Market assumptions for substitution between wood and non-wood products: The case of packaging and textile sectors

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Tiivistelmä – Referat – Abstract

Forests play a central role in climate change mitigation actions, and substitution, that is the use of wood products in place of fossil intensive materials, has been recognized as a potential way to avoid emissions. While there are studies estimating the substitution impact of products, i.e., the avoided emissions, there is a lack of studies integrating market perspectives into substitution estimation. To contribute to this research gap, this study explores the market assumptions of substitution through the theoretical lenses of value chains and microeconomic theory on demand. The objectives are to recognize powerful decision-makers in the value chains, to establish a better understanding for the current state of substitution in the markets, and to explore the determinants of demand of the wood-based products.

To limit the scope of this study, the use of pulp-based products was examined in the cases of packaging and textile sectors. Semi-structured interviews with 14 experts were arranged to discuss their views on substitution and demand of the pulp-based products in the chosen sectors. Additionally, a Likert scale was filled at the end of each interview to supplement the interview answers and enable elasticity and cross-price elasticity analyses to examine substitution. The sample of respondents was chosen through the use of snowball sampling and a matrix to recognize potential interviewees.

First, the findings of this study suggest that in both sectors, the decision-making power on materials is held by the operators at the end of the value chain whereas the forest sector is located at the beginning of the chain. Second, in both sectors, there is willingness to find more sustainable material solutions, but the tools for this are lacking. In the case of packaging sector, the barrier capacities of plastic are unattainable with fiber-based materials, meaning that reducing plastic use does not always imply switching the feedstock itself. In the textile sector, the production of wood-based textile fibers is not yet scaled enough for it to compete with similar materials. However, the analysis of elasticities indicates that some substitution can be expected in both sectors. Third, a number of important determinants of demand were identified, yet no single factor could be identified as the most important one.

This study concluded that there is room to improve the market assumptions for substitution impact estimation. In packages, the market preferences of fiber-based packaging in some uses give a rise for interpretational issues, while plastic reduction goals do not always imply switching to wood feedstock. In textiles, the new man-made cellulosic fibers (MMCFs) are expected to mostly substitute for viscose and fill the cellulosic gap from stagnating production of cotton instead of substituting for synthetic fibers. To conclude, it is central to integrate market data and concepts better into future substitution impact analyses to facilitate more realistic estimates.

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Decision-making, determinants of demand, forest sector, packaging, price elasticity, substitution, textiles, value chain

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Tiivistelmä – Referat – Abstract

Metsät ovat avainasemassa ilmastonmuutoksen hillinnässä, ja substituutio, eli puutuotteiden käyttö fossiilisten raaka-aineiden sijaan, on tunnistettu potentiaalisena tapana vähentää päästöjä. Siinä missä substituutiokirjallisuus on tähän mennessä tuottanut arvioita substituutiovaikutuksesta, ts. vältetyistä päästöistä, analyysit eivät ole juurikaan sisällyttäneet markkinaperspektiivejä. Tämä tutkielma vastaa tähän tutkimusaukkoon tarkastelemalla substituutioon liittyviä markkinaoletuksia analysoimalla arvoketjuja ja mikroekonomista kysynnänteoriaa. Tutkimuksen tavoitteina on tunnistaa vaikutusvaltaisimmat päätöksentekijät arvoketjuissa, ymmärtää paremmin substituution tämänhetkisestä tilannetta markkinoilla sekä tutkailla puupohjaisten tuotteiden kysyntätekijöitä.

Tutkimuksen laajuutta rajoitettiin valitsemalla puusellupohjaiset tuotteet pakkaus- ja tekstiilisektoreilla tarkasteltavaksi tapaukseksi. 14 asiantuntijan näkökulmia substituutioon ja sellupohjaisten tuotteiden kysyntään valituilla sektoreilla selvitettiin puolirakenteisen haastattelun avulla. Tämän lisäksi jokaisen haastattelun lopussa täytettiin Likert-asteikko täydentämään haastatteluvastauksia ja mahdollistamaan kysynnän hintajouston ja ristijouston tarkastelu substituution näkökulmasta. Haastateltavien otos valikoitui lumipallo-otannalla sekä potentiaalisten haastateltavien tunnistamiseen valmistellun matriisin avulla.

Ensinnäkin tulokset viittaavat siihen, että molemmilla markkinoilla päätösvalta materiaalien suhteen on sijoittunut arvoketjun loppupään toimijoille, kun taas metsäsektori on sijoittunut arvoketjujen alkupäähän. Toisekseen molemmilla sektoreilla on tahtoa löytää ympäristön kannalta kestävämpiä materiaaliratkaisuja, mutta välineet tähän ovat puutteelliset. Pakkaussektorilla muovin barrier-ominaisuudet ovat saavuttamattomissa kuitupohjaisilla materiaaleilla, jolloin muovin vähentäminen ei aina tarkoita itse raaka-aineen vaihtamista. Tekstiilisektorilla puupohjaisten tekstiilikuitujen tuotanto ei ole vielä tarpeeksi skaalautunutta kilpaillakseen samankaltaisten materiaalien kanssa. Tästä huolimatta joustoanalyysit viittaavat siihen, että substituutiota voidaan odottaa esiintyvän molemmilla sektoreilla. Kolmanneksi useiden tärkeiden kysyntätekijöiden tunnistamisesta huolimatta kaikista merkittävintä tekijää ei pystytty tunnistamaan.

Tutkimuksen johtopäätökset osoittavat, että substituutiovaikutusten arviointiin käytettävissä markkinaoletuksissa on parannettavaa. Pakkaussektorilla preferenssit kuitupohjaisen pakkauksen suhteen tuovat esille tulkinnallisia ongelmia, samalla kun muovinkäytön vähentäminen ei aina johda puuraaka-aineeseen vaihtamiseen. Tekstiileissä uusien selluloosamuuntokuitujen odotetaan korvaavan enimmäkseen viskoosia ja täyttävän puuvillan tuotannon kasvun taantumisesta johtuvaa selluloosa-aukkoa synteettisten kuitujen korvaamisen sijaan. Yhteenvetona tulokset korostavat markkinadatan ja -konseptien paremman integroinnin tärkeyttä realistisimpien arvioiden saavuttamiseksi substituutiovaikutusanalyyseissä.

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1 Introduction

1.1 Background

Global warming and the climate change following it have come with new challenges for nations to find ways to prevent the upcoming issues. Whilst it is clear that the expected changes in our environments are inevitable and adaptational strategies are needed, drastic mitigation measures are required to reach the 1.5°C target of the Paris Agreement (UNFCCC, 2015) or even stay below the critical 2°C increase limit (IPCC, 2018; UNEP, 2019). The Intergovernmental Panel on Climate Change (IPCC) defines climate mitigation as the steps of addressing the increasing greenhouse gas (GHG) concentration of the atmosphere through reducing emissions and increasing sinks (IPCC, 2014). However, even the most successful mitigation efforts are no guarantee for avoiding the most severe damage of the current global warming. Instead, mitigation can only offer us better odds to avoid such harms (IPCC, 2014).

Forests play a key role in the mitigation efforts as sustainable forestry and land management represent the only large scale tool currently available for humans to sequestrate carbon back from the atmosphere to the biosphere (IPCC, 2019). Therefore, the IPCC (2014) discusses afforestation, reforestation and sustainable forest management as potential pathways to increase and conserve carbon sinks and storages. Already within sustainable management of forests, the mitigation options are numerous. Lippke et al. (2011) have recognized the following four pathways: maximizing the carbon storages of forests through minimized harvests; harvesting wood sustainably and producing wood products to store carbon; managing the forestlands to reduce the risk of forest fires and other natural disasters through thinnings and using the harvest to produce wood products and biofuels; and minimizing forest rotation cycles and finding technology to process smaller trees and forest residuals. Among these possibilities, Lippke and his colleagues (2011) recognize substitution to have high potential for emission reductions despite it being difficult to measure.

Wood product substitution refers to the use of wood-based materials and products in place of alternative products to reduce fossil emissions (Sathre & O'Connor, 2010). This entails the wood substitute providing the same function than the replaced product (Gustavsson et al., 2006). According to Lippke et al. (2011), substitution requires that the prices are impacted by a change in the market, leading to the demand of some goods increasing and the demand of other goods decreasing. In this study, the term substitution is used to refer to the replacement of a non-wood product with a wood-

based product. In general, substitution has been viewed as a long-term strategy for mitigation through holistic sustainable forest use where the benefits of avoided fossil emissions are received later on (Lemprière et al., 2013; Sathre & O'Connor, 2010). Climate mitigation through substitution is grounded on the cyclic nature of biogenic carbon: although wood harvests reduce sinks and remove carbon from the forests, this is only seen as a momentary drop as the released carbon from the forest biomass will eventually be reabsorbed under sustainable forestry regime (Sathre & O'Connor, 2010). Quite the opposite happens with fossil carbon, as there really is no effective way to sequestrate fossil carbon back to the tectonic stock cost-efficiently. This is the main argument in favor of biogenic carbon (Pingoud et al., 2012). However, the biogenic carbon cycle is not always perfect as some sources of biomass are unable to recover fully in short periods of time due to slow growth rates, which undermines the assumed mitigation potential (Pingoud et al., 2012).

The need to address the environmental issues has been widely recognized and substitution is brought up every now and then as a mitigation strategy at the international (IPCC, 2014) and national level. For instance in Finland, the government has set goals to increase the use of wood in constructions and to move to bioeconomy (Finnish Government, 2019; Valtioneuvosto, 2021). However, no consensus on the extent of the actual substitution benefits exists in academia as researchers like Harmon (2019) and Seppälä et al. (2019) have pointed out weaknesses in the underlying assumptions of, for instance, the permanency of the substitution benefits (Harmon, 2019) and the issues related to excluding the impact of increased harvests on the forest carbon balances from the calculations (Seppälä et al., 2019). Moreover, it is at the very least problematic that general averages for the avoided emissions through substitution (e.g., the average of Leskinen et al., 2018) are used to make theoretical calculations on the climate benefits of substitution. It is important to acknowledge that not all wood substitutes provide climate benefits, which makes it necessary to disaggregate the general averages and to examine substitution impact at the market level considering also the production volumes of the wood products.

Though acknowledging the differences between the product and market level, less research has concentrated on which products will be produced from wood materials, where, in which volumes, and with which motivations. Presumably different materials have different qualities and markets have different preferences over their material use, distinguishing the importance of the market perspective on substitution as well as the study of the market dynamics. Although the individual displacement factors for products are necessary in the calculations of the overall substitution impact, the

displacement factors alone do not offer information sufficiently to accurately estimate the substitution performance of a larger entity. For such aggregate estimations, it is imperative to additionally consider the market dynamics between the wood-based and rival products.

1.2 Research questions and objectives

This study contributes to filling the research gap described in the previous section – the lack of substitution studies that examine the markets and the dynamics between the different materials. This is done through considering the following three research questions:

1. Who has the decision-making power over intermediate products and material of the end product in the packaging and textile sectors?

2. To what extent do pulp-based products substitute for other materials in the packaging and textile sectors currently?

3. What are the determinants of demand of wood-based packaging and textile products?

This study does not produce substitution impact estimates but instead contributes to the market assumptions required for conducting such assessments. To do this, this study has three main objectives that are examined in the context of the packaging and textile sectors. The first objective is to find out through a value chain analysis, which operators have the power to decide upon the material use of the end market. This information is then compared to the forest sector to establish whether the forest sector has decision-making power in the two sectors. The second objective is to explore the current state of the markets through determining the current state of substitution through microeconomic analysis of elasticity and cross-price elasticity. Here, the products replaced and the materials that cannot be replaced are also shortly explored as well as the preferences of the markets and dominating materials. This exploration of product level substitution is a necessary step for the establishment of sector level estimates on substitution. The second objective supports future substitution research through enabling a better estimate of substitution that possibly already takes place and a better restriction for future calculations to only include those materials that are actually replaced with wood products in the market. The third objective explores the determinants of demand to make an attempt to contribute to expanding the future modelling of demand through aiming to recognize some of the important factors that contribute to demand and substitution.

The topic of this study is extensive. To restrict the study to a more manageable and relevant scope, the packaging and textile sectors are selected as cases, restricting the scope to the most relevant pulp-based product markets. This focus on pulp-based products is supported by the decision to adopt the perspective of the Finnish forest sector known for a high volume of pulp produced and exported (Finnish Forest Industries Federation, 2020; Luke, 2019). The decision to focus on the packaging and textile sectors is relevant from the substitution perspective as the two sectors are believed to have high substitution potential (Hurmekoski et al., 2018) but there is only little information available on substitution in these sectors (Leskinen et al., 2018). That is, the substitution impacts of pulp-based products represent a major knowledge gap, as compared to solid wood industries and energy uses of wood (Leskinen et al., 2018). Both these sectors are considerably large pulp consumers globally – the packaging sector buying mechanical, semi-chemical and kraft pulp (Pöyry, 2015) and the textile sector buying mostly dissolving pulp (Textile Exchange, 2019). Furthermore, both the packaging and textile sectors are global in nature, while a large portion of the output of the Finnish forest sector is exported (Luke, 2019). Hence, the global packaging material and textile fiber sectors are examined while integrating the Finnish forest sector as the origin of the intermediate product (pulp) and starting point of the analysis.

The thesis will be structured followingly: first, the existing literature on substitution and some critique are reviewed. After, the main characteristics and current developments of the forest, packaging and textile sectors are introduced shortly. The theoretical frameworks of value chain analysis and microeconomic theory are then presented before moving on to describe the qualitative methodology and method. After, the research results are presented thematically and discussed in relation to the existing literature. Some discussion on the trustworthiness of the study is also provided. The thesis ends with the main conclusions and future research proposition.

2 Literature review

2.1 Quantifying substitution impact

The academic studies on substitution have built on the conceptual understanding of substitution. This has been done by attempting to estimate the greenhouse gas benefits gained from substitution (Sathre & O'Connor, 2010). However, the end use of the wood material impacts the total estimated amount of avoided emission (Leskinen et al., 2018). Therefore, it is important to acknowledge that not all end uses where a wood-based product is used instead of a fossil product are expected to result in avoided emissions. At a very general level, the products replaced with wood can be divided into two main categories: fossil fuels and non-wood materials (Gustavsson et al., 2006; Lemprière et al., 2013). In the case of the first category of fossil fuels, solid biomass or liquid biofuels from wood are combusted in place of traditional fossil fuels to generate heat and/or energy (Lemprière et al., 2013). The extent to which mitigation benefits are reached with biofuels depends to a large extent on the fossil fuel being replaced and the origin of the biomass used. For instance, the use of harvest residues or production residues in biofuels is likely to have a higher positive climate benefit than using logs (Leskinen et al., 2018). This thesis concentrates to examine the second category: non-wood products.

The second category for substitution is the production of harvested wood products (HWPs) that have the properties both of a carbon storage and of a substitute for a fossil-intensive product or material (Geng et al., 2017). When harvested, the carbon storage of the forest biomass is removed, and new trees are planted to restart the carbon sequestration process. However, the cutting down of trees does not necessarily mean that the carbon is burned and released to the atmosphere immediately as it would be in the case of solid biofuels. Instead, the wood material can be used to produce HWPs that preserve the carbon for longer periods of time until their destruction. In this way, the harvested carbon is not released but instead stored in the HWP pool while the harvested stand starts to sequestrate additional carbon from the atmosphere (Geng et al., 2017; Lemprière et al., 2013). In addition to storing carbon, HWPs produce substitution benefits as more fossil-intensive materials are being replaced with wood-based products. These substitution benefits are tied to the reductions in emissions that rise from the acquisition of raw materials and production of the final product because wood-based products typically require less fossil energy and resources to manufacture (Geng et al., 2017; Sathre & O'Connor, 2010). The benefit of avoided emissions is assumed to be accumulative if the replacement of the fossil material is permanent (Sathre & O'Connor, 2010).

The calculations of the substitution impacts are based on life-cycle analyses that aim to quantify the greenhouse gas emissions and environmental impacts a certain product causes throughout its lifetime. In general, the life-cycle of a product is considered to consist of the production, use, cascade and end-of-life stages (Leskinen et al., 2018). However, Sathre and O'Connor (2010) argue that the life-cycle of a wood product starts already at the forest with tree growth and carbon sequestration being the first stage. This argument is based on the evidence indicating that harvesting a forest does not only impact the carbon levels and climate through removing wooden biomass, but also through changes in the soil and albedo that add on to the complexity of forestry from the climate perspective (Lemprière et al., 2013; Sathre & O'Connor, 2010). The output of a life-cycle analysis is used to calculate a displacement factor that assesses the substitution impact of a certain product through a comparison of the emissions generated by the wood-based product over its lifetime to the emissions generated by the non-wood product over its lifetime (Sathre & O'Connor, 2010). Thus, displacement factor is an indicator of the substitution impact. Although displacement factors aim to account for GHG emissions at all life-cycle stages, the impact of harvests on the forest carbon stocks is rarely included, as pointed out by Seppälä et al. (2019). The authors underline that in order to gain a positive net climate impact through substitution, the avoided emissions from substitution must be greater than the losses in the forest carbon stocks within a given timeframe (Seppälä et al., 2019). There has also been other calls to simultaneously consider both the carbon sinks and substitution impacts to estimate the climate impacts of the forest sector more holistically (Hurmekoski et al., 2020).

Displacement factors are often calculated for certain products. In their meta-analysis, Leskinen et al. (2018) estimated the average displacement factor across all product categories to be 1.2 kg C / kg C. In other words, approximately 1.2 kilograms of carbon emissions are reduced per each kilogram of carbon in wood products that substitute for non-wood products. However, this is the average of all product categories from constructions to textiles and chemicals. The individual displacement factors vary from -0.7 to 5.1 kg C / kg C, with industry averages of 1.3 for structural construction, 1.6 for non-structural construction, 2.8 for textiles and 1–1.5 for other product categories (Leskinen et al., 2018). Hence, remarkable differences between the displacement factors for certain product groups and their average can be observed, supporting the need for more disaggregated approach to substitution in the market level analyses.

In the context of Finland, there are only a few studies that examine substitution at the national level. The minimum required displacement factor in Finland to gain climate benefits was examined by

Seppälä et al. (2019). Based on the simulations of different harvest levels, the researcher group concluded that increased harvests to attain the forest-based bioeconomy in the current situation does not indicate net climate benefits in Finland when the loss of carbon storage in forests is included in the calculations. Hence, net substitution benefits would only be achieved with the projected harvest levels if the carbon sinks and storages of the forests were grown substantially and products with very high displacement factors and longevity were produced in a large scale (Seppälä et al., 2019). Similar outcomes were found by Soimakallio et al. (2016) who concluded that the substitution benefits are very likely to be lost due to the harvests leading to reduced forest carbon sinks in Finland. A report written by VTT Technical Research Centre of Finland and ordered by the Finnish Forest Industries Federation concluded that forest sector's products (i.e., wood-based products) offer climate benefits as their production has smaller emissions than the production of identical products from other materials (Alarotu et al., 2020). The report considered the product portfolios of the Finnish forest sector companies and followed the life-cycle analysis method of different product baskets when determining the substitution impacts. However, in difference to the studies of Seppälä et al. (2019) and Soimakallio et al. (2016), the VTT report excluded the impact of forest use and harvest in the climate impact calculations (Alarotu et al., 2020). Hence, Alarotu et al. (2020) made a rather disaggregated study on substitution while leaving out the impact on forests and carbon sinks from the scope of their report. The research approach of Alarotu et al. (2020) does solve some of the issues of aggregated estimates, as Seppälä et al. (2019) argue that country level estimations for substitution impact are often lower than the estimations for individual products.

The variability in displacement factors can, at least to some extent, rise from the wide range of products and materials replaced (Leskinen et al., 2018) as well as the different methods and decisions regarding the exclusion of some life-cycle stages researchers make (Geng et al., 2017; Leskinen et al., 2018). These differences highlight the importance of separating sectors from each other in the search of the most effective substitution strategies. A cross-sectoral or cross-market average can significantly under- or over-estimate the substitution benefits of a mitigation strategy undertaken. Therefore, the product level displacement factors must be examined in relation to market dynamics to estimate the total substitution benefits that can then be further used to model the net emissions of the forest sector and its products.

2.2 Critique on substitution impact estimates

The academic literature reveals various research gaps and uncertainties on substitution impact estimates. Harmon (2019) addressed the possible exaggeration of the substitution benefits by questioning three central assumptions of substitution calculations through a sensitivity analysis: (1) the constant displacement factor over time, (2) the permanent nature of the substitution impact that assumes no cross-sector leakage of fossil resources, and (3) the assumption of non-wood products being preferred in the market leading to the negligence of the existing market shares of the wood-based products. Finally, to add on to these three points, it is recognized that substitution management is impacted by numerous changing factors (Gustavsson et al., 2006) that further complicate the analysis of substitution impact potential in reality.

First, Harmon (2019) argues that the development patterns of the energy sector must be included in the substitution estimates. Previously, it was explained that the displacement factor is always calculated in relation to the alternative non-wood product. In the energy sector, sources vary from fossil fuels to renewable sources of energy. Therefore, as the share of renewables and natural gas grow in relation to coal and oil, the average energy source – replaced with for instance wood residues – has a lower carbon footprint and therefore the substitution benefits from the use of wood residue decrease. This scenario will then eventually lead to a declining displacement factor for the wood product. In addition to this reasoning, Harmon (2019) raises two more points in favor of the diminishing displacement factor when it comes to energy. First, evolving manufacturing processes and new products may lead to lower embodied energy in carbon intensive materials (e.g., concrete), while processing wood products further to achieve certain qualities may significantly increase the embodied energy in the wood products. Second, Harmon (2019) expects energy efficiency to increase in the future due to increasing costs and improved recycling processes. Building on these points, Harmon (2019) argues that displacement factors are in fact declining over time instead of staying constant as widely assumed. Gustavsson et al. (2006) also recognize that the factors impacting substitution can change over time, for instance through technological development. The modelling of Hurmekoski et al. (2020) supported the argument of energy sector's decreased future emissions diminishing the displacement factors in the case of rapidly reduced emissions. The authors even concluded that in general the displacement factors are likely to decline over time.

The second point of Harmon (2019) challenges the assumed permanency of substitution impact that considers the fossil fuels spared today to be kept unused infinitely in all sectors. The substitution

impact is therefore assumed to be permanent, and the global fossil fuel resources will never be depleted as a result of successful substitution. However, Harmon (2019) points out the unlikeliness of this scenario by arguing that there really is no mechanism preventing the eventual cross-sector leakage of carbon emissions. Also Leskinen et al. (2018) call for more research to address the possible leakage. Grafton et al. (2012) discuss a similar, time-related issue of carbon leakage in the context of biofuels replacing fossil fuels: the politically more favorable scheme of raising step-by-step the tax on fossil fuels might lead to a situation where the fossil fuel resources are depleted faster causing more GHG emissions from fossil fuel combustion now than in the case of no tax. This "green paradox" arises because for the fossil fuel resource owners the central question is when to extract the fuel instead of how much to extract (Grafton et al., 2012; Sinn, 2008). It must be added that from a purely climate point of view, the source of carbon (fossil or biogenetic) released to the atmosphere is unimportant, when examining the atmospheric carbon concentration and global warming in the short run (Seppälä et al., 2019). Thus, it is central to acknowledge that it might take decades for the carbon released from forest biomass to be sequestrated by the regrowing forest (Lemprière et al., 2013).

Thirdly, most of the substitution studies assume that the non-wood products are preferred in the market over the wood substitute. This means that once switched to the wood product, there is a substitution benefit because a fossil-based product is replaced and faced with a declining market share leading to accumulating avoided emissions and displacement. However, Harmon (2019) challenges this assumption by pointing out that if the market already prefers the wood-based solution, then the use of wood in the sector does not automatically lead to accumulative displacement. Due to the assumed preference for non-wood product, substitution never meets its limits and becomes endless in nature. In contrast to the assumed endless nature of substitution, for instance the HWP pool faces an outflow of carbon that eventually correlates with the size of the HWP pool: the larger HWP pool, the larger the eventual outflow of carbon from the pool (Harmon, 2019). Additionally, Harmon (2019) discusses the eventual need for replacement of the wood product with a new product: if the wood product is replaced with wood-based material, then the substitution impact is continued but not necessarily increased. In the case of replacing the wood product with a non-wood, fossil-based product, the avoided fossil emissions are released at this point. Hence, Harmon (2019) argues that when wood is or becomes the preferred material in the market, the substitution pool faces a negative feedback that correlates with the longevity of the end product.

Finally, there are numerous factors in addition to the assumptions that impact the eventual substitution in the market. In their long list of factors, Gustavsson et al. (2006) outline the avenues promoting the consumption of wood-based products. Some of the factors considered are political goals to reduce GHG emissions and legislation to discourage the use of fossil materials and encourage the use of wood materials. Moreover, economic growth that leads to increased demand of energy and materials is seen as a factor supporting increased substitution potential. Another factor for substitution listed by Gustavsson et al. (2006) is the higher relative prices of the wood products limiting their market share, which could be overcome by internalizing the external costs and benefits to make the wood product more competitive. However, as the most important factor Gustavsson et al. (2006) raise consumer demand connected to the socio-economic factors that is, according to them, in the most influential position in determining the eventual substitution impact potential. To add on these avenues promoting the consumption of wood-based products, Leskinen et al. (2018) point out that often in practice substitution is not necessarily a decision between wood and another material but instead it is a question of finding the optimal combination of the two.

2.3 Forest sector

The Cambridge dictionary defines forestry as "the science or industry of growing and managing forests" (Cambridge University Press, n.d.). This implies that forestry has to do with the management of forestlands and their growth. Forest products then, in their turn, refer to the numerous intermediate products, for instance pulp, produced from the output of forest feedstock (FAO, 2020a). Forest industry is the producer of these intermediate goods and thus the buyer and consumer of the output of forestry (Mäntyranta, 2019). For the purposes of this study, forestry and forest industry are seen to form the forest sector together.

The total global production of industrial roundwood[1] reached nearly 2,019 million cubic meters in 2019 and the trend indicates a continued steady growth (FAO, 2020b). The global forest sector is growing and harvesting more forest resources than ever. Meanwhile, the forest product markets are going through fundamental changes due to changing global competitive advantages of investments concentrating in the Asian and South American low cost production regions and the emergence of

[1] According to FAO, industrial roundwood is an umbrella term for all industrial wood except fuel wood. It includes sawlogs, veneer logs, pulpwood, round and split, and other industrial roundwood (FAO, 2020a, p. EN - 25).

bioeconomy with a strong emphasis on new products and innovation (Hetemäki & Hurmekoski, 2016). These changing market conditions along with the declining demand of some well-established, traditional products, such as graphic paper and newsprint (Buongiorno, 2009; Hetemäki & Hurmekoski, 2016; Hurmekoski et al., 2018; Jonsson, 2013), have forced the markets to adapt and find new means of growth (Hetemäki & Hurmekoski, 2016) through investments in, for instance, technological development (Gustavsson et al., 2006) to ensure future profits.

Forest sector has recognized future potential in the niche of new products which are developed with faith in the better qualities and sustainability of wood compared to alternative materials. These products include new innovations for construction, packaging, textile and chemical industries – some of them being currently more established than others (Hetemäki & Hurmekoski, 2016; Hurmekoski et al., 2018). From the traditional forest product side, sawnwood consumption is expected to continue rising as a result of the strong pull from the Chinese markets due to the rapid growth of the Chinese construction sector. Meanwhile, wood construction is expected to gain popularity even in the Western countries in the coming years (Hetemäki & Hurmekoski, 2016), as for instance suggested by the goals to increase wood construction in Finland by the current government (Finnish Government, 2019). These changes are likely to lead to a forest sector with a diverse product range rather than just a few major product categories dominating, which was the case for paper and pulp products in the twentieth century (Hetemäki & Hurmekoski, 2016).

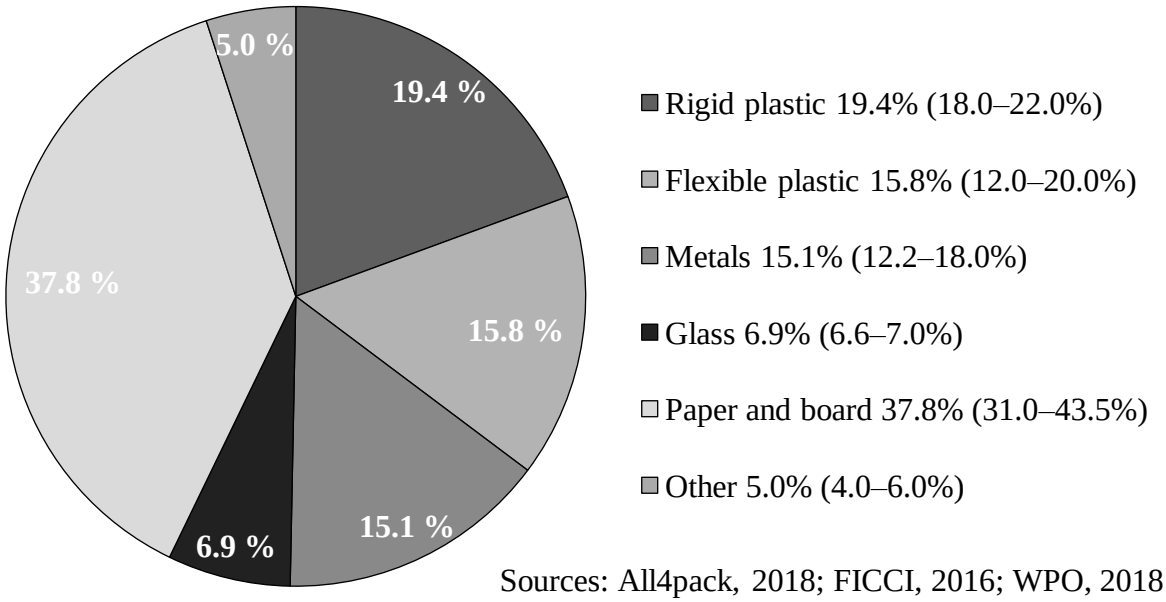
The global trends impacting the forest product markets are of high relevance for Finland as the forest sector has been perceived as the backbone of the country's economy for decades: the exports of forest sector accounted for 21% of the total Finnish exports in 2018 (Luke, 2019). The industrial wood use was for the most divided into the production of sawnwood (27.2 million m^3) and pulp (43 million m^3) in 2018 (Luke, 2019). From year 2018 to 2019, the Finnish production of chemical pulp increased by 2.1% (Finnish Forest Industries Federation, 2020). However, a decline in the paper and cardboard production as well as large fluctuations in the sawnwood production over the last six decades have been observed, illustrating the earlier presented phenomena of stagnating demand and move of production to low cost countries even in the context of Finnish forest industry (Finnish Forest Industries Federation, 2020). Therefore, even the Finnish forest sector must find ways to renew itself in order to compete in the changing global market conditions.

2.4 Packaging sector

The global packaging sector has been expected to exceed USD 1 trillion in value by 2021 with an annual growth rate of 5–7% (Smithers, 2018). The European Parliament defines packaging as products out of any materials that are used for the "containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer" (European Parliament and Council, 1994, p. 2). The packaging production is one of the key elements to trade of goods as it provides products with shelf life enabling their global transportation and sale. The industry is globalized and characterized with strictly set requirements on the packaging properties and quality (Wyrwa & Barska, 2017). Where the Western countries previously dominated the production of packaging materials, their production has recently followed the production of consumer goods to China and other emerging economies (Hetemäki & Hurmekoski, 2016). Due to the global presence of the sector, the global megatrends are influencing the development and future of the packaging market. The globally growing middle class in the populated emerging economies is a driver of the growing demand for packaging whilst environmental concerns and resource scarcity are forcing companies to rethink design and their material use (Olsmats & Kaivo-oja, 2014). Other drives of demand for packaging are global population and GDP growth and the growing e-commerce and demand for take-away (Hurmekoski et al., 2018).

Figure 1 summarizes the distribution of material use by value in the global packaging sector. The average share of each material was calculated by using data from three different sources (All4pack, 2018; FICCI, 2016; WPO, 2008) with the range in parentheses (a table of the data in appendix I). By observing figure 1, it can be concluded that paper and board products represent the largest portion of packaging materials with plastic coming close on the second place. These two materials seem to dominate the market since together they count for over two thirds of the material use by value in the market. However, in food products plastic is an important packaging material, since food products is the largest single consumer of rigid plastic packaging with 37% share of the total use of rigid plastics (All4pack, 2018). The remaining materials in the market – metals, glass and other – account for less than one third of the market value together. Both the consumption in tons and the annual value of packaging materials are currently growing in all materials, while the details on shares and changes depend on the source of the information: paper, board and plastics have gained market share and metals lost market according to some sources (All4pack, 2018; WPO, 2008) while others present different numbers with a considerably smaller market share for fiber-based packaging (FICCI, 2016).

Figure 1: Market shares of packaging materials used globally



Sources: All4pack, 2018; FICCI, 2016; WPO, 2018

The concerns over the environmental sustainability and waste management due to the growing quantity demanded of packaging materials have been addressed already in the 90s by the European Parliament. The directive to prevent the accumulation of packaging waste and to minimize the environmental burden of packaging in the member countries and third parties was introduced through setting goals for the reduction of light carrier bag use and determining minimum recycling rates for all major packaging materials (European Parliament and Council, 1994). The work towards package sustainability continues, as the increasing environmental awareness has led to a stronger push to find biobased alternatives for plastic to reduce marine plastic litter. Thus, for example biopolymers in plastic production have been acknowledged in academic research (Helanto et al., 2019). While paper and cardboard are rather traditional packaging materials, the possible substitution benefits are still unclear from the market perspective. More knowledge is needed on what can currently be replaced with a wood-based material while ensuring that the package still protects the produce, ensures food safety and complies with the regulative challenges to reduce packaging material use (Lahtinen, 2020).

2.5 Textile sector

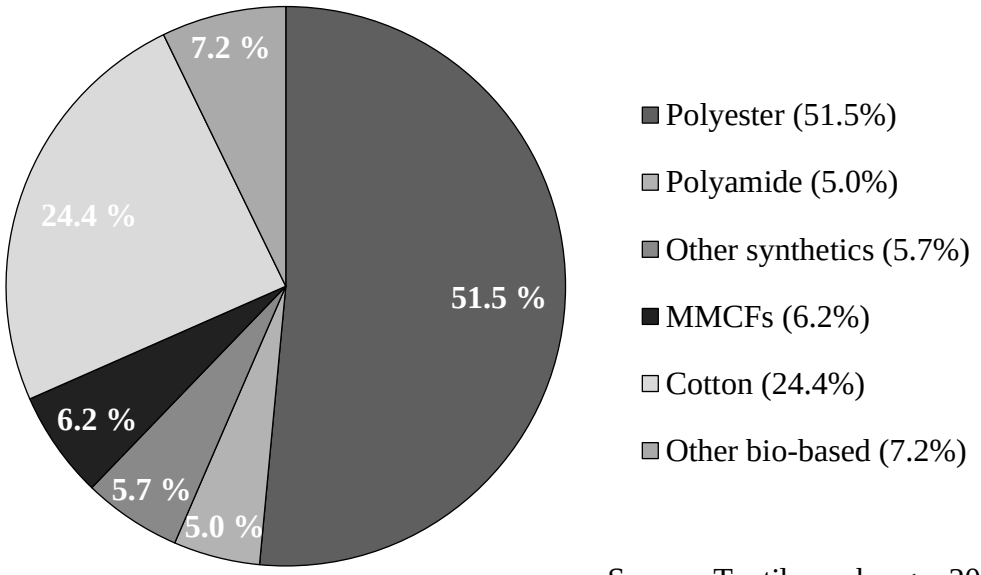
In 2018, more than 100 million megatons of textile fiber was produced with growth expectations of the output being 145 million megatons in 2030 in the business-as-usual scenario (Textile Exchange, 2019). Such a high production is driven by the popularization of fast fashion that offers the newest

fashion at a low price and quality, leading to large amounts of clothing being purchased and thrown away in a quick rotation (Bick et al., 2018). The consumption of fast fashion is concentrated at the Western markets of USA and Europe (Bick et al., 2018). Where most of the consumption happens in the Western economies, the production of textile fibers and end products has been moved to the emerging countries with low production and labor costs (Bick et al., 2018; Claudio, 2007) which, together with large quantities, ensure low prices at the end product markets.

Figure 2 presents the market shares of the different textile fibers by volume. The globally predominant textile fiber with more than half of the market is polyester that is an oil-based plastic fiber with an annual production volume of 55 million megatons in 2018, out of which 13% was recycled polyester (Textile Exchange, 2019). Polyester has grown tremendously over the last couple of decades to become the largest fiber globally (CIRFS, n.d.). Together with polyamide and other synthetic materials, the oil-based fibers make up nearly two thirds of the global fiber production. Cotton is the second largest fiber with about one fourth of the market in 2018. However, during the last decade the production of cotton has stagnated and remained on the same level despite some fluctuations from year to year (CIRFS, n.d.). Other bio-based materials such as hemp, down, wool and leather form just a minor portion of the market (Textile Exchange, 2019). Finally, Manmade Cellulosic Fibers (MMCFs) accounted for 6.2% of the global market with the production of 6.7 million megatons in 2018 (Textile Exchange, 2019). MMCFs are currently mostly made of dissolving pulp produced from wood cellulose and, hence, are considered wood-based products. Furthermore, the production of MMCFs can be divided into five different materials: viscose with 79% share of the total MMCF production in 2018; acetate with 14% share; lyocell with 4% share; modal with 2.7% share; and cupro with less than 1% share (Textile Exchange, 2019). The production of the MMCFs has grown moderately over the past decade but the impact of this on the market share has been minor due to the rapid increase in the production of polyester (CIRFS, n.d.).

The environmental footprint of the textile industry is extensive: the water, land, and chemical use of the industry along with emissions from production and waste generation are massive (GFA & BCG, 2017). Along with the environmental issues, the textile industry is characterized with social issues stemming from the move of production to the developing countries where fair wages and safe working conditions are ignored to ensure the cheap, profit-making produce to respond to the growing global demand for cheap textiles (Bick et al., 2018; Claudio, 2007). And it is not only the production that

Figure 2: Market shares of textile fibers produced globally



Source: Textile exchange, 2019

has been moved to the third world economies: even the environmental issues and pollution caused by the disposal of garments has been transferred to the developing nations (Bick et al., 2018). The growing demand for fiber and the environmental limits to the production of cotton are creating room for new innovations and bio-based materials to compensate the stagnating production of cotton. Therefore, the wood-based products are expected to contribute in large quantities to the textile industry (Hurmekoski et al., 2018) and make it possible to diminish the environmental impacts of the sector (Bick et al., 2018). According to Bick et al. (2018), the consumers in the high income countries can influence the movement to a more sustainable textile sector by favoring companies that make an effort to minimize their environmental and social damage. However, the authors also add that regulations and policies are a faster way to incorporate sustainability practices in the sector.

2.6 Theoretical frameworks

2.6.1 Value chains

The concept of value chain was first introduced by Michael Porter in 1985. His analysis aiming to identify the value chain within a firm offered support in the recognition of the competitive advantages of the firm (Porter, 1985). Thus, mapping all activities and processes that the firm has can offer better opportunities to recognize the strategically important sources of competitive advantages in order to maximize the firm's value creation. A firm's value chain is part of a value system that expands beyond

the firm's activities to its suppliers, channels and buyers (Porter, 1985). However, the value chain analysis has evolved and transformed over the past decades to reflect better the complexity of the modern world. Such evolution was observed by Ricciotti (2020) in a study that reviewed articles on value chains to examine their historical evolution over time. Nowadays value chain thinking has become a more important tool for analyzing the systems as it offers opportunities to expand the considerations to the network in which the firm is functioning in and the relationships between the different operators of that network.

In this study, the relationships within the value chains are studied in order to recognize the parties that have the power to make decisions regarding substitution. Comparing this to the placement of the forest sector in the sectoral value chains allows to explore whether or not the forest sector holds power over the use of materials in the end market. For instance, Uronen (2010) recognized that the paper and board producers (intermediate product producers from the forest sector) only create little value to the end product in the paper value chain. Hence, the limited value created at the stages of intermediate product production indicates that the influence of the operators over the final product is relatively low. Furthermore, Ali-Yrkkö and Rouvinen (2013) concluded that the brand owner and the controller of the consumer interface have relatively more bargaining power in the value chain.

2.6.2 Determinants and elasticities of demand

This thesis draws on the concepts of microeconomic theory to lay the basis for the factors affecting demand and to detect indications of substitution from the data collected in the empirical part. Two concepts are used as the basis to assess the determinants contributing to quantity demanded. First, the theory of derived demand connects the demand for the intermediate and end products. It states that the demand for the intermediate product is eventually an outcome of the demand for the end product, the elasticity of this demand and the supply conditions of the competitors (Sato & Koizumi, 1970). Second, the end product's quantity demanded comprises of the price, the availability and price of substitutes and complements, the tastes and purchase power of the consumers as well as the overall expectations of the future price levels and economic conditions (Krugman & Wells, 2013). In this study, these factors contributing to the quantity demanded are referred to as determinants of demand.

In the analysis of substitution, the first relevant aspect to demand is a product's price elasticity. Simply, price elasticity is a ratio of a percentage change in quantity demanded as a result of a percentage change in price (Krugman & Wells, 2013). At the product level, a large price elasticity

could be interpreted to indicate the existence of several close substitute products (Krugman & Wells, 2013). Aggregate demand for a sector – that consists of all substitute products – would therefore be inelastic, because a price increase of one product would decrease the demand for that product while simultaneously increasing the demand for the substitute products, leaving the aggregate demand unchanged. Thus, it is assumed that the price elasticity of aggregate demand determines whether the introduction of a new product or increased supply to the market leads to a market growth or to substitution between products, ceteris paribus (other things remain unchanged). Accordingly, in the case of inelastic aggregate demand, the introduction of a new product to the market takes up market share from the other products, leaving the total market size unchanged. Hence, an increase in the marginal supply has only a little impact on the total aggregate quantity demanded but it leads to a relatively large decrease in the price level (Krugman & Wells, 2013). In the opposite case, a price inelastic demand at the product level can be assumed to indicate that no close substitutes exist for the product (Krugman & Wells, 2013). Therefore, the aggregate demand for a sector would be elastic. In this case, an increase in the marginal supply leads to a small change in the price but to a large change in the size of the market through increasing the aggregate quantity produced and demanded in the market. Therefore, the introduction of a new product to a market with an elastic aggregate demand leads to an expansion of the total market size.

Substitution can also be detected through the analysis of cross-price elasticity of demand. Cross-price elasticity of demand for one good describes the relationship between two goods through measuring the impact of a change in the price of one good to the quantity demanded of another good (Krugman & Wells, 2013). The theory suggests that when these two goods are substitutes, the cross-price elasticity of demand is positive, indicating that an increase in the price of one good leads to an increase in the demand of the substitute good (Krugman & Wells, 2013). However, it matters how close the substitutes are to each other: a perfect substitute (a drop-in solution with equivalent properties) would face a large increase in the quantity demanded if the price of its rival product increased, while an imperfect substitute would face a smaller increase in the quantity demanded as a result of the price of the rivalry product increasing (Krugman & Wells, 2013). Therefore, the size of a positive cross-price elasticity measures the closeness of the substitutes.

In this study, the two concepts of elasticity outlined above – the price elasticity of demand and the cross-price elasticity of demand – are used to interpret the possible existence of substitution in the packaging and textile markets. The existing literature contains no estimates of elasticities for such

disaggregated markets due to a lack of available data. However, according to the assessment and literature review of Rougieux and Damette (2018), the intermediate products of the forest sector have inelastic demands at the market level. If the demand for wood-products is price elastic and the cross-price elasticity of wood-products is large, this can be assumed to lead to an inelastic aggregate market demand. This, in turn, suggests that the introduction of new products to, or increased quantities supplied of the current products, in the forest product market would take up the market shares of the existing products at a lower price level instead of expanding the total market. In this study, the determinants of demand are analyzed from the point of view of the presented elasticities in order to consider two aspects: first, does the cross-price elasticity indicate substitution between materials; and, secondly, is the introduction of new products to the market going to lead to substitution or to a growing market size. Although the empirical data collection of this study inquires information from the product level, the outcomes can be used as indicators for conclusions to be drawn from the greater context of the aggregate market as outlined above.

3 Methodology and methods

3.1 Research approach

This paper belongs to the post-positivistic epistemology that does not believe in creating sole truths from a body of observations (Avenier & Thomas, 2015). This means that, although there might exist one universal truth explaining a phenomenon, it can never be fully confirmed or applied to all cases. The research and its results are heavily impacted by the surrounding context: the conclusions can never be freed from their context, and there is always some interconnection between the researcher and the object of the research (Avenier & Thomas, 2015). One study is not accepted as the basis for universal generalizations because such simplifications would underestimate the contextual importance in research. It is recognized that even critical realism is part of the epistemological groundings of this study since it is believed that the researcher's way of constructing knowledge is just one way to depict the reality (Bryman, 2012). The axiological nature of epistemology (Carter & Little, 2007) supports the overlapping of the schools of thought, as the epistemological position reflects the values of the researcher. Thus, categorizing values and beliefs on knowledge are not as black and white as sometimes suggested. Moreover, axiology is also suggested in the epistemology itself: it is recognized that facts are always impacted by the underlying values of the teller, meaning that absolute subjectivity will never be reached (Slevitch, 2011).

The mix of the two epistemological approaches rises from the ontological position that reality exists without the effort of studying it, meaning that the reality is independent from the research. Additionally, the ontological perspective understands that reality can never be fully understood (Avenier & Thomas, 2015). Therefore, this research is not done in accordance with Slevitch's (2011) perspective on qualitative research: where Slevitch argues that qualitative research always rises from the ontology of multiple realities based on different social perceptions, and that the studied phenomenon only exists because it is currently being examined, this paper, on the other hand, is grounded on the idea that even qualitative methodology can be used to study the content itself. In this way, the phenomenon itself – not just the beliefs and experiences surrounding it – can be studied through the qualitative lens, as long as it is acknowledged that total subjectivity will never be achieved and that the findings are always context specific. Therefore, qualitative research can be the first step in addressing a research gap since, instead of aiming to prove a previously determined theory, the focus is on the findings and their meanings to generate basis for a theory (Bryman, 2012). The empirically collected data is not used to test a theory but to recognize the existence or absence of a

phenomenon in the given context while understanding that the conclusions reached are neither fully objective nor generalizable.

3.2 Scope of the study and generalizability

In order to limit the scope of this study, the packaging and textile sectors were chosen as cases. Such limitations were made to reach a level of detail that is sufficiently high in the analysis given the resources for this thesis. However, this decision means that the results of this study cannot be applied to any other sectors as there are large differences in the ways-of-doing and systems of the different industries. Moreover, as the study has qualitative groundings, the results are not meant to be generalized due to their strong connection to the context of this study (Slevitch, 2011). Although a large potential in substitution benefits has been recognized on sectors with high volume of wood use like constructions (Hurmekoski et al., 2018), the decision to not choose this sector is due to the high number of studies already existing on the topic of substitution from the perspective of constructions (e.g. Gustavsson & Sathre, 2011; Hildebrandt et al., 2017; Ramage et al., 2017). Meanwhile, the packaging and textile sectors are not as widely studied as for instance the constructions sector from the aspect of substitution (Leskinen et al., 2018) whilst a high volume substitution potential has been recognized in these two sectors (Hurmekoski et al., 2018), especially in the textile sector (Leskinen et al., 2018). Finally, both packaging and textile sectors are important pulp buyers globally while Finland is a remarkable producer and exporter of pulp (Luke, 2019). Lastly, the main focus was put on the use of pulp-based products as substitutes. This narrowing of the scope to pulp products was done in order to prevent the analysis of the packaging sector to expand too much.

3.3 Data collection and analysis

The empirical part of this study concentrates on the value chains, the current substitution in the sectors and the determinants of the demand of the pulp-based product. The data collection was executed through semi-structured interviews of experts with open questions and a Likert scale constructed based on preparations beforehand and the respective answers of the interviewees. The method decisions lead to a mixed-method approach, since Likert scale is a quantitative method (Bryman, 2012). Likert scale as a quantitative tool was used to support and complement the qualitative method and its findings (Slevitch, 2011). While having a list of questions to be covered in the interview, the semi-structure offers more flexibility to alter the order of the questions and ask follow-up questions to gain a deeper understanding of the topics discussed while ensuring cross-case comparability

(Bryman, 2012). However, there might be issues stemming from the evolution of the follow-up questions from the first interview to the last, meaning that the last interview might go in more depth than the first one. To reduce this risk, a practice interview was arranged with an external person to test the questions and the interview structure. The Likert scale was constructed to make the oral answers more concrete and comparable by studying the attitudes of the interviewees (Bryman, 2012).

The interviewees were chosen by using purposive sampling, more specifically the snowball sampling, in which the respondent names the next person to be interviewed (Bryman, 2012). Purposive sampling was chosen because interviewing experts was seen as the most efficient way to address a topic that has not been explored much previously. In order to find the right experts, the snowball sampling was chosen as it was assumed that experts of the sector are familiar with each other. The practice interview and the interviewees representing umbrella organizations were used as the starting point for the sampling. Moreover, a matrix (appendix II) was used to recognize more respondents coming from perspectives that were not yet covered by the interviewees. In these cases, online research of value chain operators was done to identify possible experts to interview.

The interview consisted of four themes: the value chains, the market shares of the materials, the substitution potential of wood products, and the determinants of the demand. The final interview questions can be found in appendix III. The respondents were even showed value chains (figures 3 and 4) and market share distributions (figures 1 and 2). The preliminary Likert scale template, that was modified in each interview according to the respondent answers, can be found in appendix IV.

In total thirteen interviews were carried through remotely with fourteen participants (participants #4 and #5 were interviewed simultaneously). The interviews were recorded although Bryman (2012) warns about the risks of respondents being cautious with their words when recorded. The interviews were carried through in Finnish with the exception of one interview being held in English. The length of the interviews varied between 22 and 66 minutes. In four of the interviews both packaging and textiles sectors were discussed. In six interviews, the packaging sector solely was discussed and in three interviews the textile sector. Table 1 summarizes the interviewees with their organization types, sectors and placements in the value chains (see figures 3 and 4 in section 4.2 for the value chains) according to the interview responses. The interviewees represented a wide range of different positions at the organizations from experts and researchers to managing directors or managers of the different functions of the organizations.

Table 1: Participants of the interview study

ID	Organization	Sector	Placement in the value chain
#1	Umbrella organization	Packaging	Entire value chain
#2	Research organization	Both	First half of the value chains
#3	Brand owner	Packaging	Package buyer/packer
#4 #5	Umbrella organization	Both	First half of the value chains
#6	Umbrella organization	Both	First half of the value chains
#7	Producer	Packaging	Manufacturing of the package
#8	Producer	Both	First half of the value chains
#9	Producer	Textiles	Pulp producer
#10	Research organization	Textiles	Middle of the value chain
#11	Retailer	Packaging	Retailer of the packed good
#12	Producer	Packaging	Processing to cardboard and paper
#13	Retailer	Packaging	Retailer of the packed good
#14	Umbrella organization	Textiles	End of the value chain

The recorded interview materials were first transcribed and then translated into English. This was followed by a coding process to categorize and label parts that were connected to the research questions. This process included multiple rounds of reading through the transcripts and reviewing the labels to remove inconsistencies and repetition (Bryman, 2012). Although the themes of the interview questions led the data analysis, even phenomenological analysis was applied through recognizing other prevalent patterns and themes in the data. The analysis of the Likert scale began with the examination of the factors that each respondent had named during the interview to assess if different wordings were used for the same phenomena. Due to the small amount of data, the analysis was restricted to the qualitative interpretation of general patterns in the frequencies of answers for the individual determinants and between the different determinants.

3.4 Research ethics

In this research process, the research ethics of the European Commission, the Finnish National Board on Research Integrity TENK, and University of Helsinki were complied with (European Commission, 2010; TENK, n.d.; University of Helsinki, 2020). Thereby the planning and conduction of the

research and the evaluation of the results was done with accuracy and integrity while the work of other researchers was respected through coherent and appropriate referencing to their work (TENK, n.d.; University of Helsinki, 2020). In the empirical part of the study, the respondents' consent to be interviewed and recorded was asked and the confidentiality ensured through pseudonymization (European Commission, 2010). Due to the pandemic during the time of this study, the interviews were arranged remotely to ensure the safety of the interviewees and the researcher.

4 Results

4.1 General remarks

In the following section, the main findings of the empirical part of the study are presented thematically according to the three research questions presented in section 1.2. Before embarking to the data, the underlying findings of the interviews suggested one fundamental difference between the packaging and textile sectors: the textile sector is closer to the consumer interface because the end product is a consumer product. Contrastingly, the packaging sector produces hardly any consumer goods: the consumer purchases a packed good, not the package itself. This point was raised by one of the interviewees when discussing the impact of the consumer preferences:

> *But in packages you do anyways buy something else than the package, you buy the content. So, is it then that big of a deal for you although they are not… Let's say fajitas wraps are in a package where the other side is paper or is not paper. So, probably it will not determine your decision of what kind of tortilla bread you buy. You are going to be looking more at whether they are made of corn, wholegrain or other.* – #2

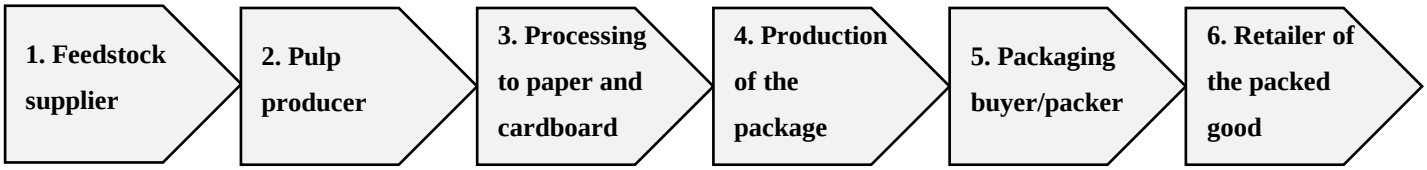
This fundamental difference between the end markets of the two sectors is important to acknowledge when approaching the joint analysis. 10 interviews on the packaging sector were conducted and 7 on the textile sector. Hence, 4 of these interviews included discussion of both sectors. Terms "fiber-based" and "pulp-based" are used interchangeably in the discussion of the packaging sector.

4.2 Value chains and decision-making power

4.2.1 Value chains and decision-making power in the packaging sector

In the case of packaging sector, the interviewees represented the whole value chain as anticipated (see table 1). The value chain discussed in the interviews is presented in figure 3. In the packaging sector, the forest industry was placed to the stage 2 (pulp producer) by all respondents. The stage 3 (processing to paper and cardboard) was included to the domain of the forest industry by all respondents except one. Five interviewees included also the stage 1 (feedstock supplier) to the forest industry. Six out of ten interviewees named the manufacturer of the packages (stage 4) in some cases to be part of the forest sector.

Figure 3: Value chain of the packaging sector



When asked about the most influential decision-maker regarding the material of the end product in the value chain, the stages held by the forest sector were not indicated to have much power by any of the respondents. The influencing power of the forest sector was seen to be more in presenting the available types of fiber-based solutions:

> *Of course, the processors might have influence on – if we now for instance talk about a cardboard package – these processors and package producers might have influence basically on what type of cardboard is being used. But which feedstock is being used, that message really comes from the buyer of the package, the brand owner.* – #12

The most frequently recognized decision-maker (named by nine of the respondents) was the package buyer/packer (stage 5 in figure 3). The influence of the package buyer/packer was seen to arise from the ownership of the packaging lines and the expensive investments required to replace the lines making it difficult to make rapid changes according to the market impulses. Hence, the packers' path dependence seemed to be a source of dominance in the packaging material decisions:

> *What I face concretely at my own work is that the producer who manufactures the product and owns the production line of the product and along with that even the packaging line decides to a great extent what is being done.* – #13

> *You will not change packaging machines just midair.* – #2

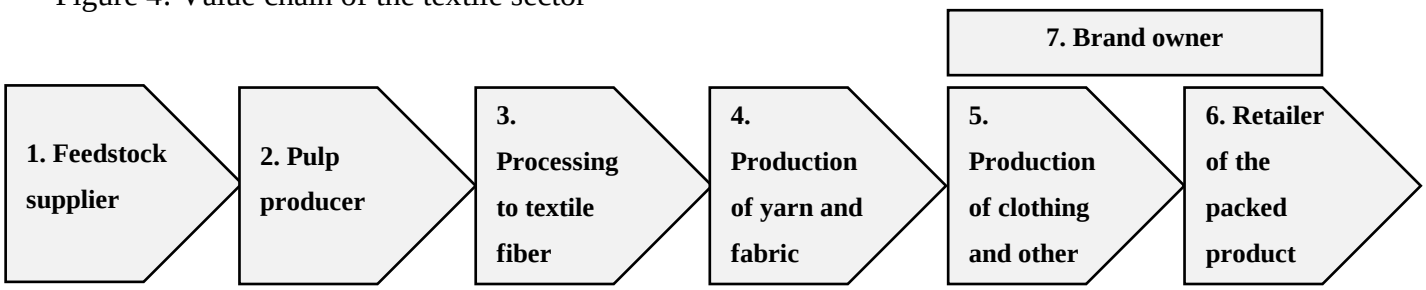
Six respondents pointed out the growing influence of the retailer of the packed end product (stage 6 in figure 3). The retailer was seen to have the best knowledge of the consumer interface that it then could forward to the packer. The differences in the influence of the retailer and the packer were described followingly when asked to name the most dominant decision-maker in the value chain:

> *Traditionally it has been five* [package buyer/packer], *and in practice, the operator who decides how the packed product and the package are combined. But even the role of the retailer has been strongly emphasized in the recent years simply because the store and these brand owners have traditionally built tight cooperation, or they have a tight interface with the consumers, and consumers' desires and reluctances impact strongly on what and how things are getting done and packed.* – #1

4.2.2 Value chains and decision-making power in the textile sector

As expected, the interviewees from the textile sector were more concentrated in the beginning of the chain with only one interviewee (#14) placing themself at the end of the chain (see table 1). The value chain discussed is presented in figure 4. In the textile sector, the forest sector was placed to fewer stages than in the packaging sector: the forest sector was named be the feedstock supplier (stage 1) by five of the respondents and the pulp producer (stage 2) by all seven respondents. Two respondents pointed out that some single operators are even working in the stage 3 (processing to textile fiber), and three respondents stated that this processing stage (3) might be incorporated by the forest sector at some point.

Figure 4: Value chain of the textile sector



One respondent argued that the forest sector is not usually even included in the textile value chain, because it only functions in the feedstock and intermediate product stages (1 and 2):

> *Forest industry is actually, if you search online for instance with the words "textile" and "apparel value chain", so forest industry does not fit into that value chain at all. Similarly, for instance, the oil industry does not fit into it at all. There in the textile value chain, the ones that you find in Google in general, there you find in a way only this third stage* [processing to textile fiber], *so the one that makes the fiber. But* […] *these one and two* [feedstock supplier and pulp producer] *are the forest industry.* – #9

Similar to the packaging sector, the forest sector was not perceived to have any direct decision-making power over the textile material choices of the end market. All respondents recognized that the brand owner holds the most decision-making power on the material use in the textile sector where the consumer demand then guides the decision-making. One respondent pointed out that the largest brand owners, for instance IKEA, have more widespread influence in the textile value chain and even contacts with the early stages. In addition, one respondent said that the yarn and fabric producers have some influence possibilities through offering different materials to the brand owners. This was explained followingly when asked about the most influential decision-maker in the value chain:

> *It is seven* [brand owner] *at the moment, because the brand owners impact the markets a lot and that is where they decide the trends and materials that will be used. Of course, four* [producer of yarn and fabric] *offers them, like "these are the ones available now", but at the end of the day it is the brand owner that decides what to use.* – #10

Hence, in both packaging and textile sectors, the forest sector was not perceived to have any real decision-making power when it comes to the material use of the end market. In both sectors, the forest industry was mainly located at the beginning of the value chains as the intermediate product producer (stage 2 in figures 3 and 4) whereas the decision-makers were located at the end of the value chains. In the packaging sector, the forest industry could present different solutions and make decisions between the different kinds of pulp-based materials, but the packer was perceived to be the most influential. Similarly, the power of the brand owner in the textile sector was seen as overruling, while the forest sector is mainly producing the intermediate product and latter operators have only some minor possibilities to influence by offering different solutions to the brand owner.

4.3 Substitution

4.3.1 Substitution in the packaging markets

The packaging sector and demand for packaging materials were perceived to be growing globally by all respondents. Some of the named reasons behind this growth were the growing e-commerce, demand for take-away products, use of single packaging, and economic growth in the Global South. Plastic and fiber-based solutions were seen as the dominating materials: plastic due to its effective barrier properties in especially food packing and corrugated cardboard due to its fitting properties for

particularly industrial packing and online retail. Both materials were perceived to have superior qualities that ensure a good price-quality-ratio and therefore advantages in the respective uses.

> *If we now go to this industrial packaging side, so then I would say that in general fiber-based packages are preferred at the moment if possible. So, they fulfill the requirements for packaging and there they are maybe fulfilled more easily. But then if we go closer to the consumer and to food, easily perishable products, then plastic is not necessarily preferred, but let's say that in some uses it has the superior properties required for the product to store well.* – #7

> *It* [plastic] *has a bad image but then again it is such a good material, as a material and in protecting the product, that it is still predicted to face growth.* – #3

According to two respondents, the growth of plastic during the last decades has yet been unable to challenge the leading position of cardboard in some types of packaging. All respondents mentioned that there is a willingness or a trend to move away from plastics. Often this willingness arises from the sustainability goals of the retailers and brand owners. Nevertheless, none of the respondents said that the trend of moving away from plastics was really taking place in a large scale by all actors. Hence, the trend was perceived to still be at the conversational level instead of the action phase:

> *Like, we talk a lot about moving away from plastic. And yea, twenty years ago we talked about how we wanted to replace glass and metal packages with flexible plastic packages, because they were light and allowed material reductions. But now again the trend is a bit like going back, because glass and metal are more easily recycled than light, multilayered plastic materials.* […] *So, twenty years ago from glass and metal to the flexible plastic packages. And on the other hand, maybe even to these sorts of Tetra Pak, and now again from flexible plastics back. But I do not know if it is visible at the global level. From these, the companies that are doing it have communicated very largely that "hey, we have now done this" but all of these require large changes in the packaging lines. So, is it then visible in this global picture? I am not sure. Not at least more than a couple of percentages.* – #3

When asked about the current substitution or replacement of materials the list was long. As mentioned in the above quote, much of the material movement over the past decades has been from glass and metals to plastics and hybrid packaging (a fiber package with a plastic film). This was pointed out by four respondents. However, two respondents speculated (e.g., the previous quote) about a small-scale trend back to metals and glass from plastics due to the better recyclability of the former two. The movement from plastics to fiber-based solutions was suggested too but for the most in individual packaging solutions. Moreover, the trend of reducing plastic use does not necessarily imply switching to fiber-based packages. Instead, the use of recycled or bio-based plastics and material reductions were listed as tools against plastic use by two respondents:

> *There are all of those three solutions. So, there is the substitution. Then, there is visibly reducing, and then there is increasing the amount of recycled feedstock. And okay as a fourth element, there is this* […] *use of renewable feedstocks instead for fossil ones, but it is pretty minor compared to the others.* – #11

> *One way to reduce* [plastic use] *is that there is a thinner plastic or new kinds of packaging solutions that reduce plastic in such products where the plastic cannot be fully removed. But if we talk about substitution, then it is usually replaced with paper or carton or cardboard.* – #13

Therefore, the reductions in plastics' use and market share do not necessarily lead to substitution, since the sustainability goals for reduced plastic use in packaging can be attained without changing the feedstock material. However, the interviewees did in general believe that fiber-based solutions are the future of the packaging materials despite the various views on whether plastic use will decrease or continue its growth. Meanwhile, one respondent argued that competition and substitution between the different fiber-based solutions can take place more easily than between different feedstocks:

> *So, if you can buy the same type of material cheaper because the price of those pulps has declined versus some other, then it has a big impact. But in that case, if you were to move from a plastic product to cardboard because the pulp prices are going down, then it probably does not have that of a big impact.* – #12

The most commonly mentioned barrier for substitution in the packaging sector was the path dependence of the sector: the investments to packaging lines are expensive and therefore rare. Making quick changes in materials is difficult, as the packaging lines are always designed and fitted for a certain material type. Moreover, one respondent named the structure of the wider system to be a limiting factor and the superior qualities of plastic in protecting the product to be necessary:

> *As an example, one that has come from somewhere, or from many other producers too, is these carton cases with a separete plastic film. So, these are in a way good examples of how the plastic, basic case is aimed to be replaced with a new one. So like, some parts can be changed, but we will not get fully rid of plastic ever in food packaging as long as we have these delivery chains and shelf life things.* – #13

Although fiber-based packaging was seen as the future path through innovation, the superior qualities of plastic in food packaging were recognized by all respondents. Hence, the packaging sector seems to hope to substitute renewable materials for plastic, but simultaneously properties like an excellent barrier against oxygen, fat and moisture cannot be attained without plastic film at the moment. Therefore, hybrid solutions combining fiber and plastic are rather mainstream. Meanwhile, in industrial packaging, corrugated cardboard does not really seem to face any real competition.

4.3.2 Substitution in the textile markets

In the textile sector, the pulp-based solutions do not dominate the market and are still rather small in volumes according to the respodents, which is also visible in the market shares of different fibers (see figure 2). All respondents agreed that the textile sector is a globally established industry with massive production volumes and global megatrends impacting the direction of the market. Additionally, competetive advantages in the market were recognized to arise mainly from high production volumes that enable low prices. Two respondents explained that during the past decades the share of polyester and other synthetic fibers has faced overgrowth, making polyester the largest fiber segment. The share of pulp-based products was decribed followingly when asked about whether the new pulp-based fibers are already used:

> *So, right now we are in the situation that in many market areas or in many companies the product development is in good speed when it comes to new fibers, for instance, in Finland these new cellulose-based textile fibers are being developed right now. So, in*

> *a way we are at the preproduction stage, so soon we will start to get the first samples to the markets.* – #14

All respondents recognized the sustainability conversation around the textile industry and its environmental impacts. Similarly, all respondents stated that the sector is developing to a direction where either sustainable textile fibers or recycled feedstock are facing increasing quantities demanded. Pulp-based fibers were seen to have potential in providing sustainable options, especially in formal clothing and fashion products where for instance viscose is already used according to two respondents. Six respondents discussed the environmental issues related to the cultivation of cotton with one respondent even referring to the other ethical issues of cotton. Cotton was recognized to have met its global production limits, leading to a cellulosic gap. Here, the same six respondents suggested that the pulp-based fibers could contribute to filling this gap since cotton and pulp-based fibers are very close in properties. According to the estimates of the six respondents, the decreasing share of cotton does not indicate declines in the total production volumes because the total volume of all fibers produced is growing (with the exception of cotton). Hence, it seems that the pulp-based product is not really used as a substitute for cotton but to fill its production gap. This moves the results to a grey area in terms of substitution impact: the pulp-based product does not seem to create avoided fossil emissions but instead responses to a growing quantity demanded of cotton-like fibers.

> *Everybody who operates in this sector knows that the situation of cotton is unsustainable, so its share is not believed to grow anymore. And it is experienced that cotton cannot be produced more globally than what is produced at the moment.* – #14

On the other hand, four respondents suggested that the pulp-based fibers could substitute for oil-based synthetic materials because textiles are commonly mixtures of different fibers and changing the ratios between the mixes is rather easy in, for instance, clothing items. However, the possibilities to compete with the volumes and price of polyester are currently seen as weak. Polyester has been able to grow due to its low price and fitness for many uses, with the help of the tremendous quantity demanded of textiles that the fast fashion industry creates. Moreover, synthetic fibers such as polyester are harder to replace due to their extensive properties and fitness to numerous end uses. The respondents named resistance, strength and moisture capture as some qualities of the synthetics (especially polyester and polyamide), that the pulp-based fibers cannot currently replicate. These issues arise especially in

sports clothing and technical textiles, although two respondents mentioned positive signals from the pulp-based fiber industry to produce pulp-based non-woven textiles.

> *If the price is competitive, then it* [pulp-based product] *can perhaps decrease the share of polyester, mostly since then they will mix a little less polyester into fabrics than now. So, the aim with the fabrics, when we mix for instance cotton and polyester, is always to find the optimal combination for that price and those properties. If we now made 75% polyester or two thirds of polyester, one third of cotton or viscose. So, there, if the price were competitive, then for instance 50% – 50%. Then you could say that the product is a bit more environmentally friendly than before.* – #10

> *It* [polyester] *is a such fiber against which it is very hard to compete in a way.* – #14

> *The reason why it* [polyester] *dominates is that it is at the moment the cheapest textile fiber and especially in these fast fashion markets, where the price decides, so there they use the cheapest options. Additionally, polyester has good basic properties. It fits well for clothing purposes, interior design textiles, technical textiles, so it can be used in many places.* […] *Polyester works in everything. It is not necessarily the best fiber always, but it is good enough, and, especially in the fast fashion industry, they are not looking for the best fiber in properties, but a solution that is good enough for the purpose.* – #10

Three respondents pointed out that substitution is and will be taking place within the pulp-based fiber category where the new solutions such as lyocell are substituting or will substitute for viscose. Although both lyocell and viscose are pulp-based, the production of the former is more environmentally friendly than that of viscose. Hence, the growing production of alternative MMCFs is believed to challenge viscose rather than cotton or synthetic fibers:

> *In fact, a very large trend is that viscose is being replaced with lyocell, so wood-based with wood-based. That will be one large trend.* – #8

The current substitution in the textile sector seems to be minor compared to the total fiber volumes and to take place mostly within the pulp-based product category. The greatest barrier for the use of

pulp-based fibers seems to be the lack of working solutions produced in such large volumes that the pulp-based products could compete in price with the synthetic fibers. In the case of cotton, the pulp-based material seemed to fill the gap in supply rather than substitute for another material. One respondent suggested that the cotton gap is also filled with polyester, which indicates that the pulp-based products might be substituting for polyester in fulfilling the stagnating cotton production.

In both packaging and textile sectors, there seems to be a trend and willingness to make more sustainable material choices by either using renewable or recycled feedstock. However, if there is substitution taking place in the sectors, it is minor. The oil-based materials are extremely competitive both in price and properties. In the packaging sector, the superior qualities of plastic were supporting its future use according to all respondents although there seemed to be a clear belief in future dominance of fiber-based packaging. Hence, this could indicate further development of hybrid solutions in the future. When asked about whether introducing a large quantity of fiber-based packaging to the market would lead to a market growth or substitution, the answers were mixed. From those who replied to the question, one believed in substitution, three in market growth and four that both would take place. Meanwhile, the substitution potential for the pulp-based fibers in the textile sector were believed to be large but not in the near future. In the coming years, substitution between the pulp-based products was seen as a more dominating direction in the textile sector instead of them challenging the dominance of the synthetic fibers. When asked about the results in the case of introducing a significant quantity of pulp-based fibers to the market today, the results were mixed even in the case of the textile market with one expecting market substitution to take place and two that a mix of substitution and market growth would happen. One stated that substitution can only be expected to take place in future in textiles.

4.4 Determinants of demand

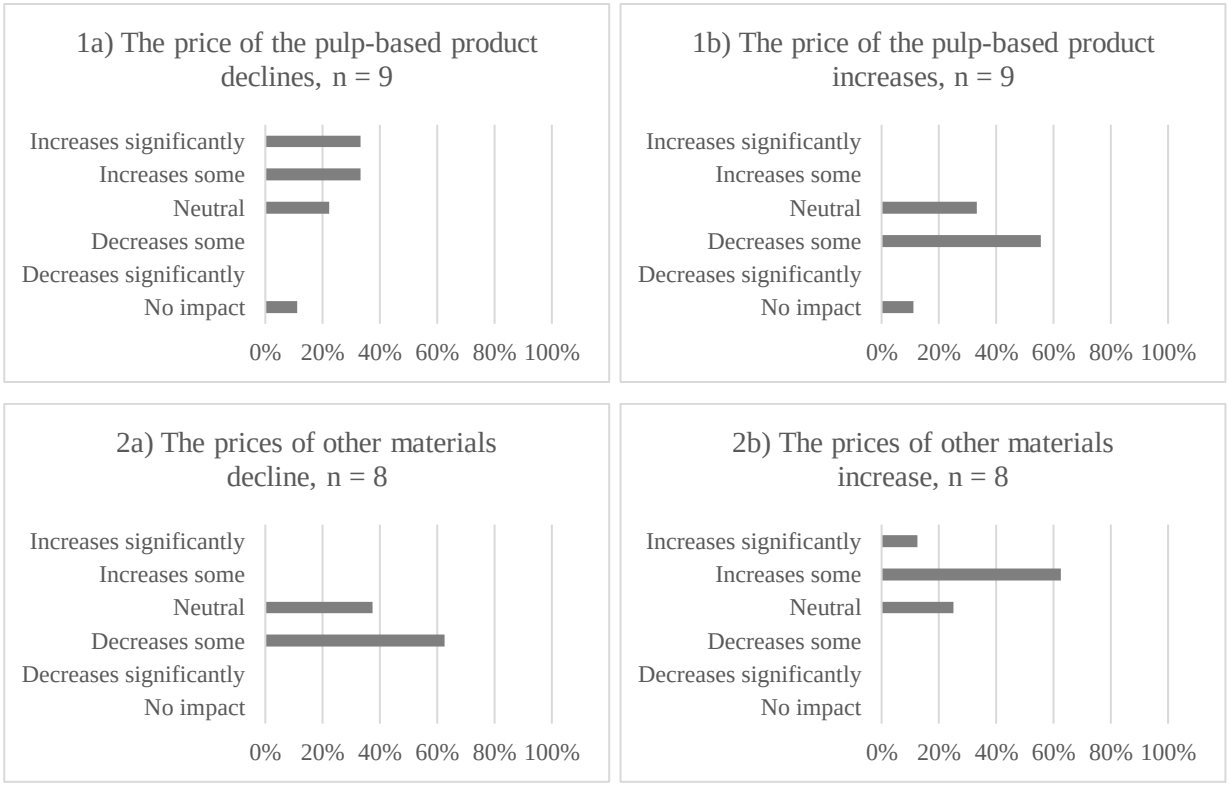
4.4.1 Determinants of demand in the packaging sector

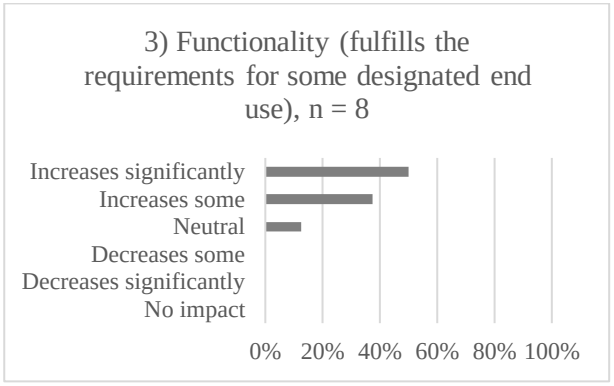
What comes to both the packaging and textiles and in general the discussion on demand, all respondents found it difficult to fill the Likert scale and determine the impacts of the different factors on the quantity demanded, because according to them demand consists of numerous interconnected determinants. Thus, the aggregate effect of multiple determinants seemed important while ceteris paribus situations seemed unlikely in reality. One respondent summarized the hardness of determining the origins of demand followingly:

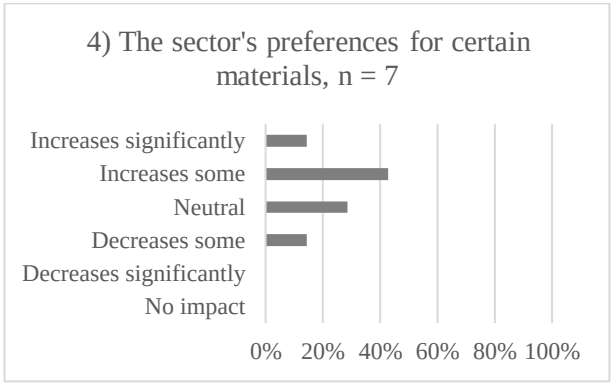
> *Your question is so complex that when you look at the consistency of demand, there are like hundreds of factors that are connected to these, like, consumer preferences that are in their turn connected to one's own values, development of the value system, mental image on what is acceptable in the society and what is not, if we talk about sustainability for instance. It can be connected to some change in demographics that new generations start to have purchasing power and they have like totally different values than the previous generations and so forth. There are so many variables and factors that it is virtually impossible to answer promptly and unambiguously.* – #5

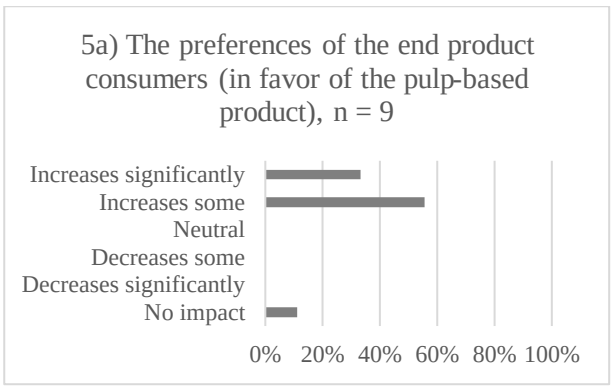
The results from the Likert scale on the determinants of demand with the most responses in the packaging sector are presented in Figure 5, where the impacts of the different determinants on the quantity demanded of the pulp-based product are portraited. In the figure, the number of data points for each determinant is presented in the title, and the percentages indicate the share of total answers for each scale level. In this section "quantity demanded" refers solely to the quantity demanded of the pulp-based packaging material in the market.

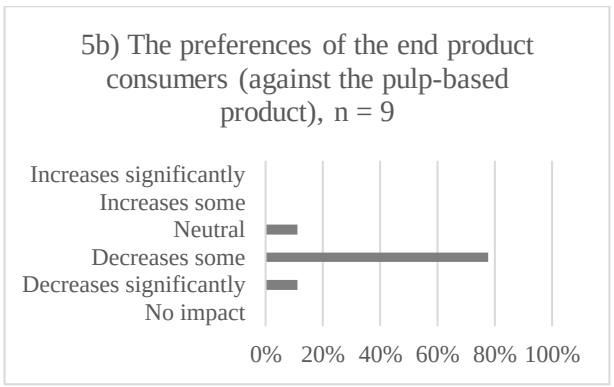
Figure 5: Determinants of demand in the packaging sector

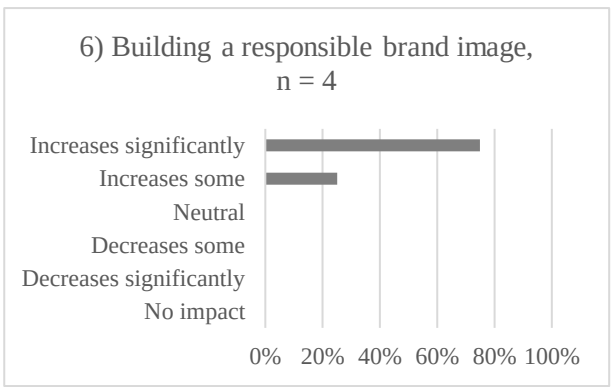


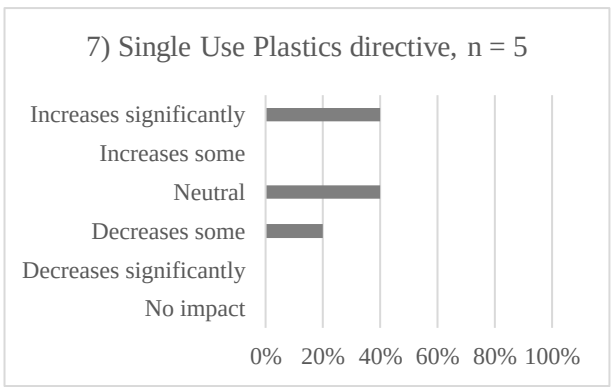












The changes in the price of the pulp-based product are presented in Figure 5: 1a and 1b. In the case of a price decline (Figure 5: 1a), two respondents speculated a neutral impact on quantity demanded, and one respondent answered no impact. In the case of a price increase (Figure 5: 1b), three respondents expected a neutral impact and one respondent no impact. In general, it seems that a price decrease (Figure 5: 1a) might have a greater increasing impact on the quantity demanded as three respondents expected a significant increase in quantity demanded. Contrastingly in the case of price increase (Figure 5: 1b), no respondents expected a significant decline in the quantity demanded, indicating that the impact of a price increase is relatively smaller. Hence, the demand seems to be convex (Figure 5: 1a and 1b) because the answers indicate that a price decrease leads to a relatively larger change in quantity demanded than a price increase. The convex demand seems to act in favor

of the fiber-based solution which could be explained by preferences of the market. Additionally, the demand seems to be neither elastic nor inelastic but something between the two extremities, indicating that some substitution can be assumed to take place in the market.

Changes in the prices of other materials are presented in Figure 5: 2a and 2b. A price decline of other materials (Figure 5: 2a) was expected to have a neutral impact by three respondents, and five respondents predicted the quantity demanded to decrease some. A price increase of other materials (Figure 5: 2b) was estimated to have a neutral impact by two respondents, some increasing impact by five respondents and a significant increasing impact by one respondent. Thus, a price increase of other materials might have a larger impact on the quantity demanded than a price decline. Overall, the changes in the prices of other materials (Figure 5: 2a and 2b) indicate a positive cross-price elasticity and, therefore, substitution can be assumed to take place in the market.

Functionality seemed to be an important attribute in the packaging sector, since the package must be able to protect the product. Meanwhile, the popularity of the fiber-based solutions was evident in the hypothetical scenario of finding the perfect fiber-based packaging solution (Figure 5: 3) that is able to offer properties such as moisture and oxygen barriers. In this case, only one respondent estimated a neutral impact. Three respondents expected some increase and four respondents estimated significant increases in the quantity demanded. The popularity of the fiber-based solution was supported by the data on the preferences of the sector (Figure 5: 4): one respondent assumed a significant increase and three respondents expected some increase in the quantity demanded. Although two respondents estimated a neural impact and one some decline in the quantity demanded, the results indicate that the sector prefers the fiber-based solutions at least in some end uses.

Although consumers purchase primarily a good instead of its package, consumer preferences seem to have an impact on the quantity demanded of the fiber-based packaging (Figure 5: 5a and 5b). Consumer preferences in favor of the pulp-based product were expected to have an increasing impact on the quantity demanded by all expect one respondent. Interestingly, the respondent estimating no impact in the case of consumers in favor of the pulp-based solution (Figure 5: 5a) concluded that consumer opposition (Figure 5: 5b) would have some decreasing impact on the quantity demanded. Otherwise, the results suggest that consumer opposition of the pulp-based packaging solutions would decrease their quantity demanded (Figure 5: 5b). However, the fiber-based packaging solutions were

perceived as an important part of a responsible brand image with four respondents believing in to have an increasing impact on the quantity demanded (Figure 5: 6).

In general, the results presented in Figure 5 illustrate an atmosphere that prefers pulp-based packaging materials. This indicates that the growth of the fiber-based solutions is likely to continue with the different factors in the market either accelerating or slowing it down:

> *In a way I think that in the background, so many drivers support the success of the fiber product in the market that if some changes, that accelerate it even further, take place in the market, then it changes the slope, not the conclusion per se.* – #1

However, regulation was perceived to possibly threaten the fiber-based packaging solutions. Regulations, especially The Single-Use Plastics Directive (the SUP Directive) aiming to reduce the plastic marine litter from single-use plastic products (European Commission, 2018), was brought up by all respondents. Although two respondents saw that the SUP Directive can increase the quantity demanded of the fiber packaging (Figure 5: 7), all respondents seemed unsure of the direction of the expectedly significant impact, since the final form of the directive was still unknown at the time of the interviews. Respondents seemed frustrated towards the current uncertainty and questioned the abilities of the SUP Directive to reduce plastic use and have positive environmental impacts:

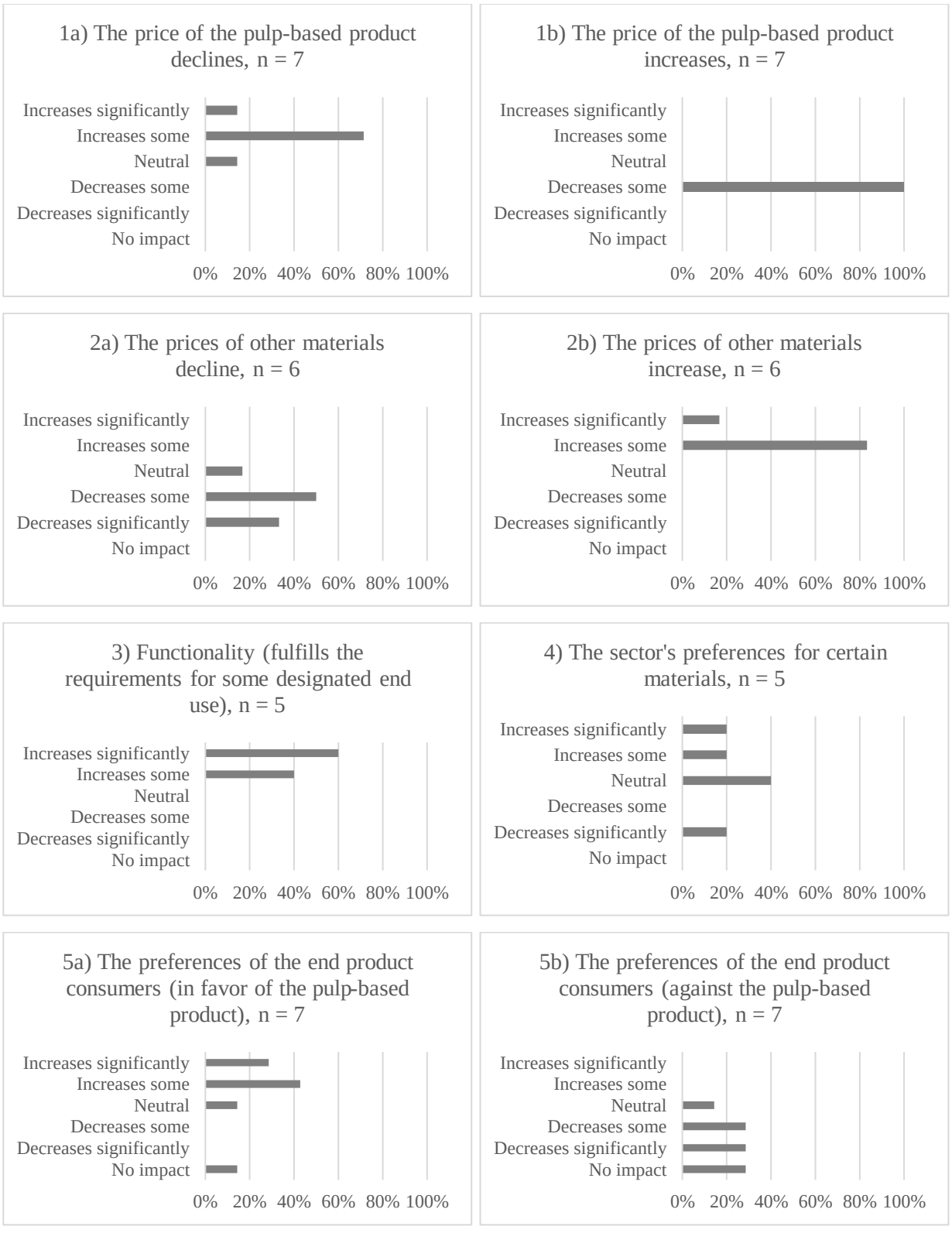
> *You can put here that SUP has a very large, significant impact on the demand of the pulp-based products. But now for example, when the SUP directive is going to the direction that any package, that is not reusable, must be reduced. So by that way, if the SUP directive continues to an even worse direction than this, then for the part of the pulp products, it can have a significant negative impact, so that it decreases significantly. So, then we will start to look for glass package solutions or porcelaine cups or whatever. Then everyone understands that the carbon footprint just grows further.* – #12

4.4.2 Determinants of demand in the textile sector

The determinants of demand in the textile sector with the most responses in the Likert scale are presented in Figure 6. Here, only the impacts of the different determinants on the quantity demanded

of the pulp-based textile fibers are illustrated. In the following section, “quantity demanded” is used to refer to the quantity demanded of the pulp-based products in the textile sector.

Figure 6: Determinants of demand in the textile sector



Changes in the price of the pulp-based product (Figure 6: 1a and 1b) showed that a price increase of the pulp-based product (Figure 6: 1b) has a declining impact on the quantity demanded, as all seven respondents answered that the demand would decrease some. Contrastingly, in the case of a price decline, the results were more spread: five respondents estimated some increase, one respondent a significant increase, and one respondent a neutral impact in the quantity demanded. Hence, the price elasticity of demand seems rather linear with a price increase and a price decreasing having impacts of similar extent. Moreover, the demand is neither elastic nor inelastic but something in between the two extremities. This indicates that some substitution can be assumed to take place in the market.

A price increase of other materials (Figure 6: 2b) is expected to have an increasing impact on the quantity demanded of the pulp product with all six respondents expecting an increase in quantity demanded. The case of a price decline of other materials (Figure 6: 2a) was more ambiguous: one respondent estimated a neutral impact, three respondents a somewhat decreasing impact, and two respondents a significant decrease in quantity demanded. Thus, a price increase of other materials is likely to increase the quantity demanded of the pulp product, while a price decrease of the other materials is likely to decrease the quantity demanded. This indicates that there is a positive cross-price elasticity, meaning that substitution can be assumed to take place in the market. However, in the case of textile fibers, interpretational issues arise from the production limitations preventing further increases in the production of cotton. Although the elasticities indicate that substitution is taking place in the market, estimating whether there are substitution impacts (i.e., avoided fossil emissions) is a more complex question that this data cannot reply to.

Developing a fitting product with the right functionality and scaling its production was expected to increase the quantity demanded by all five respondents (Figure 6: 3). Thus, product development and scaling of production to drive the price down could increase the quantity demanded even significantly. However, the answers regarding the preferences of the sector (Figure 6: 4) did not correlate with these expectations on innovation. Two respondents stated neutral preferences of the sector towards the pulp products. The remaining three respondents answered each differently: increases significantly, increases some, and decreases significantly. Hence, opinions within the sector vary making it difficult to draw other conclusions than preferences having a neutral impact on the quantity demanded.

The views on the end consumer preferences varied a lot (Figure 6: 5a and 5b) which was surprising due to the rather well-known environmental damage caused by the sector and the sector providing

end products in contrast to the packaging sector. One respondent in the case of consumers in favor of the pulp-based product (Figure 6: 5a) and two respondents in the case of consumers against the pulp-based product (Figure 6: 5b) estimated that the consumer preferences have no impact on the quantity demanded of the pulp product. One respondent justified this answer in the latter case by stating that it is extremely unlikely that consumers would be against the pulp-based product, as it is perceived to be more sustainable than the currently existing materials. The other "no impact" respondent reasoned that the consumer habits are not impacted since consumers do not know or care enough to go through the material mix of every piece of clothing. In the case of consumers favoring the pulp product, one other respondent speculated a neutral impact, three some increase and two significant increase. On the other hand, the opposition of the consumers was expected to have a neutral impact by one respondent, a somewhat decreasing impact by two respondents and a significantly decreasing impact by two respondents. Hence, if provided with adequate information that is easily accessible, the consumers might even have a significant impact on the quantity demanded of the pulp-based product.

The interviews on the textile sector indicated that the pulp-based products are not dominating the market in the same way than in the packaging sector. Consequently, the most pressing issue seemed to be to enable the production of pulp-based textile fibers in the necessary volumes to bring down the price. Three respondents stated that the textile fiber market is above all a market where scaling of production is required to achieve high production volumes and low prices, as the market is volatile due to the easiness of switching from one fiber to another. One respondent summarized the future substitution potential and the necessary scale of pulp-based textiles followingly:

> *Here you see in a way how endlessly large the markets on the textile side are and how we could in a way if… When we get our own textile applications from the forest industry to the point where the production process is validated to cost-efficient and scaling – so, when we can sort of produce relevant volumes at smart cost levels – then all these different materials that you see here* [materials presented in Figure 2], *we are going to start to replace all of them.* – #5

Interestingly, when asked about the most significant determinant of demand, the answers varied a lot in both packaging and textile sectors. Therefore, no conclusions can be drawn on the most influential determinants in either sector from the data of this study.

5 Discussion

5.1 Evaluation of the results

Similar to the presentation of the results, the discussion of the findings is done thematically according to the research questions, starting with value chains and then moving on to substitution and demand. First, the findings of this study indicate that the power to make material choices is located at the end of the value chain. In both sectors, the forest industry was perceived to be at the beginning or middle range of the value chains as intermediate product producer. Uronen (2010) has also placed the forest industries to the role of the intermediate product producer with low value-added, indicating that the forest companies are rather far away from the end product and only having limited abilities to influence the value chain. Others, like Ali-Yrkkö and Rouvinen (2013) concluded that the brand owners and especially the parties close to the consumer interface have possibilities for extensive profits as well as more bargaining power in the whole value chain. This study arrived at a similar conclusion, as in the packaging sector the packer held power through their path dependence and the retailer through their knowledge of the consumer interface, and in the textile sector, the brand owner with close ties to the consumer interface was concluded to be the most influential decision-maker. Hence, the results suggest that in order for the forest industries to gain more decision-making power, they would have to move down the value chains. Hurmekoski et al. (2018) recognized this too: innovation is needed to move the forest sector closer to the consumer interface to make greater future profits. Thus, in order for the forest sector to have more bargaining power in the value chain, it must move down from its role of an intermediate product producer to a brand-owner closer to the consumer.

Moreover, the results indicate that the policymakers too have some undefined power and abilities to have sudden and extensive impacts on the value chain. This finding fits the existing literature, as Bick et al. (2018) suggest that the policymakers have extensive power to promote sustainability in the textile sector through regulation and trade policy. In the results of this study, the power of the policymaker was discussed especially in the case of the packaging sector where the Single-Use Plastics directive along with other regulations have clear aims to reduce plastic and environmentally harmful substance use (e.g., European Commission, 2018; European Parliament and Council, 1994). Gustavsson et al. (2006) see regulations as one of the factors for the promotion of less environmentally harmful products, especially from the point of view of encouraging the use of wood products in place of fossil-based materials. However, the findings of this study do not illustrate such positive signs for the wood products, as there seems to be uncertainty over the final impact of the

SUP directive. At the time of the interviews, it was still unclear how the final interpretations of the directive would impact the market dynamics. Thus, policymakers can have a lot of regulative power over the value chain although they are not direct operators in the chain.

Second, the results of this study indicate that there is a trend to reduce plastic use in the packaging sector and a willingness to find more sustainable solutions in the textile sector. This trend to solve sustainability issues complies with the existing academic literature (e.g. Bick et al. (2018) in textiles and Lahtinen (2020) in packaging). However, it seems that substitution has not taken place in significant extents but instead mostly in some individual products. In both sectors, the hybrid materials are currently the mainstream solutions: in packaging, the combination of fiber and plastic and in textiles the combination of different fibers to attain the sought properties. Hence, substitution is not necessarily a question of switching to a wood-based product but instead to find the optimal combination of the different materials, as stated by Leskinen et al. (2018) too. Although hybrid products were seen dominant, the results indicated that there is belief in the future of the pulp-based products to offer sustainable options. Earlier studies have arrived at similar conclusions (Hetemäki & Hurmekoski, 2016; Hurmekoski et al., 2018) that in the packaging and textile sectors new innovations can help the forest industries to grow their profits and to create substitution impact in the near future.

The future substitution potential of textiles has been recognized to be especially high (Hurmekoski et al., 2020; Leskinen et al., 2018) while the results of this study indicate that once the volumes and prices are at competitive levels, the markets to substitute are extensive. However, as recognized by Hurmekoski et al. (2018), the increased production of pulp-based textile fibers could be directed towards filling the predicted cellulosic gap that the stagnating production of cotton is causing due to the close properties of MMCFs to cotton. This study arrived at the same conclusion of pulp-based products being likely to fulfill the production gap of cotton. Therefore, the textile sector is on a grey area when it comes to the definition of substitution from the perspective of avoided emissions since, in the case of cellulosic gap, it is unclear what the pulp-based product is substituting for: cotton, other fibers, or just simply answering to a growing demand. This is problematic since it is ambiguous which product to use as the non-wood product in the substitution impact calculations. The findings of MMCFs substituting mainly for each other – lyocell to substitute for viscose – indicate that the pulp-based fibers are not close substitutes for the dominant textile fibers. These results make it troublesome to use the sector's average mix of materials (or the market share division of the materials) as basis for the climate impact calculations.

What comes to the assumptions on preferences, the results of this study indicate that the fiber-based solution is currently preferred in some end uses, especially in the case of packaging sector where wood-based solutions are one of the market leaders. Hence, Harmon's (2019) critique on the assumption of the sectors preferring the fossil-based material is supported by the findings of this study. Although oil-based plastic as a packaging material is dominating in some end uses (especially in food packaging due to its excellent barrier capacities), corrugated cardboard is hard to compete with in industrial packaging according to the findings of this study. Therefore, building on the thoughts of Harmon (2019), increased use of fiber-based packaging does not necessarily lead to climate benefits in all packaging types. This is due to the existing preferences for wood-based packaging that entail the new wood-based products possibly replacing other wood-based products instead of fossil intensive materials. This would be in line with most substitution impact estimates to date which assume substitution impacts for pulp-based products only from the end-of-life energy recovery and not from the production stage (e.g. Soimakallio et al., 2016). However, this has primarily been due to a lack of data for the life-cycle analysis rather than conscious market assumptions. The preference assumption can even be made in case of the textile sector but in a smaller scale as pulp-based fibers are only preferred in some end uses, for instance in high fashion products. Similarly, some respondents indicated that the perceived sustainability of the MMCFs can alter preferences in the textile sector which is also supported by Bick et al. (2018). Although Harmon (2019) discusses substitution in the context of constructions industry, the points raised are also valid in the case of packaging and textile sectors, as they target the general assumptions of substitution. However, the sectoral preferences are complex and product specific making it difficult to estimate the overall sectoral preferences.

Third, the findings of this study demonstrate that there is no unambiguous way to depict the factors impacting substitution or the market demand. Gustavsson et al. (2006) discussed the same complexity of multiple factors affecting substitution and market demand with focus on the importance of relative prices, political goals, legislation and regulation, and economic growth. Most of the factors named by Gustavsson and his colleagues were also recognized in the results of this study. However, the assumption of the consumer demand being the most important factor for intermediate wood products (Gustavsson et al., 2006) was not supported by this study although even the theory of derived demand suggests the high importance of the end product demand (Sato & Koizumi, 1970). Instead, this study could not conclude any determinant or factor to be above others in the quantity demanded of the pulp-based products. There are differing opinions in the existing literature too. For instance, Bick et al.

(2018) emphasize the importance of consumer influence for effectively solving environmental and social issues of the textile industry while still seeing political tools and regulations as the most effective means of change. Meanwhile, the results of this study did not indicate current influence of policymakers on material decisions in the textile sector, while the respondent opinions on the extent of the consumer influence varied from no impact to significant impact. However, the results suggest that preferences and sectoral path dependence can have significant impact over the material choices.

The definition of substitution by Lippke et al. (2011) states that substitution does not take place without a market change that affects prices and thus, increases the quantity demanded of one product and contrastingly decreases the quantity demanded of another product. Gustavsson et al. (2006) also emphasize the need to decrease the relative prices of the wood-based products in order to establish competitive grounds from them. The results of this study indicate numerous important determinants of demand forming the quantity demanded and substitution decision-making, in contrast to the definition of substitution by Lippke et al. (2011) outlined above. While substitution can be assumed to take place in the markets through examining the moderate price elasticity of demand and the positive cross-price elasticity in both packaging and textiles, substitution can also arise from other factors than price change according to the findings of this study. Hence, it seems that price alone is not determining the quantity demanded of the substitute product, but that also other factors, such as consumer preferences or sustainability efforts, can drive the substitution decision: the complex ensemble formed by all of these factors is more important than any individual factor, indicating that the products are not perfect substitutes. Therefore, tools to measure substitution arising from the other determinants of demand (e.g., the determinants examined in the empirical part of this study), in combination to examining price and cross-price elasticities, are necessary to gain a more comprehensive understanding of the extent of substitution and the market dynamics.

Finally, the results indicate a continued growth in both sectors, as suggested by historical data on textile fibers (CIRFS, n.d.) and market predictions on the packaging sector (Smithers, 2018). Especially in the case of packaging materials, the growth in quantity demanded for forest industry's products is expected to be further driven by the global megatrends (Hurmekoski et al., 2018). However, when considering whether the future innovation and use of wood-based products are in fact beneficial for the climate, it is good to remember that increasing the production of wood-based products requires increased harvests despite enhanced efficiency of the processes. The increased harvests may have then their own negative impacts on the carbon stocks and sinks of the forests

(Soimakallio et al., 2016) and biodiversity that are too needed in successful climate mitigation (IPCC, 2014). Although making market analyses and considering product level substitution is important, the comparison of substitution benefits to the forest carbon sink impacts is essential (Leskinen et al., 2018). However, the substitution impact of wood use can also, at least in theory, be increased without affecting the forest carbon sinks by changes in the product portfolios and redirection of wood feedstock to the products with the most substitution benefits.

5.2 Trustworthiness and limitations

The assessment of the trustworthiness and limitations this study is done through adopting four perspectives on the qualitative method as defined by Bryman (2012): credibility, transferability, dependability, and confirmability. First, credibility of findings refers to the correct interpretation of the results: the conclusions and ideas presented by the researcher must be in line with those of the respondents (Bryman, 2012). Although the subjectivity of the researcher is an inseparable part of qualitative research (Slevitch, 2011), the credibility of the results was enhanced by transcribing the interviews and presenting quotes and data in the work itself along with the data interpretation of the researcher that was based on cross-analysis of all interview materials. However, having to translate the transcripts for the purposes of this study might have weakened the credibility. In addition, the credibility of the results could have been enhanced by collecting more data and cooperating with other researchers to analyze the data.

Second, transferability of findings refers to the interchangeability of the results to another context (Bryman, 2012). Due to the qualitative nature of this study, generalization of the results was not intended. However, the results give a good picture of the phenomenon studied in the context of this study, since the respondents represented multiple different actors and perspectives to the sectors and value chains. Despite the different backgrounds of the respondents, the data saturated well, indicating a good representation of the given context. The results of this study are essential steps to lay the foundations for more extensive sectoral analyses: more research and data are required to develop a deeper understanding of substitution and demand in the packaging and textile sectors from the perspectives provided in this study.

Third, dependability, or reliability, ensures that similar results can be obtained at a later occasion by other researchers (Bryman, 2012). To increase the reliability of the results, the problem formulation,

method and data analysis decisions were described in detail. The decision to use purposive sampling, more specifically snowball sampling, increased the reliability building on the assumption of experts naming other experts to be interviewed. This enabled the selection of interviewees who had the required knowledge to participate in the interviews. Of course, the purposive sampling entails the risk of a homogeneous sample where all respondents represent similar views or backgrounds. The risk for this was mitigated, as some respondents were recognized by the researcher with the help of a matrix to ensure that all aspects are covered in the study. Though increasing validity, the use of such matrix decreased reliability.

Fourth, confirmability refers to the aims to minimize subjectivity of the researcher (Bryman, 2012). In order to enhance the confirmability, quotes and data are presented in the results section of this paper, separate from the interpretations of the researcher. Additionally, although the data analysis was led by the themes of the interview, even thematical analysis was applied to recognize other patterns and phenomena than those specifically aimed to study.

6 Conclusion

This study examined substitution in the case of packaging and textile sectors with emphasis on the market assumptions related to substitution. The aim was to use value chain analysis to reveal the decision-makers enabling substitution in the packaging and textile sectors, to determine the current state of substitution in the sectors, and finally to explore the determinants of demand for the pulp-based products. A qualitative case study approach was chosen. As literature on detailing the market assumptions for substitution remains scarce, the chosen market and demand centered perspectives were seen as necessary in order to enhance the understanding of substitution and its assumptions in the context of using wood products to avoid fossil emissions.

The findings of this study succeeded in delivering answers to the three research questions. First, the value chain analysis revealed that the decision-making on materials is done at the end of the value chains close to the consumer interface while the forest sector is located at the beginning of the value chains. Therefore, the forest sector has only minimal influence over the material choices of the packaging and textile sectors, and to gain power the forest sector companies would have to move down the value chain. In the case of the packaging sector, the packer was perceived to have the most power and, in the case of the textile sector, the brand owner. Second, there seems to be no clear answer on whether substitution is currently taking place in the markets or not. In packaging, there is a strong will to reduce plastic use and find more sustainable solutions. Although fiber-based packaging is perceived as the future direction, the reduction of plastic use does not necessarily lead to an increased use of fiber-based packaging. Moreover, the market assumptions related to preferences in the market complicate the substitution analysis since corrugated cardboard is dominating, for instance, the industrial packaging market. In the textile sector, there is also a willingness to make more sustainable material decisions but the tools for this seem lacking. Meanwhile, the results indicate that instead of challenging the dominating fibers such as polyester, the new MMCFs are likely to substitute for viscose or fill the cellulosic gap arising from the stagnating production of cotton. Thus, although the elasticity analysis and the positive cross-price elasticity in both sectors indicate that there is potential for substitution to take place, the implications to market assumptions are not straightforward. Third, the results on the determinants of demand revealed no single determinant to be dominating but instead the complex ensemble of multiple factors was concluded to be of the uttermost importance.

To conclude, it seems like wood-based solutions are expected to grow in both packaging and textile sectors. However, even the growth of both markets and interpretational issues arising from the markets preferencing fiber-based packaging in some uses and the cellulosic gap in the textile sector indicate that estimating substitution impacts from the climate perspective might not be as simple as the elasticity and cross-price elasticity analyses on market substitution suggest. Additionally, the product development and innovation does not necessarily respond in significant quantities or even to the right problems as illustrated by the example of the textile sector: the new MMCFs are expected to substitute for viscose rather than synthetic fibers. Meanwhile, although plastic is the material to replace in the packaging sector, it is at the same time the material that is not possible to be yet replaced fully due to its excellent barrier capacities. Hence, the efforts in reducing plastic use might not even concentrate on finding solutions from other feedstocks. The results of this study emphasize the importance of understanding the market dynamics and the relationships between the different materials when making statements about the climate benefits of substitution on the market level: making the substitutability assumptions more systematic and transparent is essential for improving the reliability of substitution impact estimates.

This study was a step forward in laying the foundations for market-based assumptions to substitution impact estimates. As the results reveal, there are numerous issues to overcome and perspectives to adopt in the future substitution studies in order to enhance the knowledge on substitution impact. Future research could concentrate, for instance, on more extensive studies of the materials actually replaced in the markets and the determinants of demand through quantitative means to arrive at more generalizable conclusions in the cases of packaging and textile sectors. This would require using unconventional methods and data sources, as secondary statistics sources do not allow econometric analysis at this level of disaggregation. Moreover, the analysis should be expanded to other sectors to broaden the understanding of substitution and its possible climate benefits.

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Appendix I: Data on market shares of packaging materials

Global market shares of packaging materials by value, the sources used for the calculation of the average market shares (see figure 1):

Source	**WPO, 2008**	**FICCI, 2016**	**All4pack, 2018**
Year of statistics	2003	2014–2015?	2016
Rigid plastic	*18.00%*	*22.00%*	*18.20%*
Flexible plastics	*12.00%*	*20.00%*	*15.53%*
Metals	*18.00%*	*15.00%*	*12.20%*
Glass	*7.00%*	*7.00%*	*6.60%*
Paper and board	*39.00%*	*31.00%*	*43.47%*
Other	*6.00%*	*5.00%*	*4.00%*

Appendix II: Matrix for respondent recognition

B2B vs. consumer market	Placement in the value chain	R&D	Sales (operative)	Marketing/ branding	Industry umbrella organization
B2B	Intermediate product producer (pulp)				
	Processing of the intermediate product				
	End-product producer (packages/ textile products)				
Consumer market	End-use (packer and retailer)				

Appendix III: Interview questions

Introduction: Substitution refers to the use of wood instead of other materials in a product that would otherwise be produced from some other material. The use of wood can lead to a diminished carbon footprint and reduced environmental impacts of the end-product. In this study, substitution will be examined from a market perspective. Thus, we will be looking at the wood product's market position, the competing products and the possible preferences impacting the decision on material and its use. Special emphasis is put on the determinants of the demand. The study aims to explore wood use on the sectoral and market level instead of individual firms. Regarding wood-based products, we focus on products made of wood pulp in the textile and packaging sectors.

A. Interviewee and sector:

1. Shortly: What is your job description and/or what kind of experience do you have from the packaging/textile sector?
2. Where in this value chain would you place yourself and the operator you are representing? / To which parts of the value chain do you as a researcher concentrate the most?
3. Where in general would you place the forest industry in this value chain?
4. Which part of the value chain is the most influential decision-maker when it comes to the use of materials in the end-market?

B. Market share:

1. Are the global market share numbers in the chart realistic?
   → if not: What is your estimate on the market shares*?*
2. Has the market share distribution been subject to significant variation or remarkable changes over the past few years or decades?
3. Is the demand of the total market for textile/packaging materials increasing, decreasing or constant right now? Why?
4. Is there some submarket that stands out from the total market in terms of the development of demand?
5. If the pulp-based product became more used in the market, would this lead to an increase in the size of the total market or would the pulp-based product take over the market shares of other materials? Why?

C. Substitutability of wood products:

1. Between which materials especially is there substitution?
2. Are there some products or materials that the pulp-based product cannot replace because of, for example, functionality? Which and why?

D. Determinants of demand:

1. Do the markets prefer some products or materials? Why?
2. Which factors impact the demand of materials on the textile/packaging industry?

E. Likert scale

F. Do you have anything else to add on the topics discussed?

G. Who should I interview next? Could you name some persons to interview?

Appendix IV: Likert scale template

	1 – Decreases significantly	2 – Decreases some	3 – Neutral	4 – Increases some	5 – Increases significantly	No impact	Most impact on demand
The price of the pulp-based product declines							
The price of the pulp-based product increases							
The prices of other materials decline							
The prices of other materials increase							
Functionality							
The sector's preferences for certain materials							
The preferences of the end-product consumers (in favor of the pulp-based product)							
The preferences of the end-product consumers (against the pulp-based product)							