benny Valtersson, *CEO* Carl Dalgren, *Production Engineer* Emil Falck, *Production Engineer* Fredrik Engvall, *Project Manager*	Stångebro Bygg is a construction company of 27 employees located in Linköping. They have some experience of working with massive wood as frame material from earlier projects.
Åhlin & Ekeroth Byggnads AB Peter Stråhlin, *Business Area Manager* Carl Johan Danckwardt-Lillieström, *Project Manager*	Åhlin & Ekeroth Byggads AB is a construction company of 450 employees located with headquarters in Linköping and local offices in Norrköping, Motala, Mjölby and Finspång. They have been the involved as construction contractors in the project Valla Berså a circular residential building with massive wood as frame material and Cedarwood as façade material. Present, they are also involved in a couple of other projects using massive wood.

Project Developers	
Folkhem Kenneth Wilén, *Vice President*	Folkhem, owned by Veidekke and Rikshem, builds only with wood as frame material and focuses on construction in the Stockholm region. They have for example been involved in the project of *Strandparken*, an eight-storey house with massive wood as frame material.

Appendix 5

In the tables below, the data from the results of the survey is presented.

Descriptive Statistics – Frame material – All actors

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	203	1	5	4,21	,808
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	194	1	5	3,25	1,197
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	197	1	5	3,71	1,071
The frame material's impact on the… [project's transportation, machine and other costs]	197	1	5	3,79	1,023
The frame material's impact on the… [rental and sales revenues]	187	1	5	3,68	1,184
The frame material's impact on your… [brand/image]	202	1	5	3,72	1,121
The frame material's impact on the… [possibility of prefabrication]	201	1	5	3,84	1,043
The frame material's impact on the… [construction time]	202	1	5	4,26	,824
The frame material's impact on the… [energy consumption in the operation of the building]	203	1	5	4,27	,895
The frame material's impact on the… [indoor environment for the end user]	203	1	5	4,27	,868
The frame material's impact on the… [appearance of the building]	201	1	5	3,75	,979
The frame material's impact on the… [life span of the building]	203	1	5	4,44	,815
That the frame material is… [fossil free]	196	1	5	3,58	1,057
That the frame material is… [renewable]	198	1	5	3,72	1,022
That the frame material has… [carbon storage properties]	185	1	5	3,42	1,116
That the frame material is… [locally produced]	198	1	5	3,10	1,151
The frame material's… [acoustic properties]	200	1	5	4,00	,885
The frame material's… [fire properties]	201	2	5	4,47	,707
The frame material's… [heat and cold insulating properties]	202	1	5	4,23	,887
The frame material's… [weight]	198	1	5	3,36	1,006
The impact on the frame material from... [rain and moisture during construction]	200	1	5	4,12	,905
The frame material's impact on the… [stability of the construct]	200	1	5	4,43	,753
The frame material's… [delivery time]	196	1	5	3,76	,927
The frame material's… [precision]	194	1	5	3,93	,913
The frame material's… [compatibility with other building materials/systems]	195	1	5	4,12	,826
The frame material's… [modifiability]	195	1	5	4,03	,837
The amount of… [greenhouse gas emissions arising from production of the frame material]	196	1	5	3,74	1,070
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	196	1	5	3,52	1,040
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	196	1	5	3,65	1,039
The amount of… [frame-material waste arising from production of the frame material]	194	1	5	3,48	1,044
The amount of… [frame-material waste arising at the worksite]	198	1	5	3,71	,978
The frame material's impact on the... [construction site's safety]	199	1	5	4,22	,922
The frame material's impact on the… [construction site's noise level]	195	1	5	3,54	,975
The frame material's impact on the… [construction site's general working environment]	199	1	5	4,01	,902
The frame material's impact on the… [construction site's disturbance to the surroundings]	195	1	5	3,59	,928
Valid N (listwise)	148				

Descriptive Statistics – Frame material - Architects

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	27	2	5	4,07	,874
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	24	1	5	3,00	1,180
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	24	1	5	3,54	1,250
The frame material's impact on the… [project's transportation, machine and other costs]	26	1	5	3,77	1,142
The frame material's impact on the… [rental and sales revenues]	25	1	5	3,44	1,003
The frame material's impact on your… [brand/image]	27	1	5	3,89	1,121
The frame material's impact on the… [possibility of prefabrication]	27	1	5	3,67	1,000
The frame material's impact on the… [construction time]	27	1	5	3,93	,997
The frame material's impact on the… [energy consumption in the operation of the building]	27	1	5	4,00	1,109
The frame material's impact on the… [indoor environment for the end user]	27	2	5	4,48	,893
The frame material's impact on the… [appearance of the building]	27	3	5	4,44	,751
The frame material's impact on the… [life span of the building]	27	1	5	4,15	1,199
That the frame material is… [fossil free]	27	1	5	4,04	1,192
That the frame material is… [renewable]	27	1	5	4,07	1,035
That the frame material has… [carbon storage properties]	26	1	5	4,00	1,131
That the frame material is… [locally produced]	26	2	5	4,04	1,038
The frame material's… [acoustic properties]	27	2	5	3,93	1,035
The frame material's… [fire properties]	27	2	5	4,19	1,039
The frame material's… [heat and cold insulating properties]	27	1	5	4,11	1,086
The frame material's… [weight]	27	1	5	3,52	1,156
The impact on the frame material from... [rain and moisture during construction]	27	1	5	3,59	1,217
The frame material's impact on the… [stability of the construct]	27	2	5	4,26	,984
The frame material's… [delivery time]	26	2	5	3,62	1,023
The frame material's… [precision]	26	2	5	3,88	,864
The frame material's… [compatibility with other building materials/systems]	24	2	5	4,04	,690
The frame material's… [modifiability]	26	2	5	4,19	,939
The amount of… [greenhouse gas emissions arising from production of the frame material]	27	1	5	4,26	1,095
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	27	1	5	3,89	1,251
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	27	1	5	3,81	1,210
The amount of… [frame-material waste arising from production of the frame material]	27	1	5	3,74	1,059
The amount of… [frame-material waste arising at the worksite]	27	1	5	3,85	1,027
The frame material's impact on the... [construction site's safety]	26	1	5	3,85	1,084
The frame material's impact on the… [construction site's noise level]	27	1	5	3,44	1,086
The frame material's impact on the… [construction site's general working environment]	27	2	5	3,81	1,001
The frame material's impact on the… [construction site's disturbance to the surroundings]	27	1	5	3,56	1,086

Valid N (listwise)	18				

Descriptive Statistics – Frame material – Structual engineers

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	29	2	5	4,07	,884
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	28	1	5	3,00	1,155
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	28	1	5	3,43	1,260
The frame material's impact on the… [project's transportation, machine and other costs]	28	1	5	3,57	1,034
The frame material's impact on the… [rental and sales revenues]	24	1	5	2,96	1,367
The frame material's impact on your… [brand/image]	29	1	5	3,24	1,455
The frame material's impact on the… [possibility of prefabrication]	29	1	5	3,90	,976
The frame material's impact on the… [construction time]	29	2	5	4,41	,825
The frame material's impact on the… [energy consumption in the operation of the building]	29	2	5	3,90	,817
The frame material's impact on the… [indoor environment for the end user]	29	1	5	4,00	,886
The frame material's impact on the… [appearance of the building]	29	1	5	3,28	1,131
The frame material's impact on the… [life span of the building]	29	1	5	4,41	,907
That the frame material is… [fossil free]	28	1	5	3,21	1,228
That the frame material is… [renewable]	29	1	5	3,24	1,154
That the frame material has… [carbon storage properties]	24	1	5	3,12	1,329
That the frame material is… [locally produced]	29	1	5	2,93	1,033
The frame material's… [acoustic properties]	29	1	5	3,45	1,055
The frame material's… [fire properties]	29	3	5	4,24	,739
The frame material's… [heat and cold insulating properties]	29	2	5	3,93	,998
The frame material's… [weight]	29	1	5	3,48	1,090
The impact on the frame material from... [rain and moisture during construction]	29	2	5	3,90	,900
The frame material's impact on the… [stability of the construct]	29	3	5	4,55	,686
The frame material's… [delivery time]	29	1	5	3,41	1,053
The frame material's… [precision]	29	1	5	3,69	1,039
The frame material's… [compatibility with other building materials/systems]	29	1	5	3,90	,900
The frame material's… [modifiability]	28	3	5	4,00	,720
The amount of… [greenhouse gas emissions arising from production of the frame material]	27	1	5	3,30	1,265
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	26	1	5	3,15	1,047
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	26	1	5	3,19	1,201
The amount of… [frame-material waste arising from production of the frame material]	26	1	5	3,12	1,107
The amount of… [frame-material waste arising at the worksite]	27	1	5	3,37	1,149
The frame material's impact on the... [construction site's safety]	28	2	5	3,96	,838
The frame material's impact on the… [construction site's noise level]	28	1	5	3,11	,994
The frame material's impact on the… [construction site's general working environment]	28	1	5	3,75	,967
The frame material's impact on the… [construction site's disturbance to the surroundings]	27	1	5	3,41	,888
Valid N (listwise)	19				

Descriptive Statistics – Frame material - Construction contractors

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	33	2	5	4,45	,711
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	32	1	5	3,59	1,292
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	33	2	5	4,00	,968
The frame material's impact on the… [project's transportation, machine and other costs]	33	2	5	3,94	1,029
The frame material's impact on the… [rental and sales revenues]	28	1	5	3,54	1,232
The frame material's impact on your… [brand/image]	32	2	5	3,75	1,078
The frame material's impact on the… [possibility of prefabrication]	33	1	5	4,39	,827
The frame material's impact on the… [construction time]	33	3	5	4,73	,517
The frame material's impact on the… [energy consumption in the operation of the building]	33	2	5	3,79	1,023
The frame material's impact on the… [indoor environment for the end user]	33	2	5	3,79	1,111
The frame material's impact on the… [appearance of the building]	33	1	5	3,61	1,088
The frame material's impact on the… [life span of the building]	33	2	5	4,03	,918
That the frame material is… [fossil free]	33	1	5	3,58	,969
That the frame material is… [renewable]	33	2	5	3,79	,960
That the frame material has… [carbon storage properties]	30	2	5	3,47	1,008
That the frame material is… [locally produced]	33	1	5	3,03	1,185
The frame material's… [acoustic properties]	32	2	5	4,00	,916
The frame material's… [fire properties]	33	3	5	4,55	,617
The frame material's… [heat and cold insulating properties]	33	2	5	4,24	,936
The frame material's… [weight]	33	1	5	3,55	1,092
The impact on the frame material from... [rain and moisture during construction]	33	3	5	4,61	,556
The frame material's impact on the… [stability of the construct]	33	3	5	4,55	,666
The frame material's… [delivery time]	33	2	5	4,36	,895
The frame material's… [precision]	31	2	5	4,23	,845
The frame material's… [compatibility with other building materials/systems]	31	3	5	4,35	,709
The frame material's… [modifiability]	32	2	5	4,34	,787
The amount of… [greenhouse gas emissions arising from production of the frame material]	33	1	5	3,76	1,001
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	33	1	5	3,48	1,121
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	33	2	5	4,03	,918
The amount of… [frame-material waste arising from production of the frame material]	32	1	5	3,44	1,134
The amount of… [frame-material waste arising at the worksite]	33	2	5	4,18	,808
The frame material's impact on the... [construction site's safety]	33	4	5	4,85	,364
The frame material's impact on the… [construction site's noise level]	33	2	5	3,94	,933
The frame material's impact on the… [construction site's general working environment]	33	3	5	4,45	,564
The frame material's impact on the… [construction site's disturbance to the surroundings]	33	2	5	4,03	,810
Valid N (listwise)	24				

Descriptive Statistics – Frame material - Private property owners

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	21	4	5	4,62	,498
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	21	1	5	3,48	1,250
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	21	2	5	4,00	1,000
The frame material's impact on the… [project's transportation, machine and other costs]	21	3	5	4,10	,768
The frame material's impact on the… [rental and sales revenues]	21	2	5	4,19	1,078
The frame material's impact on your… [brand/image]	21	3	5	4,38	,590
The frame material's impact on the… [possibility of prefabrication]	20	1	5	3,90	1,210
The frame material's impact on the… [construction time]	21	2	5	4,38	,865
The frame material's impact on the… [energy consumption in the operation of the building]	21	3	5	4,62	,740
The frame material's impact on the… [indoor environment for the end user]	21	3	5	4,57	,676
The frame material's impact on the… [appearance of the building]	21	1	5	3,76	,995
The frame material's impact on the… [life span of the building]	21	3	5	4,71	,561
That the frame material is… [fossil free]	21	1	5	3,67	1,065
That the frame material is… [renewable]	21	2	5	4,10	,995
That the frame material has… [carbon storage properties]	20	1	5	3,35	1,137
That the frame material is… [locally produced]	21	2	5	3,24	1,261
The frame material's… [acoustic properties]	21	3	5	4,10	,768
The frame material's… [fire properties]	21	3	5	4,57	,676
The frame material's… [heat and cold insulating properties]	21	2	5	4,29	1,007
The frame material's… [weight]	21	1	5	3,38	,921
The impact on the frame material from... [rain and moisture during construction]	21	2	5	4,14	,854
The frame material's impact on the… [stability of the construct]	21	3	5	4,48	,750
The frame material's… [delivery time]	20	2	5	3,70	,865
The frame material's… [precision]	21	2	5	4,05	,973
The frame material's… [compatibility with other building materials/systems]	21	2	5	4,19	,873
The frame material's… [modifiability]	21	2	5	3,95	,921
The amount of… [greenhouse gas emissions arising from production of the frame material]	21	2	5	4,10	,889
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	21	2	5	3,76	,831
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	21	2	5	3,90	,768
The amount of… [frame-material waste arising from production of the frame material]	21	1	5	3,76	,995
The amount of… [frame-material waste arising at the worksite]	21	2	5	4,00	,775
The frame material's impact on the... [construction site's safety]	21	2	5	4,48	,873
The frame material's impact on the… [construction site's noise level]	21	1	5	3,62	1,024
The frame material's impact on the… [construction site's general working environment]	21	2	5	4,14	,854
The frame material's impact on the… [construction site's disturbance to the surroundings]	21	1	5	3,62	,973
Valid N (listwise)	18				

Descriptive Statistics – Frame material – Public property owners

	N	Min	Max	Mean	Std. Deviation
The frame material's impact on the… [material costs in the project]	81	1	5	4,10	,846
The frame material's impact on the… [projects labor costs for architects, structural engineers etc.]	78	1	5	3,31	1,166
The frame material's impact on the… [projects labor costs for workers (construction workers etc.)]	79	1	5	3,72	,933
The frame material's impact on the… [project's transportation, machine and other costs]	77	1	5	3,70	1,065
The frame material's impact on the… [rental and sales revenues]	78	1	5	3,90	1,135
The frame material's impact on your… [brand/image]	81	1	5	3,60	1,045
The frame material's impact on the… [possibility of prefabrication]	80	1	5	3,60	1,074
The frame material's impact on the… [construction time]	80	1	5	4,09	,783
The frame material's impact on the… [energy consumption in the operation of the building]	80	1	5	4,57	,671
The frame material's impact on the… [indoor environment for the end user]	80	2	5	4,41	,724
The frame material's impact on the… [appearance of the building]	80	1	5	3,71	,830
The frame material's impact on the… [life span of the building]	81	3	5	4,62	,538
That the frame material is… [fossil free]	75	1	5	3,44	,933
That the frame material is… [renewable]	76	1	5	3,55	,929
That the frame material has… [carbon storage properties]	73	1	5	3,19	1,009
That the frame material is… [locally produced]	77	1	5	2,77	1,025
The frame material's… [acoustic properties]	79	2	5	4,19	,717
The frame material's… [fire properties]	79	3	5	4,59	,543
The frame material's… [heat and cold insulating properties]	79	2	5	4,34	,732
The frame material's… [weight]	76	1	5	3,13	,900
The impact on the frame material from... [rain and moisture during construction]	78	2	5	4,21	,812
The frame material's impact on the… [stability of the construct]	78	1	5	4,44	,713
The frame material's… [delivery time]	76	1	5	3,70	,800
The frame material's… [precision]	76	1	5	3,86	,905
The frame material's… [compatibility with other building materials/systems]	78	1	5	4,09	,856
The frame material's… [modifiability]	76	1	5	3,86	,812
The amount of… [greenhouse gas emissions arising from production of the frame material]	76	1	5	3,55	,999
The amount of… [greenhouse gas emissions arising from transportation of the frame material]	77	1	5	3,36	,931
The amount of... [greenhouse gas emissions arising from handling of the frame material at the construction site]	77	1	5	3,48	,954
The amount of… [frame-material waste arising from production of the frame material]	76	1	5	3,39	,953
The amount of… [frame-material waste arising at the worksite]	77	1	5	3,49	,912
The frame material's impact on the... [construction site's safety]	78	1	5	4,08	,964
The frame material's impact on the… [construction site's noise level]	74	1	5	3,51	,895
The frame material's impact on the… [construction site's general working environment]	77	1	5	3,91	,948
The frame material's impact on the… [construction site's disturbance to the surroundings]	76	1	5	3,43	,869
Valid N (listwise)	61				

Descriptives – Massive Wood – All Actors

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Massive wood's impact on your… [total costs in the project]	No experience	67	,57	1,270	,155	,26	,88	-2	2
	Earlier experience	82	,48	1,114	,123	,23	,72	-2	2
	Total	149	,52	1,183	,097	,33	,71	-2	2
Massive wood's impact on your… [total revenues in the project]	No experience	64	,48	1,039	,130	,22	,74	-2	2
	Earlier experience	74	,43	,966	,112	,21	,66	-2	2
	Total	138	,46	,997	,085	,29	,62	-2	2
Massive wood's impact on your... [profitability in the project]	No experience	67	,52	1,185	,145	,23	,81	-2	2
	Earlier experience	78	,45	1,065	,121	,21	,69	-2	2
	Total	145	,48	1,119	,093	,30	,67	-2	2
Massive wood's impact on the… [material costs in the project]	No experience	68	,40	1,223	,148	,10	,69	-2	2
	Earlier experience	81	,47	1,174	,130	,21	,73	-2	2
	Total	149	,44	1,193	,098	,24	,63	-2	2
Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	66	,17	,852	,105	-,04	,38	-2	2
	Earlier experience	73	,21	1,027	,120	-,03	,45	-2	2
	Total	139	,19	,945	,080	,03	,35	-2	2
Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	64	,33	,944	,118	,09	,56	-2	2
	Earlier experience	74	,55	1,022	,119	,32	,79	-2	2
	Total	138	,45	,990	,084	,28	,62	-2	2
Massive wood's impact on the… [project's transportation, machine and other costs]	No experience	66	,52	,827	,102	,31	,72	-1	2
	Earlier experience	75	,76	,819	,095	,57	,95	-1	2
	Total	141	,65	,829	,070	,51	,78	-1	2
Massive wood's impact on the... [rental and sales revenues]	No experience	65	,51	,970	,120	,27	,75	-2	2
	Earlier experience	63	,75	,879	,111	,52	,97	-2	2
	Total	128	,63	,931	,082	,46	,79	-2	2
Massive wood's impact on your… [brand/image]	No experience	83	1,10	,919	,101	,90	1,30	-2	2
	Earlier experience	84	1,26	,778	,085	1,09	1,43	-1	2
	Total	167	1,18	,852	,066	1,05	1,31	-2	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	77	1,09	,920	,105	,88	1,30	-2	2
	Earlier experience	88	1,43	,691	,074	1,29	1,58	-1	2
	Total	165	1,27	,822	,064	1,15	1,40	-2	2
Massive wood's impact on the… [construction time]	No experience	78	1,01	,960	,109	,80	1,23	-2	2
	Earlier experience	87	1,13	,938	,101	,93	1,33	-2	2
	Total	165	1,07	,947	,074	,93	1,22	-2	2
Massive wood's impact on the… [possibility of using local producers]	No experience	76	,45	1,076	,123	,20	,69	-2	2
	Earlier experience	86	,59	1,045	,113	,37	,82	-2	2
	Total	162	,52	1,059	,083	,36	,69	-2	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	78	,91	,928	,105	,70	1,12	-1	2
	Earlier experience	83	,77	,831	,091	,59	,95	-1	2
	Total	161	,84	,880	,069	,70	,98	-1	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	82	,99	,949	,105	,78	1,20	-2	2
	Earlier experience	85	1,16	,769	,083	1,00	1,33	-1	2
	Total	167	1,08	,864	,067	,95	1,21	-2	2
Massive wood's impact on the... [appearance of the building]	No experience	86	,79	,959	,103	,59	1,00	-2	2
	Earlier experience	91	,92	,859	,090	,74	1,10	-1	2
	Total	177	,86	,909	,068	,72	,99	-2	2
Massive wood's impact on the… [life span of the building]	No experience	74	,46	1,295	,151	,16	,76	-2	2
	Earlier experience	83	,69	,974	,107	,47	,90	-1	2
	Total	157	,58	1,139	,091	,40	,76	-2	2
That massive wood is… [fossil free]	No experience	95	1,36	,771	,079	1,20	1,51	-1	2
	Earlier experience	88	1,44	,741	,079	1,29	1,60	-1	2
	Total	183	1,40	,755	,056	1,29	1,51	-1	2
That massive wood is… [renewable]	No experience	97	1,44	,736	,075	1,30	1,59	0	2
	Earlier experience	90	1,52	,722	,076	1,37	1,67	-1	2
	Total	187	1,48	,728	,053	1,38	1,59	-1	2
That massive wood has… [carbon storage properties]	No experience	91	1,34	,806	,084	1,17	1,51	0	2
	Earlier experience	81	1,42	,756	,084	1,25	1,59	0	2
	Total	172	1,38	,781	,060	1,26	1,50	0	2
Massive wood's… [acoustic properties]	No experience	79	,00	1,301	,146	-,29	,29	-2	2
	Earlier experience	86	,14	1,382	,149	-,16	,44	-2	2
	Total	165	,07	1,341	,104	-,13	,28	-2	2
Massive wood's… [fire properties]	No experience	83	,11	1,259	,138	-,17	,38	-2	2
	Earlier experience	91	,16	1,267	,133	-,10	,43	-2	2
	Total	174	,14	1,260	,096	-,05	,33	-2	2
Massive wood's… [heat and cold insulating properties]	No experience	78	,58	,961	,109	,36	,79	-2	2
	Earlier experience	91	,75	,877	,092	,56	,93	-1	2
	Total	169	,67	,918	,071	,53	,81	-2	2
Massive wood's… [weight]	No experience	85	,79	,901	,098	,59	,98	-1	2
	Earlier experience	91	,92	,897	,094	,74	1,11	-2	2
	Total	176	,86	,899	,068	,72	,99	-2	2
The impact on massive wood from… [rain and moisture during construction]	No experience	84	-,62	1,191	,130	-,88	-,36	-2	2
	Earlier experience	89	,02	1,270	,135	-,25	,29	-2	2
	Total	173	-,29	1,270	,097	-,48	-,10	-2	2
Massive wood's impact on the… [stability of the construct]	No experience	79	,16	1,079	,121	-,08	,41	-2	2
	Earlier experience	90	,36	1,084	,114	,13	,58	-2	2

	Total	169	,27	1,083	,083	,10	,43	-2	2
Massive wood's… [delivery time]	No experience	63	,40	,925	,117	,16	,63	-1	2
	Earlier experience	76	,66	,888	,102	,46	,86	-1	2
	Total	139	,54	,911	,077	,39	,69	-1	2
Massive wood's... [precision]	No experience	74	,46	,847	,098	,26	,66	-1	2
	Earlier experience	85	1,01	,880	,095	,82	1,20	-1	2
	Total	159	,75	,905	,072	,61	,90	-1	2
Massive wood's… [compatibility with other building materials/systems]	No experience	79	,49	,890	,100	,29	,69	-2	2
	Earlier experience	87	,90	,822	,088	,72	1,07	-1	2
	Total	166	,70	,876	,068	,57	,84	-2	2
Massive wood's… [modifiability]	No experience	76	,72	,974	,112	,50	,95	-2	2
	Earlier experience	88	1,20	,833	,089	1,03	1,38	-1	2
	Total	164	,98	,930	,073	,84	1,13	-2	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	79	1,05	,799	,090	,87	1,23	-1	2
	Earlier experience	80	1,25	,864	,097	1,06	1,44	-1	2
	Total	159	1,15	,836	,066	1,02	1,28	-1	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	78	,56	,831	,094	,38	,75	-1	2
	Earlier experience	84	,87	,954	,104	,66	1,08	-1	2
	Total	162	,72	,907	,071	,58	,86	-1	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	78	,64	,852	,097	,45	,83	-2	2
	Earlier experience	84	1,05	,904	,099	,85	1,24	-1	2
	Total	162	,85	,900	,071	,71	,99	-2	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	77	,69	,877	,100	,49	,89	-2	2
	Earlier experience	74	,95	,842	,098	,75	1,14	-1	2
	Total	151	,81	,867	,071	,68	,95	-2	2
The amount of… [massive wood waste arising at the construction site]	No experience	78	,65	,835	,095	,47	,84	-2	2
	Earlier experience	83	,98	,910	,100	,78	1,17	-1	2
	Total	161	,82	,887	,070	,68	,96	-2	2
Massive wood's impact on the… [construction site's safety]	No experience	71	,61	,902	,107	,39	,82	-2	2
	Earlier experience	79	,85	,893	,100	,65	1,05	-2	2
	Total	150	,73	,902	,074	,59	,88	-2	2
Massive wood's impact on the… [construction site's noise level]	No experience	74	,64	,804	,093	,45	,82	-2	2
	Earlier experience	81	1,17	,818	,091	,99	1,35	-1	2
	Total	155	,92	,852	,068	,78	1,05	-2	2
Massive wood's impact on the… [construction site's general working environment]	No experience	75	,69	,805	,093	,51	,88	-2	2
	Earlier experience	82	1,13	,750	,083	,97	1,30	0	2
	Total	157	,92	,805	,064	,80	1,05	-2	2
Massive wood's impact on the… [construction site's disturbance to the surroundings]	No experience	78	,62	,793	,090	,44	,79	-2	2
	Earlier experience	82	,96	,838	,093	,78	1,15	-1	2
	Total	160	,79	,832	,066	,66	,92	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	88	,34	1,049	,112	,12	,56	-2	2
	Earlier experience	88	,51	1,028	,110	,29	,73	-2	2
	Total	176	,43	1,039	,078	,27	,58	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	91	,00	1,211	,127	-,25	,25	-2	2
	Earlier experience	89	,63	1,101	,117	,40	,86	-2	2
	Total	180	,31	1,197	,089	,14	,49	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	92	,21	1,163	,121	-,03	,45	-2	2
	Earlier experience	89	,71	1,025	,109	,49	,92	-2	2
	Total	181	,45	1,123	,083	,29	,62	-2	2

Descriptives – Architects – Massive Wood

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Massive wood's impact on your… [total costs in the project]	No experience	10	,90	1,101	,348	,11	1,69	-1	2
	Earlier experience	12	,67	,985	,284	,04	1,29	-1	2
	Total	22	,77	1,020	,218	,32	1,23	-1	2
Massive wood's impact on your… [total revenues in the project]	No experience	10	,60	1,075	,340	-,17	1,37	-1	2
	Earlier experience	11	,82	,982	,296	,16	1,48	0	2
	Total	21	,71	1,007	,220	,26	1,17	-1	2
Massive wood's impact on your... [profitability in the project]	No experience	10	,70	1,059	,335	-,06	1,46	-1	2
	Earlier experience	11	,64	1,027	,310	-,05	1,33	-1	2
	Total	21	,67	1,017	,222	,20	1,13	-1	2
Massive wood's impact on the… [material costs in the project]	No experience	10	,50	1,269	,401	-,41	1,41	-1	2
	Earlier experience	12	,50	1,087	,314	-,19	1,19	-1	2
	Total	22	,50	1,144	,244	-,01	1,01	-1	2
Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	9	,33	1,000	,333	-,44	1,10	-1	2
	Earlier experience	10	,40	1,174	,371	-,44	1,24	-1	2
	Total	19	,37	1,065	,244	-,14	,88	-1	2
Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	9	,44	1,236	,412	-,51	1,39	-1	2
	Earlier experience	10	,60	1,174	,371	-,24	1,44	-1	2
	Total	19	,53	1,172	,269	-,04	1,09	-1	2
Massive wood's impact on the… [project's transportation, machine and other costs]	No experience	9	,44	1,130	,377	-,42	1,31	-1	2
	Earlier experience	11	1,09	,701	,211	,62	1,56	0	2
	Total	20	,80	,951	,213	,35	1,25	-1	2
Massive wood's impact on the... [rental and sales revenues]	No experience	9	,67	1,118	,373	-,19	1,53	-1	2
	Earlier experience	10	1,10	,994	,314	,39	1,81	0	2

	Total	19	,89	1,049	,241	,39	1,40	-1	2
Massive wood's impact on your… [brand/image]	No experience	12	1,00	1,348	,389	,14	1,86	-2	2
	Earlier experience	15	1,67	,617	,159	1,32	2,01	0	2
	Total	27	1,37	1,043	,201	,96	1,78	-2	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	10	1,30	1,059	,335	,54	2,06	-1	2
	Earlier experience	13	1,62	,506	,140	1,31	1,92	1	2
	Total	23	1,48	,790	,165	1,14	1,82	-1	2
Massive wood's impact on the… [construction time]	No experience	12	1,00	1,279	,369	,19	1,81	-1	2
	Earlier experience	13	1,38	,768	,213	,92	1,85	0	2
	Total	25	1,20	1,041	,208	,77	1,63	-1	2
Massive wood's impact on the… [possibility of using local producers]	No experience	10	1,20	1,033	,327	,46	1,94	-1	2
	Earlier experience	14	1,00	,961	,257	,45	1,55	-1	2
	Total	24	1,08	,974	,199	,67	1,49	-1	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	10	1,30	,949	,300	,62	1,98	0	2
	Earlier experience	12	,92	,793	,229	,41	1,42	0	2
	Total	22	1,09	,868	,185	,71	1,48	0	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	11	1,55	,688	,207	1,08	2,01	0	2
	Earlier experience	15	1,20	,676	,175	,83	1,57	0	2
	Total	26	1,35	,689	,135	1,07	1,62	0	2
Massive wood's impact on the... [appearance of the building]	No experience	11	1,36	,809	,244	,82	1,91	0	2
	Earlier experience	15	1,27	,704	,182	,88	1,66	0	2
	Total	26	1,31	,736	,144	1,01	1,60	0	2
Massive wood's impact on the… [life span of the building]	No experience	10	,90	,876	,277	,27	1,53	0	2
	Earlier experience	13	1,00	1,000	,277	,40	1,60	0	2
	Total	23	,96	,928	,194	,56	1,36	0	2
That massive wood is… [fossil free]	No experience	11	1,45	,820	,247	,90	2,01	0	2
	Earlier experience	15	1,47	,915	,236	,96	1,97	-1	2
	Total	26	1,46	,859	,169	1,11	1,81	-1	2
That massive wood is… [renewable]	No experience	11	1,64	,809	,244	1,09	2,18	0	2
	Earlier experience	15	1,53	,915	,236	1,03	2,04	-1	2
	Total	26	1,58	,857	,168	1,23	1,92	-1	2
That massive wood has… [carbon storage properties]	No experience	11	1,45	,820	,247	,90	2,01	0	2
	Earlier experience	15	1,67	,617	,159	1,32	2,01	0	2
	Total	26	1,58	,703	,138	1,29	1,86	0	2
Massive wood's… [acoustic properties]	No experience	11	,73	1,272	,384	-,13	1,58	-2	2
	Earlier experience	14	,14	1,351	,361	-,64	,92	-2	2
	Total	25	,40	1,323	,265	-,15	,95	-2	2
Massive wood's… [fire properties]	No experience	10	,40	1,075	,340	-,37	1,17	-1	2
	Earlier experience	15	,47	1,246	,322	-,22	1,16	-1	2
	Total	25	,44	1,158	,232	-,04	,92	-1	2
Massive wood's… [heat and cold insulating properties]	No experience	10	1,00	,943	,298	,33	1,67	-1	2
	Earlier experience	15	,93	1,033	,267	,36	1,51	-1	2
	Total	25	,96	,978	,196	,56	1,36	-1	2
Massive wood's… [weight]	No experience	12	,75	,866	,250	,20	1,30	-1	2
	Earlier experience	15	,93	1,335	,345	,19	1,67	-2	2
	Total	27	,85	1,134	,218	,40	1,30	-2	2
The impact on massive wood from… [rain and moisture during construction]	No experience	10	-,50	,850	,269	-1,11	,11	-1	1
	Earlier experience	15	,53	1,302	,336	-,19	1,25	-2	2
	Total	25	,12	1,236	,247	-,39	,63	-2	2
Massive wood's impact on the… [stability of the construct]	No experience	9	,56	,882	,294	-,12	1,23	-1	2
	Earlier experience	14	,50	1,160	,310	-,17	1,17	-1	2
	Total	23	,52	1,039	,217	,07	,97	-1	2
Massive wood's… [delivery time]	No experience	9	,44	1,014	,338	-,33	1,22	-1	2
	Earlier experience	12	,75	,965	,279	,14	1,36	-1	2
	Total	21	,62	,973	,212	,18	1,06	-1	2
Massive wood's... [precision]	No experience	9	,78	,972	,324	,03	1,52	-1	2
	Earlier experience	12	1,42	,669	,193	,99	1,84	0	2
	Total	21	1,14	,854	,186	,75	1,53	-1	2
Massive wood's… [compatibility with other building materials/systems]	No experience	10	,40	,843	,267	-,20	1,00	-1	2
	Earlier experience	13	1,15	,689	,191	,74	1,57	0	2
	Total	23	,83	,834	,174	,47	1,19	-1	2
Massive wood's… [modifiability]	No experience	10	,70	1,059	,335	-,06	1,46	-1	2
	Earlier experience	14	1,43	,756	,202	,99	1,87	0	2
	Total	24	1,13	,947	,193	,73	1,52	-1	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	11	,91	,831	,251	,35	1,47	0	2
	Earlier experience	12	1,50	,674	,195	1,07	1,93	0	2
	Total	23	1,22	,795	,166	,87	1,56	0	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	10	,50	,972	,307	-,20	1,20	-1	2
	Earlier experience	14	1,14	1,027	,275	,55	1,74	-1	2
	Total	24	,88	1,035	,211	,44	1,31	-1	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	11	,82	,874	,263	,23	1,41	0	2
	Earlier experience	13	1,31	,751	,208	,85	1,76	0	2
	Total	24	1,08	,830	,169	,73	1,43	0	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	11	,73	1,104	,333	-,01	1,47	-1	2
	Earlier experience	12	,92	,793	,229	,41	1,42	-1	2
	Total	23	,83	,937	,195	,42	1,23	-1	2
The amount of… [massive wood waste arising at the construction site]	No experience	11	,73	,786	,237	,20	1,26	0	2
	Earlier experience	12	1,17	,718	,207	,71	1,62	0	2
	Total	23	,96	,767	,160	,62	1,29	0	2

Massive wood's impact on the… [construction site's safety]	No experience	9	,89	,782	,261	,29	1,49	0	2
	Earlier experience	12	1,00	,853	,246	,46	1,54	0	2
	Total	21	,95	,805	,176	,59	1,32	0	2
Massive wood's impact on the… [construction site's noise level]	No experience	10	1,10	,738	,233	,57	1,63	0	2
	Earlier experience	13	1,23	,725	,201	,79	1,67	0	2
	Total	23	1,17	,717	,149	,86	1,48	0	2
Massive wood's impact on the… [construction site's general working environment]	No experience	9	1,11	,782	,261	,51	1,71	0	2
	Earlier experience	13	1,31	,751	,208	,85	1,76	0	2
	Total	22	1,23	,752	,160	,89	1,56	0	2
Massive wood's impact on the… [construction site's disturbance to the surroundings]	No experience	9	,89	,601	,200	,43	1,35	0	2
	Earlier experience	13	1,00	,816	,226	,51	1,49	0	2
	Total	22	,95	,722	,154	,63	1,27	0	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	11	,82	,874	,263	,23	1,41	0	2
	Earlier experience	14	,86	,770	,206	,41	1,30	0	2
	Total	25	,84	,800	,160	,51	1,17	0	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	11	,18	1,079	,325	-,54	,91	-1	2
	Earlier experience	14	,36	1,008	,269	-,22	,94	-1	2
	Total	25	,28	1,021	,204	-,14	,70	-1	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	11	,82	,982	,296	,16	1,48	-1	2
	Earlier experience	15	,67	,976	,252	,13	1,21	-1	2
	Total	26	,73	,962	,189	,34	1,12	-1	2

Descriptives – Structual Engineers – Massive Wood

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Massive wood's impact on your… [total costs in the project]	No experience	2	1,00	,000	,000	1,00	1,00	1	1
	Earlier experience	15	,53	1,187	,307	-,12	1,19	-1	2
	Total	17	,59	1,121	,272	,01	1,16	-1	2
Massive wood's impact on your… [total revenues in the project]	No experience	3	1,00	1,000	,577	-1,48	3,48	0	2
	Earlier experience	14	,50	,855	,228	,01	,99	0	2
	Total	17	,59	,870	,211	,14	1,04	0	2
Massive wood's impact on your... [profitability in the project]	No experience	3	1,00	1,000	,577	-1,48	3,48	0	2
	Earlier experience	14	,79	,975	,261	,22	1,35	0	2
	Total	17	,82	,951	,231	,33	1,31	0	2
Massive wood's impact on the… [material costs in the project]	No experience	3	,67	1,528	,882	-3,13	4,46	-1	2
	Earlier experience	15	,73	1,163	,300	,09	1,38	-1	2
	Total	18	,72	1,179	,278	,14	1,31	-1	2
Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	3	,67	1,155	,667	-2,20	3,54	0	2
	Earlier experience	14	,14	,949	,254	-,41	,69	-1	2
	Total	17	,24	,970	,235	-,26	,73	-1	2
Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	2	1,50	,707	,500	-4,85	7,85	1	2
	Earlier experience	14	,64	1,008	,269	,06	1,22	-1	2
	Total	16	,75	1,000	,250	,22	1,28	-1	2
Massive wood's impact on the… [project's transportation, machine and other costs]	No experience	2	1,50	,707	,500	-4,85	7,85	1	2
	Earlier experience	13	,92	,760	,211	,46	1,38	0	2
	Total	15	1,00	,756	,195	,58	1,42	0	2
Massive wood's impact on the... [rental and sales revenues]	No experience	1	,00	.	.	.	.	0	0
	Earlier experience	10	,70	,675	,213	,22	1,18	0	2
	Total	11	,64	,674	,203	,18	1,09	0	2
Massive wood's impact on your… [brand/image]	No experience	4	1,25	,957	,479	-,27	2,77	0	2
	Earlier experience	15	,87	,834	,215	,40	1,33	0	2
	Total	19	,95	,848	,195	,54	1,36	0	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	7	1,29	,488	,184	,83	1,74	1	2
	Earlier experience	19	1,42	,607	,139	1,13	1,71	0	2
	Total	26	1,38	,571	,112	1,15	1,62	0	2
Massive wood's impact on the… [construction time]	No experience	7	1,57	,535	,202	1,08	2,07	1	2
	Earlier experience	18	1,28	,669	,158	,95	1,61	0	2
	Total	25	1,36	,638	,128	1,10	1,62	0	2
Massive wood's impact on the… [possibility of using local producers]	No experience	7	,57	,976	,369	-,33	1,47	-1	2
	Earlier experience	18	,78	1,003	,236	,28	1,28	-1	2
	Total	25	,72	,980	,196	,32	1,12	-1	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	7	,57	,976	,369	-,33	1,47	-1	2
	Earlier experience	16	,69	,873	,218	,22	1,15	-1	2
	Total	23	,65	,885	,184	,27	1,03	-1	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	7	,86	,900	,340	,03	1,69	0	2
	Earlier experience	16	1,19	,750	,188	,79	1,59	0	2
	Total	23	1,09	,793	,165	,74	1,43	0	2
Massive wood's impact on the... [appearance of the building]	No experience	7	,71	,756	,286	,02	1,41	0	2
	Earlier experience	19	,95	1,026	,235	,45	1,44	-1	2
	Total	26	,88	,952	,187	,50	1,27	-1	2
Massive wood's impact on the… [life span of the building]	No experience	7	,71	1,113	,421	-,31	1,74	-1	2
	Earlier experience	17	,71	,985	,239	,20	1,21	-1	2
	Total	24	,71	,999	,204	,29	1,13	-1	2
That massive wood is… [fossil free]	No experience	8	1,50	,535	,189	1,05	1,95	1	2
	Earlier experience	16	1,50	,730	,183	1,11	1,89	0	2
	Total	24	1,50	,659	,135	1,22	1,78	0	2

That massive wood is… [renewable]	No experience	8	1,50	,535	,189	1,05	1,95	1	2
	Earlier experience	18	1,56	,705	,166	1,21	1,91	0	2
	Total	26	1,54	,647	,127	1,28	1,80	0	2
That massive wood has… [carbon storage properties]	No experience	8	1,50	,535	,189	1,05	1,95	1	2
	Earlier experience	15	1,53	,743	,192	1,12	1,94	0	2
	Total	23	1,52	,665	,139	1,23	1,81	0	2
Massive wood's… [acoustic properties]	No experience	6	-,33	1,366	,558	-1,77	1,10	-2	2
	Earlier experience	18	-,72	1,274	,300	-1,36	-,09	-2	2
	Total	24	-,63	1,279	,261	-1,17	-,08	-2	2
Massive wood's… [fire properties]	No experience	6	,33	1,633	,667	-1,38	2,05	-2	2
	Earlier experience	19	,32	1,293	,297	-,31	,94	-2	2
	Total	25	,32	1,345	,269	-,24	,88	-2	2
Massive wood's… [heat and cold insulating properties]	No experience	7	,86	1,069	,404	-,13	1,85	-1	2
	Earlier experience	19	,68	,820	,188	,29	1,08	-1	2
	Total	26	,73	,874	,171	,38	1,08	-1	2
Massive wood's… [weight]	No experience	8	1,00	1,069	,378	,11	1,89	-1	2
	Earlier experience	19	1,05	,621	,143	,75	1,35	0	2
	Total	27	1,04	,759	,146	,74	1,34	-1	2
The impact on massive wood from… [rain and moisture during construction]	No experience	8	-,38	1,506	,532	-1,63	,88	-2	2
	Earlier experience	18	-,33	1,138	,268	-,90	,23	-2	2
	Total	26	-,35	1,231	,241	-,84	,15	-2	2
Massive wood's impact on the… [stability of the construct]	No experience	8	,00	1,414	,500	-1,18	1,18	-2	2
	Earlier experience	19	,42	1,427	,327	-,27	1,11	-2	2
	Total	27	,30	1,409	,271	-,26	,85	-2	2
Massive wood's… [delivery time]	No experience	4	,00	1,414	,707	-2,25	2,25	-1	2
	Earlier experience	11	,55	1,036	,312	-,15	1,24	-1	2
	Total	15	,40	1,121	,289	-,22	1,02	-1	2
Massive wood's... [precision]	No experience	6	1,00	,894	,365	,06	1,94	0	2
	Earlier experience	17	1,18	,809	,196	,76	1,59	0	2
	Total	23	1,13	,815	,170	,78	1,48	0	2
Massive wood's… [compatibility with other building materials/systems]	No experience	8	,13	1,356	,479	-1,01	1,26	-2	2
	Earlier experience	18	,83	,707	,167	,48	1,18	0	2
	Total	26	,62	,983	,193	,22	1,01	-2	2
Massive wood's… [modifiability]	No experience	7	,86	1,069	,404	-,13	1,85	-1	2
	Earlier experience	18	1,06	,938	,221	,59	1,52	-1	2
	Total	25	1,00	,957	,191	,60	1,40	-1	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	7	1,00	,816	,309	,24	1,76	0	2
	Earlier experience	17	1,47	,624	,151	1,15	1,79	0	2
	Total	24	1,33	,702	,143	1,04	1,63	0	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	7	,71	,951	,360	-,17	1,59	-1	2
	Earlier experience	17	,94	,659	,160	,60	1,28	0	2
	Total	24	,88	,741	,151	,56	1,19	-1	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	7	,86	,690	,261	,22	1,50	0	2
	Earlier experience	17	1,12	,781	,189	,72	1,52	-1	2
	Total	24	1,04	,751	,153	,72	1,36	-1	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	7	,86	1,069	,404	-,13	1,85	-1	2
	Earlier experience	16	,94	,854	,213	,48	1,39	-1	2
	Total	23	,91	,900	,188	,52	1,30	-1	2
The amount of… [massive wood waste arising at the construction site]	No experience	7	1,00	,816	,309	,24	1,76	0	2
	Earlier experience	15	1,13	,743	,192	,72	1,54	0	2
	Total	22	1,09	,750	,160	,76	1,42	0	2
Massive wood's impact on the… [construction site's safety]	No experience	6	1,00	,632	,258	,34	1,66	0	2
	Earlier experience	15	,93	1,163	,300	,29	1,58	-2	2
	Total	21	,95	1,024	,223	,49	1,42	-2	2
Massive wood's impact on the… [construction site's noise level]	No experience	6	,67	,816	,333	-,19	1,52	0	2
	Earlier experience	16	1,38	,719	,180	,99	1,76	0	2
	Total	22	1,18	,795	,169	,83	1,53	0	2
Massive wood's impact on the… [construction site's general working environment]	No experience	6	,67	,816	,333	-,19	1,52	0	2
	Earlier experience	15	1,13	,640	,165	,78	1,49	0	2
	Total	21	1,00	,707	,154	,68	1,32	0	2
Massive wood's impact on the… [construction site's disturbance to the surroundings]	No experience	6	,50	,837	,342	-,38	1,38	0	2
	Earlier experience	16	1,13	,806	,202	,70	1,55	0	2
	Total	22	,95	,844	,180	,58	1,33	0	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	9	,67	1,414	,471	-,42	1,75	-1	2
	Earlier experience	19	,63	1,422	,326	-,05	1,32	-2	2
	Total	28	,64	1,393	,263	,10	1,18	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	9	,33	1,414	,471	-,75	1,42	-2	2
	Earlier experience	19	,79	1,357	,311	,14	1,44	-2	2
	Total	28	,64	1,367	,258	,11	1,17	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	9	,67	1,000	,333	-,10	1,44	0	2
	Earlier experience	19	,84	1,302	,299	,21	1,47	-2	2
	Total	28	,79	1,197	,226	,32	1,25	-2	2

Descriptives – Construction Contractors – Massive Wood

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Massive wood's impact on your… [total costs in the project]	No experience	8	1,38	,916	,324	,61	2,14	0	2
	Earlier experience	17	,94	1,029	,250	,41	1,47	-1	2
	Total	25	1,08	,997	,199	,67	1,49	-1	2
Massive wood's impact on your… [total revenues in the project]	No experience	8	1,38	,744	,263	,75	2,00	0	2
	Earlier experience	15	,93	,961	,248	,40	1,47	-1	2
	Total	23	1,09	,900	,188	,70	1,48	-1	2
Massive wood's impact on your... [profitability in the project]	No experience	8	1,13	1,126	,398	,18	2,07	-1	2
	Earlier experience	17	,82	1,131	,274	,24	1,41	-2	2
	Total	25	,92	1,115	,223	,46	1,38	-2	2
Massive wood's impact on the… [material costs in the project]	No experience	8	,88	,991	,350	,05	1,70	0	2
	Earlier experience	17	,82	1,237	,300	,19	1,46	-2	2
	Total	25	,84	1,143	,229	,37	1,31	-2	2
Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	9	,44	1,014	,338	-,33	1,22	-1	2
	Earlier experience	15	,93	1,163	,300	,29	1,58	-2	2
	Total	24	,75	1,113	,227	,28	1,22	-2	2
Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	9	,56	,882	,294	-,12	1,23	-1	2
	Earlier experience	16	1,06	1,063	,266	,50	1,63	-1	2
	Total	25	,88	1,013	,203	,46	1,30	-1	2
Massive wood's impact on the… [project's transportation, machine and other costs]	No experience	9	,56	,882	,294	-,12	1,23	-1	2
	Earlier experience	17	,76	,970	,235	,27	1,26	-1	2
	Total	26	,69	,928	,182	,32	1,07	-1	2
Massive wood's impact on the... [rental and sales revenues]	No experience	9	,44	,882	,294	-,23	1,12	-1	2
	Earlier experience	10	,90	1,287	,407	-,02	1,82	-2	2
	Total	19	,68	1,108	,254	,15	1,22	-2	2
Massive wood's impact on your… [brand/image]	No experience	11	1,09	,701	,211	,62	1,56	0	2
	Earlier experience	17	1,24	,903	,219	,77	1,70	-1	2
	Total	28	1,18	,819	,155	,86	1,50	-1	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	13	1,62	,650	,180	1,22	2,01	0	2
	Earlier experience	17	1,53	,717	,174	1,16	1,90	0	2
	Total	30	1,57	,679	,124	1,31	1,82	0	2
Massive wood's impact on the… [construction time]	No experience	11	1,45	,688	,207	,99	1,92	0	2
	Earlier experience	17	1,29	,920	,223	,82	1,77	0	2
	Total	28	1,36	,826	,156	1,04	1,68	0	2
Massive wood's impact on the… [possibility of using local producers]	No experience	11	,73	1,191	,359	-,07	1,53	-2	2
	Earlier experience	17	,47	1,179	,286	-,14	1,08	-1	2
	Total	28	,57	1,168	,221	,12	1,02	-2	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	11	1,00	,632	,191	,58	1,42	0	2
	Earlier experience	16	,69	,946	,237	,18	1,19	-1	2
	Total	27	,81	,834	,160	,48	1,14	-1	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	11	,91	,944	,285	,27	1,54	-1	2
	Earlier experience	16	1,13	,957	,239	,61	1,64	-1	2
	Total	27	1,04	,940	,181	,67	1,41	-1	2
Massive wood's impact on the... [appearance of the building]	No experience	13	1,00	1,000	,277	,40	1,60	-1	2
	Earlier experience	17	1,00	,935	,227	,52	1,48	0	2
	Total	30	1,00	,947	,173	,65	1,35	-1	2
Massive wood's impact on the… [life span of the building]	No experience	10	1,10	,994	,314	,39	1,81	-1	2
	Earlier experience	15	,80	,862	,223	,32	1,28	0	2
	Total	25	,92	,909	,182	,54	1,30	-1	2
That massive wood is… [fossil free]	No experience	12	,83	,937	,271	,24	1,43	-1	2
	Earlier experience	17	1,35	,786	,191	,95	1,76	0	2
	Total	29	1,14	,875	,163	,81	1,47	-1	2
That massive wood is… [renewable]	No experience	12	1,08	,793	,229	,58	1,59	0	2
	Earlier experience	17	1,41	,795	,193	1,00	1,82	0	2
	Total	29	1,28	,797	,148	,97	1,58	0	2
That massive wood has… [carbon storage properties]	No experience	12	1,17	,835	,241	,64	1,70	0	2
	Earlier experience	14	1,21	,802	,214	,75	1,68	0	2
	Total	26	1,19	,801	,157	,87	1,52	0	2
Massive wood's… [acoustic properties]	No experience	10	,10	,994	,314	-,61	,81	-1	2
	Earlier experience	16	1,06	1,340	,335	,35	1,78	-2	2
	Total	26	,69	1,289	,253	,17	1,21	-2	2
Massive wood's… [fire properties]	No experience	12	,50	1,168	,337	-,24	1,24	-2	2
	Earlier experience	17	,59	1,502	,364	-,18	1,36	-2	2
	Total	29	,55	1,352	,251	,04	1,07	-2	2
Massive wood's… [heat and cold insulating properties]	No experience	10	,40	1,075	,340	-,37	1,17	-1	2
	Earlier experience	17	,88	1,111	,270	,31	1,45	-1	2
	Total	27	,70	1,103	,212	,27	1,14	-1	2
Massive wood's… [weight]	No experience	12	1,00	,953	,275	,39	1,61	-1	2
	Earlier experience	17	1,00	,866	,210	,55	1,45	-1	2
	Total	29	1,00	,886	,165	,66	1,34	-1	2
The impact on massive wood from… [rain and moisture during construction]	No experience	12	-,92	1,379	,398	-1,79	-,04	-2	2
	Earlier experience	17	,41	1,543	,374	-,38	1,21	-2	2
	Total	29	-,14	1,597	,297	-,75	,47	-2	2

Massive wood’s impact on the… [stability of the construct]	No experience	10	,50	,972	,307	-,20	1,20	-1	2
	Earlier experience	17	,76	,970	,235	,27	1,26	-1	2
	Total	27	,67	,961	,185	,29	1,05	-1	2
Massive wood’s… [delivery time]	No experience	7	,86	,690	,261	,22	1,50	0	2
	Earlier experience	17	,88	,928	,225	,41	1,36	0	2
	Total	24	,88	,850	,174	,52	1,23	0	2
Massive wood’s... [precision]	No experience	11	,73	,647	,195	,29	1,16	0	2
	Earlier experience	17	1,12	,928	,225	,64	1,59	0	2
	Total	28	,96	,838	,158	,64	1,29	0	2
Massive wood’s… [compatibility with other building materials/systems]	No experience	11	,82	,603	,182	,41	1,22	0	2
	Earlier experience	17	1,00	,866	,210	,55	1,45	0	2
	Total	28	,93	,766	,145	,63	1,23	0	2
Massive wood’s… [modifiability]	No experience	11	1,00	,775	,234	,48	1,52	0	2
	Earlier experience	17	1,24	,903	,219	,77	1,70	-1	2
	Total	28	1,14	,848	,160	,81	1,47	-1	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	11	1,09	,831	,251	,53	1,65	0	2
	Earlier experience	13	1,15	,899	,249	,61	1,70	0	2
	Total	24	1,13	,850	,174	,77	1,48	0	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	11	,64	,809	,244	,09	1,18	0	2
	Earlier experience	15	,73	,799	,206	,29	1,18	0	2
	Total	26	,69	,788	,155	,37	1,01	0	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	11	,64	,809	,244	,09	1,18	0	2
	Earlier experience	16	,94	,998	,249	,41	1,47	-1	2
	Total	27	,81	,921	,177	,45	1,18	-1	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	12	,75	,754	,218	,27	1,23	0	2
	Earlier experience	12	1,00	,953	,275	,39	1,61	-1	2
	Total	24	,88	,850	,174	,52	1,23	-1	2
The amount of… [massive wood waste arising at the construction site]	No experience	12	,67	,778	,225	,17	1,16	0	2
	Earlier experience	17	,82	1,131	,274	,24	1,41	-1	2
	Total	29	,76	,988	,183	,38	1,13	-1	2
Massive wood’s impact on the… [construction site’s safety]	No experience	10	,60	,843	,267	,00	1,20	0	2
	Earlier experience	16	1,06	,772	,193	,65	1,47	0	2
	Total	26	,88	,816	,160	,55	1,21	0	2
Massive wood’s impact on the… [construction site’s noise level]	No experience	11	,45	,934	,282	-,17	1,08	-1	2
	Earlier experience	16	1,25	,775	,194	,84	1,66	0	2
	Total	27	,93	,917	,176	,56	1,29	-1	2
Massive wood’s impact on the… [construction site’s general working environment]	No experience	12	,58	,793	,229	,08	1,09	0	2
	Earlier experience	16	1,25	,775	,194	,84	1,66	0	2
	Total	28	,96	,838	,158	,64	1,29	0	2
Massive wood’s impact on the… [construction site’s disturbance to the surroundings]	No experience	12	,67	,778	,225	,17	1,16	0	2
	Earlier experience	16	1,00	,966	,242	,49	1,51	-1	2
	Total	28	,86	,891	,168	,51	1,20	-1	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	11	,45	1,036	,312	-,24	1,15	-1	2
	Earlier experience	17	,59	1,064	,258	,04	1,14	-1	2
	Total	28	,54	1,036	,196	,13	,94	-1	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	14	,07	1,269	,339	-,66	,80	-2	2
	Earlier experience	17	1,00	1,173	,284	,40	1,60	-1	2
	Total	31	,58	1,285	,231	,11	1,05	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	14	,36	1,216	,325	-,34	1,06	-2	2
	Earlier experience	17	,88	,993	,241	,37	1,39	-1	2
	Total	31	,65	1,112	,200	,24	1,05	-2	2

Descriptives – Private Property Owners – Massive Wood

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min	Max
Massive wood’s impact on your… [total costs in the project]	No experience	10	,00	1,155	,365	-,83	,83	-2	2
	Earlier experience	8	,38	1,302	,460	-,71	1,46	-1	2
	Total	18	,17	1,200	,283	-,43	,76	-2	2
Massive wood’s impact on your… [total revenues in the project]	No experience	10	,40	,699	,221	-,10	,90	-1	1
	Earlier experience	8	,38	,916	,324	-,39	1,14	-1	2
	Total	18	,39	,778	,183	,00	,78	-1	2
Massive wood’s impact on your… [profitability in the project]	No experience	10	,20	,789	,249	-,36	,76	-1	1
	Earlier experience	8	,50	,926	,327	-,27	1,27	-1	2
	Total	18	,33	,840	,198	-,08	,75	-1	2
Massive wood’s impact on the… [material costs in the project]	No experience	10	,10	,994	,314	-,61	,81	-1	2
	Earlier experience	8	,38	1,302	,460	-,71	1,46	-1	2
	Total	18	,22	1,114	,263	-,33	,78	-1	2
Massive wood’s impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	10	,10	,738	,233	-,43	,63	-1	1
	Earlier experience	7	-,14	1,215	,459	-1,27	,98	-2	2
	Total	17	,00	,935	,227	-,48	,48	-2	2
Massive wood’s impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	10	,30	,675	,213	-,18	,78	-1	1
	Earlier experience	7	,14	1,215	,459	-,98	1,27	-2	2
	Total	17	,24	,903	,219	-,23	,70	-2	2
Massive wood’s impact on the… [project’s transportation, machine and other costs]	No experience	10	,70	,675	,213	,22	1,18	0	2
	Earlier experience	7	,71	,756	,286	,02	1,41	0	2
	Total	17	,71	,686	,166	,35	1,06	0	2

Massive wood's impact on the... [rental and sales revenues]	No experience	11	,64	,809	,244	,09	1,18	0	2
	Earlier experience	8	,88	,835	,295	,18	1,57	0	2
	Total	19	,74	,806	,185	,35	1,13	0	2
Massive wood's impact on your… [brand/image]	No experience	11	1,45	,688	,207	,99	1,92	0	2
	Earlier experience	8	1,25	,707	,250	,66	1,84	0	2
	Total	19	1,37	,684	,157	1,04	1,70	0	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	10	1,00	,667	,211	,52	1,48	0	2
	Earlier experience	8	1,50	,535	,189	1,05	1,95	1	2
	Total	18	1,22	,647	,152	,90	1,54	0	2
Massive wood's impact on the… [construction time]	No experience	10	,50	,707	,224	-,01	1,01	-1	1
	Earlier experience	8	,75	1,389	,491	-,41	1,91	-2	2
	Total	18	,61	1,037	,244	,10	1,13	-2	2
Massive wood's impact on the… [possibility of using local producers]	No experience	9	,67	,707	,236	,12	1,21	0	2
	Earlier experience	8	,88	,835	,295	,18	1,57	0	2
	Total	17	,76	,752	,182	,38	1,15	0	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	11	1,18	,874	,263	,59	1,77	0	2
	Earlier experience	8	,88	,991	,350	,05	1,70	-1	2
	Total	19	1,05	,911	,209	,61	1,49	-1	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	11	1,09	,701	,211	,62	1,56	0	2
	Earlier experience	8	1,25	,886	,313	,51	1,99	0	2
	Total	19	1,16	,765	,175	,79	1,53	0	2
Massive wood's impact on the... [appearance of the building]	No experience	11	1,27	,647	,195	,84	1,71	0	2
	Earlier experience	8	1,00	1,069	,378	,11	1,89	0	2
	Total	19	1,16	,834	,191	,76	1,56	0	2
Massive wood's impact on the… [life span of the building]	No experience	10	,40	1,174	,371	-,44	1,24	-1	2
	Earlier experience	8	,38	1,408	,498	-,80	1,55	-1	2
	Total	18	,39	1,243	,293	-,23	1,01	-1	2
That massive wood is… [fossil free]	No experience	12	1,58	,669	,193	1,16	2,01	0	2
	Earlier experience	8	1,38	,744	,263	,75	2,00	0	2
	Total	20	1,50	,688	,154	1,18	1,82	0	2
That massive wood is… [renewable]	No experience	13	1,54	,660	,183	1,14	1,94	0	2
	Earlier experience	8	1,75	,463	,164	1,36	2,14	1	2
	Total	21	1,62	,590	,129	1,35	1,89	0	2
That massive wood has… [carbon storage properties]	No experience	12	1,50	,674	,195	1,07	1,93	0	2
	Earlier experience	7	1,14	,900	,340	,31	1,97	0	2
	Total	19	1,37	,761	,175	1,00	1,74	0	2
Massive wood's… [acoustic properties]	No experience	10	-,10	1,287	,407	-1,02	,82	-2	2
	Earlier experience	8	,25	1,165	,412	-,72	1,22	-1	2
	Total	18	,06	1,211	,286	-,55	,66	-2	2
Massive wood's… [fire properties]	No experience	10	,00	1,247	,394	-,89	,89	-2	2
	Earlier experience	8	-,38	1,302	,460	-1,46	,71	-2	2
	Total	18	-,17	1,249	,294	-,79	,45	-2	2
Massive wood's… [heat and cold insulating properties]	No experience	10	,40	,843	,267	-,20	1,00	-1	2
	Earlier experience	8	,63	,916	,324	-,14	1,39	-1	2
	Total	18	,50	,857	,202	,07	,93	-1	2
Massive wood's… [weight]	No experience	10	,90	,994	,314	,19	1,61	-1	2
	Earlier experience	8	1,00	,756	,267	,37	1,63	0	2
	Total	18	,94	,873	,206	,51	1,38	-1	2
The impact on massive wood from… [rain and moisture during construction]	No experience	11	-,55	1,214	,366	-1,36	,27	-2	2
	Earlier experience	8	-,63	1,061	,375	-1,51	,26	-2	1
	Total	19	-,58	1,121	,257	-1,12	-,04	-2	2
Massive wood's impact on the… [stability of the construct]	No experience	10	-,10	,994	,314	-,81	,61	-1	2
	Earlier experience	8	,13	,991	,350	-,70	,95	-1	2
	Total	18	,00	,970	,229	-,48	,48	-1	2
Massive wood's… [delivery time]	No experience	10	,10	,568	,180	-,31	,51	-1	1
	Earlier experience	7	,71	1,254	,474	-,45	1,87	-1	2
	Total	17	,35	,931	,226	-,13	,83	-1	2
Massive wood's... [precision]	No experience	10	,20	,632	,200	-,25	,65	-1	1
	Earlier experience	8	,75	1,165	,412	-,22	1,72	-1	2
	Total	18	,44	,922	,217	-,01	,90	-1	2
Massive wood's… [compatibility with other building materials/systems]	No experience	10	,10	,568	,180	-,31	,51	-1	1
	Earlier experience	7	1,43	,787	,297	,70	2,16	0	2
	Total	17	,65	,931	,226	,17	1,13	-1	2
Massive wood's… [modifiability]	No experience	10	,60	,966	,306	-,09	1,29	-1	2
	Earlier experience	8	1,50	,756	,267	,87	2,13	0	2
	Total	18	1,00	,970	,229	,52	1,48	-1	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	9	1,11	,601	,200	,65	1,57	0	2
	Earlier experience	8	1,25	1,165	,412	,28	2,22	-1	2
	Total	17	1,18	,883	,214	,72	1,63	-1	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	9	,67	,707	,236	,12	1,21	0	2
	Earlier experience	8	1,25	1,165	,412	,28	2,22	-1	2
	Total	17	,94	,966	,234	,44	1,44	-1	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	9	,67	,707	,236	,12	1,21	0	2
	Earlier experience	8	1,50	,756	,267	,87	2,13	0	2
	Total	17	1,06	,827	,201	,63	1,48	0	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	8	,50	,535	,189	,05	,95	0	1
	Earlier experience	8	1,25	,707	,250	,66	1,84	0	2
	Total	16	,88	,719	,180	,49	1,26	0	2
The amount of… [massive wood waste arising at the	No experience	8	,63	,518	,183	,19	1,06	0	1

construction site]	Earlier experience	8	1,38	,744	,263	,75	2,00	0	2
	Total	16	1,00	,730	,183	,61	1,39	0	2
Massive wood's impact on the… [construction site's safety]	No experience	9	,44	,726	,242	-,11	1,00	0	2
	Earlier experience	7	,86	1,069	,404	-,13	1,85	0	2
	Total	16	,63	,885	,221	,15	1,10	0	2
Massive wood's impact on the… [construction site's noise level]	No experience	9	,67	,500	,167	,28	1,05	0	1
	Earlier experience	7	,86	1,345	,508	-,39	2,10	-1	2
	Total	16	,75	,931	,233	,25	1,25	-1	2
Massive wood's impact on the… [construction site's general working environment]	No experience	8	,75	,463	,164	,36	1,14	0	1
	Earlier experience	7	1,14	,900	,340	,31	1,97	0	2
	Total	15	,93	,704	,182	,54	1,32	0	2
Massive wood's impact on the… [construction site's disturbance to the surroundings]	No experience	9	,78	,441	,147	,44	1,12	0	1
	Earlier experience	7	1,29	,756	,286	,59	1,98	0	2
	Total	16	1,00	,632	,158	,66	1,34	0	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	11	,64	,924	,279	,02	1,26	-1	2
	Earlier experience	8	,88	,835	,295	,18	1,57	0	2
	Total	19	,74	,872	,200	,32	1,16	-1	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	11	,00	1,483	,447	-1,00	1,00	-2	2
	Earlier experience	8	,63	,744	,263	,00	1,25	0	2
	Total	19	,26	1,240	,285	-,33	,86	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	11	-,09	1,514	,456	-1,11	,93	-2	2
	Earlier experience	8	1,00	1,069	,378	,11	1,89	-1	2
	Total	19	,37	1,422	,326	-,32	1,05	-2	2

Descriptives – Public Property Owners – Massive Wood

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Min	Max
Massive wood's impact on your… [total costs in the project]	No experience	33	,42	1,324	,230	-,05	,89	-2	2
	Earlier experience	24	,00	1,142	,233	-,48	,48	-2	2
	Total	57	,25	1,258	,167	-,09	,58	-2	2
Massive wood's impact on your… [total revenues in the project]	No experience	29	,14	1,093	,203	-,28	,55	-2	2
	Earlier experience	22	-,05	,950	,203	-,47	,38	-2	2
	Total	51	,06	1,028	,144	-,23	,35	-2	2
Massive wood's impact on your... [profitability in the project]	No experience	32	,41	1,292	,228	-,06	,87	-2	2
	Earlier experience	23	-,09	1,083	,226	-,56	,38	-2	2
	Total	55	,20	1,223	,165	-,13	,53	-2	2
Massive wood's impact on the… [material costs in the project]	No experience	33	,30	1,262	,220	-,14	,75	-2	2
	Earlier experience	23	,00	1,206	,251	-,52	,52	-2	2
	Total	56	,18	1,237	,165	-,15	,51	-2	2
Massive wood's impact on the… [projects labor costs for architects, structural engineers etc.]	No experience	32	,00	,803	,142	-,29	,29	-2	2
	Earlier experience	22	-,18	,664	,142	-,48	,11	-2	1
	Total	54	-,07	,749	,102	-,28	,13	-2	2
Massive wood's impact on the… [projects labor costs for workers (construction workers etc.)]	No experience	31	,23	,884	,159	-,10	,55	-1	2
	Earlier experience	22	,23	,869	,185	-,16	,61	-2	2
	Total	53	,23	,869	,119	-,01	,47	-2	2
Massive wood's impact on the… [project's transportation, machine and other costs]	No experience	32	,38	,751	,133	,10	,65	-1	2
	Earlier experience	22	,64	,790	,168	,29	,99	-1	2
	Total	54	,48	,771	,105	,27	,69	-1	2
Massive wood's impact on the... [rental and sales revenues]	No experience	32	,44	1,045	,185	,06	,81	-2	2
	Earlier experience	21	,48	,750	,164	,13	,82	-1	2
	Total	53	,45	,932	,128	,20	,71	-2	2
Massive wood's impact on your… [brand/image]	No experience	40	,98	,891	,141	,69	1,26	-1	2
	Earlier experience	23	1,26	,689	,144	,96	1,56	0	2
	Total	63	1,08	,829	,104	,87	1,29	-1	2
Massive wood's impact on the… [possibility of prefabrication]	No experience	33	,85	1,034	,180	,48	1,22	-2	2
	Earlier experience	25	1,28	,843	,169	,93	1,63	-1	2
	Total	58	1,03	,973	,128	,78	1,29	-2	2
Massive wood's impact on the… [construction time]	No experience	34	,91	,965	,166	,58	1,25	-2	2
	Earlier experience	25	,84	1,068	,214	,40	1,28	-2	2
	Total	59	,88	1,001	,130	,62	1,14	-2	2
Massive wood's impact on the… [possibility of using local producers]	No experience	35	,06	1,083	,183	-,31	,43	-2	2
	Earlier experience	23	,26	1,010	,211	-,18	,70	-2	2
	Total	58	,14	1,050	,138	-,14	,41	-2	2
Massive wood's impact on the… [energy consumption in the operation of the building]	No experience	35	,74	1,010	,171	,40	1,09	-1	2
	Earlier experience	25	,72	,792	,158	,39	1,05	0	2
	Total	60	,73	,918	,119	,50	,97	-1	2
Massive wood's impact on the… [indoor environment for the end user]	No experience	37	,76	1,038	,171	,41	1,10	-2	2
	Earlier experience	24	1,08	,776	,158	,76	1,41	0	2
	Total	61	,89	,950	,122	,64	1,13	-2	2
Massive wood's impact on the... [appearance of the building]	No experience	39	,38	,963	,154	,07	,70	-2	2
	Earlier experience	26	,77	,652	,128	,51	1,03	0	2
	Total	65	,54	,867	,108	,32	,75	-2	2
Massive wood's impact on the… [life span of the building]	No experience	33	,12	1,453	,253	-,39	,64	-2	2
	Earlier experience	25	,56	,917	,183	,18	,94	-1	2
	Total	58	,31	1,259	,165	-,02	,64	-2	2
That massive wood is… [fossil free]	No experience	47	1,36	,735	,107	1,15	1,58	0	2

	Earlier experience	26	1,50	,648	,127	1,24	1,76	0	2
	Total	73	1,41	,704	,082	1,25	1,58	0	2
That massive wood is… [renewable]	No experience	48	1,44	,741	,107	1,22	1,65	0	2
	Earlier experience	26	1,54	,647	,127	1,28	1,80	0	2
	Total	74	1,47	,707	,082	1,31	1,64	0	2
That massive wood has… [carbon storage properties]	No experience	43	1,26	,875	,133	,99	1,53	0	2
	Earlier experience	24	1,46	,721	,147	1,15	1,76	0	2
	Total	67	1,33	,824	,101	1,13	1,53	0	2
Massive wood's… [acoustic properties]	No experience	37	-,19	1,371	,225	-,65	,27	-2	2
	Earlier experience	24	,13	1,361	,278	-,45	,70	-2	2
	Total	61	-,07	1,365	,175	-,42	,28	-2	2
Massive wood's… [fire properties]	No experience	40	-,08	1,309	,207	-,49	,34	-2	2
	Earlier experience	26	,00	1,095	,215	-,44	,44	-2	2
	Total	66	-,05	1,221	,150	-,35	,25	-2	2
Massive wood's… [heat and cold insulating properties]	No experience	36	,50	1,000	,167	,16	,84	-2	2
	Earlier experience	26	,62	,697	,137	,33	,90	0	2
	Total	62	,55	,881	,112	,32	,77	-2	2
Massive wood's… [weight]	No experience	38	,68	,904	,147	,39	,98	-1	2
	Earlier experience	26	,77	,815	,160	,44	1,10	-1	2
	Total	64	,72	,863	,108	,50	,93	-1	2
The impact on massive wood from… [rain and moisture during construction]	No experience	39	-,72	1,191	,191	-1,10	-,33	-2	2
	Earlier experience	25	,04	1,207	,241	-,46	,54	-2	2
	Total	64	-,42	1,245	,156	-,73	-,11	-2	2
Massive wood's impact on the… [stability of the construct]	No experience	38	,05	1,138	,185	-,32	,43	-2	2
	Earlier experience	26	,15	,881	,173	-,20	,51	-2	2
	Total	64	,09	1,035	,129	-,16	,35	-2	2
Massive wood's… [delivery time]	No experience	30	,40	,968	,177	,04	,76	-1	2
	Earlier experience	25	,48	,653	,131	,21	,75	0	2
	Total	55	,44	,834	,112	,21	,66	-1	2
Massive wood's... [precision]	No experience	35	,29	,893	,151	-,02	,59	-1	2
	Earlier experience	25	,68	,802	,160	,35	1,01	0	2
	Total	60	,45	,872	,113	,22	,68	-1	2
Massive wood's… [compatibility with other building materials/systems]	No experience	36	,61	,934	,156	,29	,93	-1	2
	Earlier experience	26	,62	,804	,158	,29	,94	-1	2
	Total	62	,61	,875	,111	,39	,84	-1	2
Massive wood's… [modifiability]	No experience	34	,68	1,065	,183	,30	1,05	-2	2
	Earlier experience	25	1,00	,764	,153	,68	1,32	0	2
	Total	59	,81	,955	,124	,56	1,06	-2	2
The amount of… [greenhouse gas emissions arising from production of the massive wood]	No experience	36	1,03	,845	,141	,74	1,31	-1	2
	Earlier experience	24	1,08	,881	,180	,71	1,46	-1	2
	Total	60	1,05	,852	,110	,83	1,27	-1	2
The amount of... [greenhouse gas emissions arising from transportation of the massive wood]	No experience	36	,44	,843	,141	,16	,73	-1	2
	Earlier experience	24	,63	1,013	,207	,20	1,05	-1	2
	Total	60	,52	,911	,118	,28	,75	-1	2
The amount of… [greenhouse gas emissions arising from handling of the massive wood at the construction site]	No experience	35	,46	,919	,155	,14	,77	-2	2
	Earlier experience	24	,75	1,032	,211	,31	1,19	-1	2
	Total	59	,58	,969	,126	,32	,83	-2	2
The amount of… [massive wood waste arising from production of the frame material]	No experience	34	,65	,917	,157	,33	,97	-2	2
	Earlier experience	22	,82	,907	,193	,42	1,22	-1	2
	Total	56	,71	,909	,121	,47	,96	-2	2
The amount of… [massive wood waste arising at the construction site]	No experience	35	,57	,979	,165	,24	,91	-2	2
	Earlier experience	25	,84	,943	,189	,45	1,23	-1	2
	Total	60	,68	,965	,125	,43	,93	-2	2
Massive wood's impact on the… [construction site's safety]	No experience	33	,48	1,034	,180	,12	,85	-2	2
	Earlier experience	24	,50	,722	,147	,19	,81	-1	2
	Total	57	,49	,909	,120	,25	,73	-2	2
Massive wood's impact on the… [construction site's noise level]	No experience	34	,56	,860	,147	,26	,86	-2	2
	Earlier experience	24	1,00	,780	,159	,67	1,33	0	2
	Total	58	,74	,849	,112	,52	,96	-2	2
Massive wood's impact on the… [construction site's general working environment]	No experience	36	,61	,871	,145	,32	,91	-2	2
	Earlier experience	25	,92	,759	,152	,61	1,23	0	2
	Total	61	,74	,835	,107	,52	,95	-2	2
Massive wood's impact on the… [construction site's disturbance to the surroundings]	No experience	38	,50	,893	,145	,21	,79	-2	2
	Earlier experience	25	,60	,764	,153	,28	,92	-1	2
	Total	63	,54	,839	,106	,33	,75	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of available information of massive wood]	No experience	42	-,02	,950	,147	-,32	,27	-2	2
	Earlier experience	24	-,04	,690	,141	-,33	,25	-1	1
	Total	66	-,03	,859	,106	-,24	,18	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of experience I have of using massive wood]	No experience	42	-,21	1,138	,176	-,57	,14	-2	2
	Earlier experience	25	,44	1,044	,209	,01	,87	-1	2
	Total	67	,03	1,141	,139	-,25	,31	-2	2
For you to prefer massive wood as frame material, how do you view the following factors? [The amount of knowledge I have about massive wood]	No experience	43	-,07	1,078	,164	-,40	,26	-2	2
	Earlier experience	24	,38	,875	,179	,01	,74	-1	2
	Total	67	,09	1,026	,125	-,16	,34	-2	2

Descriptives – Complementary Variables – All Actors

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	109	3,33	1,195	,114	3,10	3,56	1	5
	Earlier experience	93	3,57	1,087	,113	3,35	3,79	1	5
	Total	202	3,44	1,150	,081	3,28	3,60	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	109	3,55	1,206	,115	3,32	3,78	1	5
	Earlier experience	93	3,67	1,004	,104	3,46	3,87	1	5
	Total	202	3,60	1,116	,079	3,45	3,76	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	109	3,70	1,182	,113	3,47	3,92	1	5
	Earlier experience	93	3,84	1,025	,106	3,63	4,05	1	5
	Total	202	3,76	1,112	,078	3,61	3,92	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	107	4,22	,974	,094	4,04	4,41	1	5
	Earlier experience	93	4,15	1,021	,106	3,94	4,36	1	5
	Total	200	4,19	,994	,070	4,05	4,33	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	105	4,43	,853	,083	4,26	4,59	1	5
	Earlier experience	87	4,23	,936	,100	4,03	4,43	1	5
	Total	192	4,34	,895	,065	4,21	4,47	1	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	73	4,79	1,536	,180	4,44	5,15	1	7
	Earlier experience	81	5,06	1,435	,159	4,74	5,38	1	7
	Total	154	4,94	1,485	,120	4,70	5,17	1	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	89	5,82	1,134	,120	5,58	6,06	3	7
	Earlier experience	88	6,19	1,004	,107	5,98	6,41	3	7
	Total	177	6,01	1,084	,082	5,84	6,17	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	70	4,80	1,314	,157	4,49	5,11	2	7
	Earlier experience	75	5,16	1,356	,157	4,85	5,47	2	7
	Total	145	4,99	1,344	,112	4,77	5,21	2	7
What is your general opinion about massive wood as frame material?	No experience	111	5,05	1,381	,131	4,79	5,31	1	7
	Earlier experience	94	5,83	1,224	,126	5,58	6,08	2	7
	Total	205	5,41	1,364	,095	5,22	5,60	1	7

Descriptives – Complementary Variables - Architects

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	12	3,42	1,165	,336	2,68	4,16	2	5
	Earlier experience	15	3,13	,990	,256	2,58	3,68	2	5
	Total	27	3,26	1,059	,204	2,84	3,68	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	12	3,83	1,115	,322	3,13	4,54	2	5
	Earlier experience	15	3,47	,990	,256	2,92	4,02	2	5
	Total	27	3,63	1,043	,201	3,22	4,04	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	12	3,67	1,435	,414	2,75	4,58	1	5
	Earlier experience	15	4,33	,976	,252	3,79	4,87	2	5
	Total	27	4,04	1,224	,236	3,55	4,52	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	12	4,00	1,044	,302	3,34	4,66	2	5
	Earlier experience	15	4,07	1,223	,316	3,39	4,74	1	5
	Total	27	4,04	1,126	,217	3,59	4,48	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	12	4,00	,853	,246	3,46	4,54	2	5
	Earlier experience	15	4,27	1,163	,300	3,62	4,91	1	5
	Total	27	4,15	1,027	,198	3,74	4,55	1	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	9	5,67	1,414	,471	4,58	6,75	3	7
	Earlier experience	15	5,27	1,280	,330	4,56	5,98	4	7
	Total	24	5,42	1,316	,269	4,86	5,97	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	11	6,27	1,191	,359	5,47	7,07	3	7
	Earlier experience	15	6,27	1,100	,284	5,66	6,88	4	7
	Total	26	6,27	1,116	,219	5,82	6,72	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	10	5,30	1,494	,473	4,23	6,37	3	7
	Earlier experience	15	5,33	1,345	,347	4,59	6,08	3	7
	Total	25	5,32	1,376	,275	4,75	5,89	3	7
What is your general opinion about massive wood as frame material?	No experience	12	6,33	,888	,256	5,77	6,90	4	7
	Earlier experience	15	6,33	,724	,187	5,93	6,73	5	7
	Total	27	6,33	,784	,151	6,02	6,64	4	7

Descriptives –Complementary Variables - Structual Engineers

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	10	3,50	1,080	,342	2,73	4,27	2	5
	Earlier experience	19	3,89	1,100	,252	3,36	4,43	2	5
	Total	29	3,76	1,091	,203	3,34	4,17	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	10	3,30	,675	,213	2,82	3,78	2	4
	Earlier experience	19	3,68	1,108	,254	3,15	4,22	1	5
	Total	29	3,55	,985	,183	3,18	3,93	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	10	3,60	,966	,306	2,91	4,29	2	5
	Earlier experience	19	3,89	,737	,169	3,54	4,25	3	5
	Total	29	3,79	,819	,152	3,48	4,10	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	9	4,44	1,014	,338	3,67	5,22	2	5
	Earlier experience	19	4,05	,911	,209	3,61	4,49	3	5
	Total	28	4,18	,945	,179	3,81	4,54	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	10	4,50	,972	,307	3,80	5,20	2	5
	Earlier experience	19	4,21	1,032	,237	3,71	4,71	2	5
	Total	29	4,31	1,004	,186	3,93	4,69	2	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	6	4,00	1,265	,516	2,67	5,33	2	5
	Earlier experience	16	4,81	1,223	,306	4,16	5,46	3	7
	Total	22	4,59	1,260	,269	4,03	5,15	2	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	6	5,17	,753	,307	4,38	5,96	4	6
	Earlier experience	19	6,37	,831	,191	5,97	6,77	4	7
	Total	25	6,08	,954	,191	5,69	6,47	4	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	4	4,50	1,000	,500	2,91	6,09	4	6
	Earlier experience	14	5,43	1,284	,343	4,69	6,17	3	7
	Total	18	5,22	1,263	,298	4,59	5,85	3	7
What is your general opinion about massive wood as frame material?	No experience	10	5,30	,949	,300	4,62	5,98	3	6
	Earlier experience	19	6,21	,918	,211	5,77	6,65	4	7
	Total	29	5,90	1,012	,188	5,51	6,28	3	7

Descriptives – Complementary Variables – Construction Contractors

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	16	3,88	1,025	,256	3,33	4,42	2	5
	Earlier experience	17	4,24	,903	,219	3,77	4,70	2	5
	Total	33	4,06	,966	,168	3,72	4,40	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	16	3,94	,998	,249	3,41	4,47	2	5
	Earlier experience	17	4,00	1,061	,257	3,45	4,55	2	5
	Total	33	3,97	1,015	,177	3,61	4,33	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	16	4,19	,911	,228	3,70	4,67	2	5
	Earlier experience	17	3,71	,920	,223	3,23	4,18	2	5
	Total	33	3,94	,933	,162	3,61	4,27	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	16	4,25	1,000	,250	3,72	4,78	2	5
	Earlier experience	17	4,35	,786	,191	3,95	4,76	3	5
	Total	33	4,30	,883	,154	3,99	4,62	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	16	4,50	,730	,183	4,11	4,89	3	5
	Earlier experience	16	4,38	,719	,180	3,99	4,76	3	5
	Total	32	4,44	,716	,127	4,18	4,70	3	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	9	5,00	1,000	,333	4,23	5,77	4	7
	Earlier experience	14	5,50	1,401	,374	4,69	6,31	3	7
	Total	23	5,30	1,259	,263	4,76	5,85	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	13	6,08	,954	,265	5,50	6,65	4	7
	Earlier experience	16	6,00	1,265	,316	5,33	6,67	3	7
	Total	29	6,03	1,117	,208	5,61	6,46	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	8	5,25	1,165	,412	4,28	6,22	4	7
	Earlier experience	13	5,15	1,625	,451	4,17	6,14	3	7
	Total	21	5,19	1,436	,313	4,54	5,84	3	7
What is your general opinion about massive wood as frame material?	No experience	16	5,19	,655	,164	4,84	5,54	4	6
	Earlier experience	18	5,83	1,383	,326	5,15	6,52	2	7
	Total	34	5,53	1,134	,195	5,13	5,93	2	7

Descriptives – Complementary Variables – Private Property Owners

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	13	3,38	1,193	,331	2,66	4,11	1	5
	Earlier experience	8	3,50	,535	,189	3,05	3,95	3	4
	Total	21	3,43	,978	,213	2,98	3,87	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	13	3,15	1,214	,337	2,42	3,89	1	5
	Earlier experience	8	3,88	1,126	,398	2,93	4,82	2	5
	Total	21	3,43	1,207	,263	2,88	3,98	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	13	3,46	,967	,268	2,88	4,05	1	5
	Earlier experience	8	4,00	,756	,267	3,37	4,63	3	5
	Total	21	3,67	,913	,199	3,25	4,08	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	12	4,00	,739	,213	3,53	4,47	3	5
	Earlier experience	8	4,25	1,165	,412	3,28	5,22	2	5
	Total	20	4,10	,912	,204	3,67	4,53	2	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	13	4,62	,506	,140	4,31	4,92	4	5
	Earlier experience	8	4,50	,535	,189	4,05	4,95	4	5
	Total	21	4,57	,507	,111	4,34	4,80	4	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	7	4,86	1,676	,634	3,31	6,41	3	7
	Earlier experience	8	5,13	,835	,295	4,43	5,82	4	7
	Total	15	5,00	1,254	,324	4,31	5,69	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	10	6,00	,943	,298	5,33	6,67	5	7
	Earlier experience	8	6,38	,744	,263	5,75	7,00	5	7
	Total	18	6,17	,857	,202	5,74	6,59	5	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	8	5,38	1,061	,375	4,49	6,26	4	7
	Earlier experience	8	5,50	1,195	,423	4,50	6,50	4	7
	Total	16	5,44	1,094	,273	4,85	6,02	4	7
What is your general opinion about massive wood as frame material?	No experience	13	5,15	1,068	,296	4,51	5,80	4	7
	Earlier experience	8	6,00	,926	,327	5,23	6,77	5	7
	Total	21	5,48	1,078	,235	4,99	5,97	4	7

Descriptives – Complementary Variables – Public Property Owners

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Min	Max
In general, how much influence do you think the following actors have over the choice of a building material? [Architects]	No experience	52	3,12	1,247	,173	2,77	3,46	1	5
	Earlier experience	27	3,30	1,103	,212	2,86	3,73	1	5
	Total	79	3,18	1,196	,135	2,91	3,45	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Structual Engineers]	No experience	52	3,50	1,321	,183	3,13	3,87	1	5
	Earlier experience	27	3,63	,884	,170	3,28	3,98	1	5
	Total	79	3,54	1,185	,133	3,28	3,81	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Construction Contractors]	No experience	52	3,69	1,276	,177	3,34	4,05	1	5
	Earlier experience	27	3,52	1,282	,247	3,01	4,03	1	5
	Total	79	3,63	1,273	,143	3,35	3,92	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Public Property Owners]	No experience	53	4,34	,919	,126	4,09	4,59	2	5
	Earlier experience	27	4,11	1,121	,216	3,67	4,55	1	5
	Total	80	4,26	,990	,111	4,04	4,48	1	5
In general, how much influence do you think the following actors have over the choice of a building material? [Private Property Owners]	No experience	48	4,54	,798	,115	4,31	4,77	2	5
	Earlier experience	23	3,96	1,022	,213	3,51	4,40	2	5
	Total	71	4,35	,912	,108	4,14	4,57	2	5
In the construction industry, how do you think massive wood as frame material contributes to ... [economic sustainability?]	No experience	36	4,58	1,538	,256	4,06	5,10	2	7
	Earlier experience	23	4,70	1,820	,379	3,91	5,48	1	7
	Total	59	4,63	1,639	,213	4,20	5,05	1	7
In the construction industry, how do you think massive wood as frame material contributes to ... [environmental sustainability?]	No experience	43	5,60	1,198	,183	5,24	5,97	3	7
	Earlier experience	24	6,13	1,035	,211	5,69	6,56	4	7
	Total	67	5,79	1,162	,142	5,51	6,07	3	7
In the construction industry, how do you think massive wood as frame material contributes to ... [social sustainability?]	No experience	34	4,32	1,249	,214	3,89	4,76	2	7
	Earlier experience	21	4,62	1,244	,271	4,05	5,19	2	7
	Total	55	4,44	1,244	,168	4,10	4,77	2	7
What is your general opinion about massive wood as frame material?	No experience	54	4,57	1,422	,194	4,19	4,96	2	7
	Earlier experience	27	5,30	1,325	,255	4,77	5,82	2	7
	Total	81	4,81	1,424	,158	4,50	5,13	2	7

Appendix 6

The tables below present how different actors with different levels of experience view their most important value creating factors when the frame material is massive wood.

If the mean value of the factor is significantly higher than 0 (neutral) this is marked with (+) and is viewed as an *advantage* in order to prefer massive wood as the frame material. In the same way, a factor with the mean value significantly lower than 0, marked with (-), is viewed as a *disadvantage*. If the mean value is not significantly higher, or lower, than 0 it is viewed as *both an advantage and a disadvantage*. In theory, if the mean value is not significantly higher or lower than 0, all the respondents could have viewed the factor as neutral. However, in practice, there is a considerable number of respondents rating the factor as either an advantage or a disadvantage.

Private Property Owners				
Aspect	**Potential value creating factor**	**No experience**	**Earlier experience**	**Total**
Economic	Massive wood's impact on the... **[life span of the building]**	+/-	+/-	+/-
Economic	Massive wood's impact on the... **[material costs in the project]**	+/-	+/-	+/-
Environmental	Massive wood's impact on the... **[energy consumption in the operation of the building]**	+	+	+
Social	The massive wood's impact on the... **[construction site's safety]**	+/-	+/-	+
Social	Massive wood's impact on the... **[indoor environment for the end user]**	+	+	+
Social	Massive wood's... **[fire properties]**	+/-	+/-	+/-

Public Property Owners				
Aspect	**Potential value creating factor**	**No experience**	**Earlier experience**	**Total**
Economic	Massive wood's impact on the... **[life span of the building]**	+/-	+	+/-
Economic	Massive wood's impact on the... **[construction time]**	+	+	+
Economic	Massive wood's impact on the... **[material costs in the project]**	+/-	+/-	+/-
Economic	The impact on massive wood from... **[rain and moisture during construction]**	-	+/-	-
Economic	Massive wood's impact on the... **[stability of the construct]**	+/-	+/-	+/-
Environmental	Massive wood's impact on the... **[energy consumption in the operation of the building]**	+	+	+
Environmental	Massive wood's... **[heat and cold insulating properties]**	+	+	+
Social	The massive wood's impact on the... **[construction site's safety]**	+	+	+
Social	Massive wood's impact on the... **[indoor environment for the end user]**	+	+	+
Social	Massive wood's... **[acoustic properties]**	+/-	+/-	+/-
Social	Massive wood's... **[fire properties]**	+/-	+/-	+/-
Social	Massive wood's... **[compatibility with other building materials/systems]**	+	+	+

Architects				
Aspect	**Potential value creating factor**	**No experience**	**Earlier experience**	**Total**
Economic	Massive wood's impact on the… **[material costs in the project]**	+/-	+/-	+/-
Economic	Massive wood's impact on the… **[stability of the construct]**	+/-	+/-	+
Environmental	That massive wood is… **[fossil free]**	+	+	+
Environmental	That massive wood is… **[renewable]**	+	+	+
Environmental	That massive wood has… **[carbon storage properties]**	+	+	+
Environmental	The amount of**…** **[massive wood waste arising at the worksite]**	+	+	+
Environmental	The amount of… **[massive wood waste arising from production of the frame material]**	+/-	+	+
Environmental	The amount of… **[greenhouse gas emissions arising from handling of the massive wood at the construction site]**	+	+	+
Environmental	The amount of… **[greenhouse gas emissions arising from production of the massive wood]**	+	+	+
Environmental	The amount of… **[greenhouse gas emissions arising from transportation of the massive wood]**	+/-	+	+
Environmental	Massive wood's impact on the… **[energy consumption in the operation of the building]**	+	+	+
Environmental	Massive wood's… **[heat and cold insulating properties]**	+	+	+
Social	Massive wood's impact on the… **[indoor environment for the end user]**	+	+	+
Social	Massive wood's impact on the… **[appearance of the building]**	+	+	+

Structural Engineers				
Aspect	**Potential value creating factor**	**No experience**	**Earlier experience**	**Total**
Economic	Massive wood's impact on the… **[life span of the building]**	+/-	+	+
Economic	Massive wood's impact on the… **[construction time]**	+	+	+
Economic	Massive wood's impact on the… **[material costs in the project]**	+/-	+	+
Economic	Massive wood's impact on the… **[stability of the construct]**	+/-	+/-	+/-
Environmental	Massive wood's impact on the… **[energy consumption in the operation of the building]**	+/-	+	+
Environmental	Massive wood's… **[heat and cold insulating properties]**	+/-	+	+
Social	The massive wood's impact on the… **[construction site's safety]**	+	+	+
Social	Massive wood's impact on the… **[indoor environment for the end user]**	+	+	+
Social	Massive wood's… **[modifiability]**	+/-	+	+
Social	Massive wood's… **[fire properties]**	+/-	+/-	+/-

Construction Contractors				
Aspect	**Potential value creating factor**	**No experience**	**Earlier experience**	**Total**
Economic	Massive wood's impact on the… **[construction time]**	+	+	+
Economic	Massive wood's impact on the… **[material costs in the project]**	+	+	+
Economic	The impact on massive wood from… **[rain and moisture during construction]**	-	+/-	+/-
Economic	Massive wood's impact on the… **[stability of the construct]**	+/-	+	+
Environmental	The amount of… **[massive wood waste arising at the worksite]**	+	+	+
Environmental	Massive wood's… **[heat and cold insulating properties]**	+/-	+	+
Social	Massive wood's impact on the… **[construction site's general working environment]**	+	+	+
Social	The massive wood's impact on the… **[construction site's safety]**	+/-	+	+
Social	Massive wood's… **[modifiability]**	+	+	+
Social	Massive wood's… **[fire properties]**	+/-	+/-	+
Social	Massive wood's… **[compatibility with other building materials/systems]**	+	+	+