Long-term outlook for engineered wood products in Europe

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ABSTRACT

Several emerging factors along with the lack of research increase the need and motivation for future oriented market research of engineered wood products (EWP) in Europe. For example, the need for CO_2 emission mitigation in the construction sector, political willingness to promote wood construction, the pressure to develop new innovative wood products in Western countries due to increasing competition from emerging economies in wood products markets, and new technological and construction business concept innovations are changing EWP markets and their prospects in many ways. Information about EWP future prospects is topical and important for decision-makers, forest industry and construction sector.

The main objectives of the study are to introduce and review the current state of EWP markets, and to provide a long-term outlook for EWP markets in Europe. This is accomplished by qualitative methods; i.e. using literature review and PESTE analysis to assess the factors that affect the EWP market development in the future. The literature review consists of research studies as well as industry, consulting, and expert analyses. The background data are gathered from official statistical databases and also from more informal sources. Taken into consideration the relatively short history and exceptional development of EWP markets, and the lack of robust data, qualitative methods are more valid for the given research problem.

EWP markets in Europe have increased rapidly in the past decade in spite of the economic downturn. In the light of the results, positive prospects also for the future of the European EWP can be justified. The study indicates that the most important factor which could lead to the growing usage of EWP in the future construction seems to be their improved cost competitiveness. Moreover, that is expected to improve further as new construction business models become more familiar in the construction sector, political willingness to promote institutional changes, such as revising wood-framed multi-storey building standards, and EWP innovation work continues. On the other hand, some factors, such as the lack of education and skills, may also hinder the development.

EWP are just at the beginning of their life cycle. The first building projects have to succeed in achieving the confidence of customers and the key actors in the construction sector in order to expand the usage of EWP. EWP have great possibilities to succeed, but the rate and nature of the EWP market development and adapting the new construction practices in different parts of Europe need to be studied further.

Keywords: Engineered wood products, outlook, wooden multi-storey building, PESTE-analysis, cost competitiveness.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Background and motivation

Several global changes have led the global and European forest sector to face multidimensional structural changes. For example, globalization and the increasing role of emerging economies like China are increasingly moving the importance of global forest products markets from the West to the East, and also from the North to the South, due to lower manufacturing costs, and/or more favourable natural conditions for fast growing wood (Hetemäki et al. 2011). At the same time, the decrease in communication paper consumption in many OECD countries is affecting the forest sector in an unparalleled way (Hetemäki et al. 2013). When the production and consumption of traditional pulp and paper are shifting to the low cost emerging economies, the old industrial countries need to re-innovate their businesses and increasingly focus on high value-added forest products and services.

Also the climate change is affecting strongly the forest sector. Mobilizing actions for the climate change mitigation increase the need for international climate and energy policies. These both encourage increasing the usage of renewable natural resources, which offers significant possibilities to the forest sector. This has already led for example to large investments and prospects for forest bioenergy and political willingness to increase new wood construction. The global changes offer both challenges and opportunities to the forest sector where old traditional manufacturing processes are disappearing and new businesses have space to capture the field (Hetemäki et al. 2011). The new businesses can be something very different from what has usually been considered as traditional forest industry. For example, UPM forest industry company has made a strategic choice to develop new innovative products as biocomposite products, such as biofuel, in addition to the traditional businesses (UPM 2013).

The many global changes mentioned above and the structural changes in the forest sector have drawn manufacturers to develop more value-added wood products. A very interesting product group is engineered wood products (EWP) which are mainly used for construction, e.g. in multi-storey buildings. According to one definition of EWP, they are made by gluing wood, veneers, panels, strands or fibres together to form pillars, elements or modules that can be used in building family houses, multi-storey buildings or other constructs, such as bridges (Forestry Innovation Investment 2014). In this thesis, we use EWP concept especially to refer to relatively new structural load-bearing products, such as cross laminated timber (CLT), gluelam and finger-jointed structural timber.

It could be thought that, as well as for sawnwood, the short-term market development of EWP will depend mainly on cyclical changes in construction activity which is still stagnating due to the global financial crisis (Jonsson 2009, Alderman & Shelburne 2012). However, in contrast to the weak short-term prospects, in many reviews (e.g. UNECE & FAO 2011) the demand for EWP is expected to be greater in the long term. Furthermore, the increase in EWP markets has been impressive during recent years in spite of the economic downturn. This is mainly the result of improved cost competitiveness of wood construction solutions by new innovations such as modular elements. The modules are prefabricated and design-build systems based on EWP. The EWP can be competitive in answering the demand for packaged assemblies by mass timber solutions due to quicker assembly and fewer tasks required to be performed on site compared to some of the competing materials such as concrete (FPAC & FPInnovations 2013). These EWP properties may also be significant for renovation construction which seems to be more and more essential in the future of the construction sector.

One recent and rising demand driver for EWP is related to multi-storey buildings. Although studies and outlook reports on timber frame multi-storey buildings have been published (e.g. John et al. 2008, Jonsson 2009, Mahapatra & Gustavsson 2009b), especially the outlook for the overall markets of EWP and their significance in construction have received less attention. This appears to be, at least partly, in consequence of the fact that EWP are of recent origin, and the number of products is large and diverse, which makes it a challenge to obtain robust and consistent statistics on the products. Nevertheless, the subject is particularly important as there are a number of institutional, political, economic and technological factors that appear to strengthen the prospects for EWP. For example, the changes in the fire regulations allowing multi-storey wooden buildings, the heightened concerns of CO_2 impacts of construction materials, new innovations in EWP manufacturing systems and the consumers' image of wooden materials. These all appear to improve the competitiveness of EWP, and therefore, to increase the expectations of increasing demand for them.

Unlike the communication paper products, there is no indication of stagnation or decline of wood products. On the contrary, as the global construction continues to strengthen, the prospects for wood products (including EWP) seem favourable. The production of wood products has long traditions, but due to innovative EWP solutions their usage in construction could be significantly increased. EWP have shown notable potential as a substitute or complement for concrete and steel even in multi-storey buildings. Consequently, information and outlook for the future prospects of the EWP are certainly of importance for the forest products industry, the construction sector and the decision makers.

Given the many ongoing changes in the forest sector and in the factors impacting on EWP markets, the future prospects of EWP have not received enough attention in research. Earlier studies have focused mainly on general prospects for timber frame multi-storey buildings (e.g. Jonsson 2009, Mahapatra & Gustavsson 2009a&b), and especially on the potential of wood construction for climate change mitigation (e.g. John et al. 2008, Eriksson et al. 2012). Pahkasalo et al. (2012, 2013) are examples of the rare reviews of EWP markets, but have mainly focused on the past development and market situation of specific EWP, and not on the long-term structural changes. These reviews describe market development, production, consumption and trade of EWP. Clark et al. (2012, 2013) list some benefits and preconditions for increasing markets for one novel EWP product - cross laminated timber (CLT). However, a systematic analysis of long-term future prospects of EWP remains scarce.

1.2 Objectives

The aim of this study is to contribute to the scarce literature by providing a systematic analysis of the present market situation of EWP, and evaluating the long-term future prospects and the factors affecting them. The study is particularly focused on a single wood construction product or group, EWP, and on the outlook for European markets (mainly EU-28). The main objectives are to analyze; how the institutional changes, such as fire-regulations, climate policies (CO_2), energy efficiency requirements, building health issues, etc., are going to affect the long-term prospects of EWP in Europe. Furthermore, the aim is to study how the potentially changing role of wood in construction, such as in multi-storey buildings, will affect the European demand for EWP in the coming decades?

For these purposes it is necessary to explore the current and future EWP market situation in Europe and globally, and the changes in the construction sector more generally. The literature review and current knowledge of recognized drivers and barriers affecting EWP development provide the basis for a long-term analysis. Finally, due to the fact that EWP are of such a new origin, and because there is not yet large awareness or experience of using them, particularly in wooden multi-storey buildings, there is a need to explore and assess in more detail what the key end applications of EWP in Europe are, and what their potential for substituting or complementing other existing construction materials is?

2 ENGINEERED WOOD PRODUCTS MARKETS

2.1 What are engineered wood products?

According to Forestry Innovation Investment (2014) EWP are value-added wood products that are made by bonding lumber, veneers, strands or fibres together, usually with glue. This manufacturing process generates high performance dimensionally stable products for different size building projects. Large structural EWP solutions such as pillars, elements or modules can be used in building family houses, multi-storey buildings or other constructs, such as bridges. EWP started to develop already since the Second World War when they were mainly used for surfacing. However, later in the 1980s they were also started to be used for diverse purposes especially in North America. EWP were developed also for structural elements, due to the demand for lightweight, strong and large diameter joints (American Wood Council 2013). The innovations made it possible that even smaller-scale wood could be used in load bearing joints, and that much larger structures could be attained than before. The focus in this study is particularly on these strong structural EWP.

These structural elements and modules made of EWP are today particularly interesting in Europe, where construction markets are dominated by concrete and steel especially in multi-storey buildings. There are also significant quantities of wood frame single- and two-family houses built in Europe, albeit regional variation is notable. Traditionally these wooden buildings were made of sawn timber on site by carpenters, whereas today EWP provide lightweight prefabricated and standardized elements which are mainly built in factories and only assembled in building sites. Prefabrication can be brought such far that almost ready rooms or parts of apartments can be manufactured already in factories. The prefabricated modules have wood frames and the content is finished up to surfaces, electrical installations and HPAC (heating, plumbing and air-conditioning) techniques. Manufacturing processes are fast, standardized, and of high quality in factories (Bergström 2004). It is also remarkable that traditional concrete multi-story buildings are assembled from start to finish on site, whereas with EWP based systems only module assemblies are completed on building site (Figure 1). Hence, time spent in building site can be only half of the earlier amount in multi-storey construction (Lehmann 2012). All these advantages generate cost savings and improve competitiveness (Mahapatra & Gustavsson 2009a). Consequently, prefabrication is expected to be in an essential role in future construction (FPAC & FPInnovations 2013). The best advantages of EWP and prefabrication are gained particularly in multi-storey construction. Due to EWP innovations, wood frame multi-storey construction may have become competitive for the first time compared to concrete and steel framing.

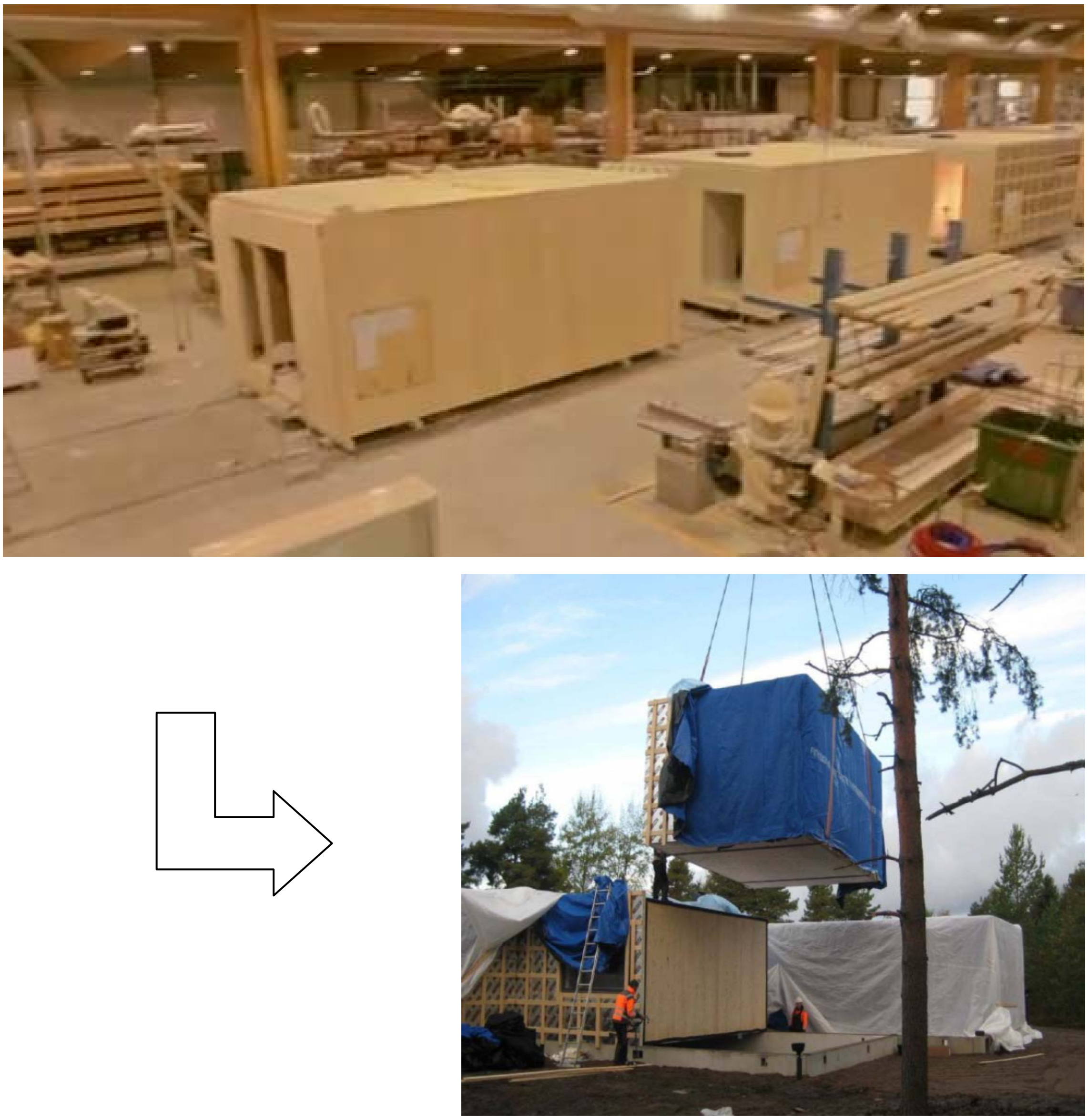

Figure 1. Prefabricated CLT-modules are fast to build on site (Pictures: Woodsolutions 2014 and Puumerkki 2014, Plan of action: Stora Enso).

The most consumed EWP in European markets is gluelam. It is manufactured by gluing individual pieces of lumber to reach large dimension beams (Figure 2.). Manufacturing small-scale lumber can be based on raw material from forest thinnings, which also helps to improve the cost effectiveness of the end product. The gluing method enables achieving strong and long load-bearing structural beams with benefits of wood, such as the light weight. In fact, gluelam joints have better strength in relation to weight than steel, which makes it an excellent product in building projects with large spans, like bridges. Gluelam assorts also very well for framing material for example in residential buildings, and provides great opportunities to architects due to its great appearance and easy modelling (APA 2008).

Figure 2. Gluelam usage in load-bearing structures (Timberfreak 2013).

Another significant EWP in European markets is the finger-jointed structural timber which is simply produced by gluing coniferous solid wood lengthwise with finger-joints. The finger-joints improve the straightness and the strength of lumber, and naturally enable to use larger dimensions. Finger-jointed structural timber is used in load-bearing structures, such as girders and posts, especially in places where the appearance is of great importance (TimberFinland 2013). Due to its load-bearing capability and especially a bit lower price, it can be a substitute for gluelam (Pahkasalo et al. 2012).

In addition, an especially interesting and relatively new EWP is cross laminated timber (CLT). In this study we focus on this product in more detail, due to the high expectations for its potential in wooden multi-storey construction. Technically, CLT is made of several layers of lumber boards that have been glued together crosswise (typically at 90 degrees), usually on their wide faces (Figure 3). The number of layers varies, but the minimum is three layers. The thickness of individual lumber pieces varies between 16 mm and 51 mm and the width between 60 mm and 240 mm. The final size of the product depends on the manufacturer and application. The largest CLT panels could be even 18 m long with 3 m width and half metre thickness. In practise transportation regulations limit the size of CLT panels (CLT Handbook 2013). CLT was introduced to the markets in the early 1990s in Germany and Austria. However, the production increased significantly only in the early 2000s. CLT is mainly used as a substitute for concrete, masonry or steel in mid-rise multi-storey buildings (CLT Handbook 2013). However, CLT can also be used as a complement with other construction materials. For example, CLT framed modules could also be built using concrete or gypsum for wet rooms, or to improve sound insulation. Furthermore, recent EWP module-based multi-storey buildings have basements made of concrete.

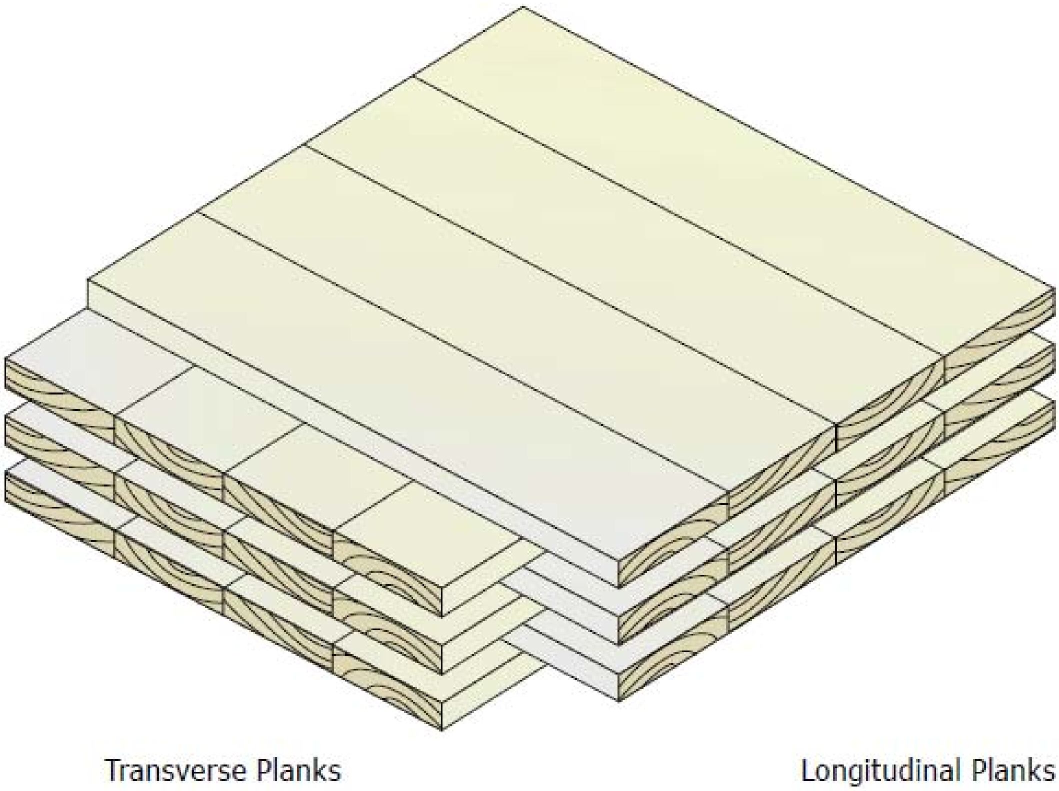

Figure 3. CLT panel gets its strength properties from crosswise glued layers (CLT Handbook 2013).

2.2 EWP markets in Europe

The markets of all three mentioned EWP have increased notably in Europe in the past decade. Currently the most of European EWP production is also consumed within Europe. Consumption of gluelam has almost doubled during the past decade, and was almost three million cubic meters in Europe in 2012 (globally about 5 mil m^3) (Figure 4) (Pahkasalo et al. 2013). The majority of European gluelam is produced in Germany, Austria and Finland. Most of the gluelam products are sold in regional markets with the exception of Japan, to where for example Finland exports about 70 % (214 000 m^3) of its total production (302 000 m^3 in 2012) (Pahkasalo et al. 2013). Italy has grown to be one of the most significant importing countries during the 2000s, and its consumption of gluelam was over million cubic metres in the record year of 2007. However, in the case of Italy, the growth has stopped and the imports have fallen due to the economic downturn in recent years. Nevertheless, the producers expect increasing export quantities for example to France and Japan. (Pahkasalo et al. 2013).

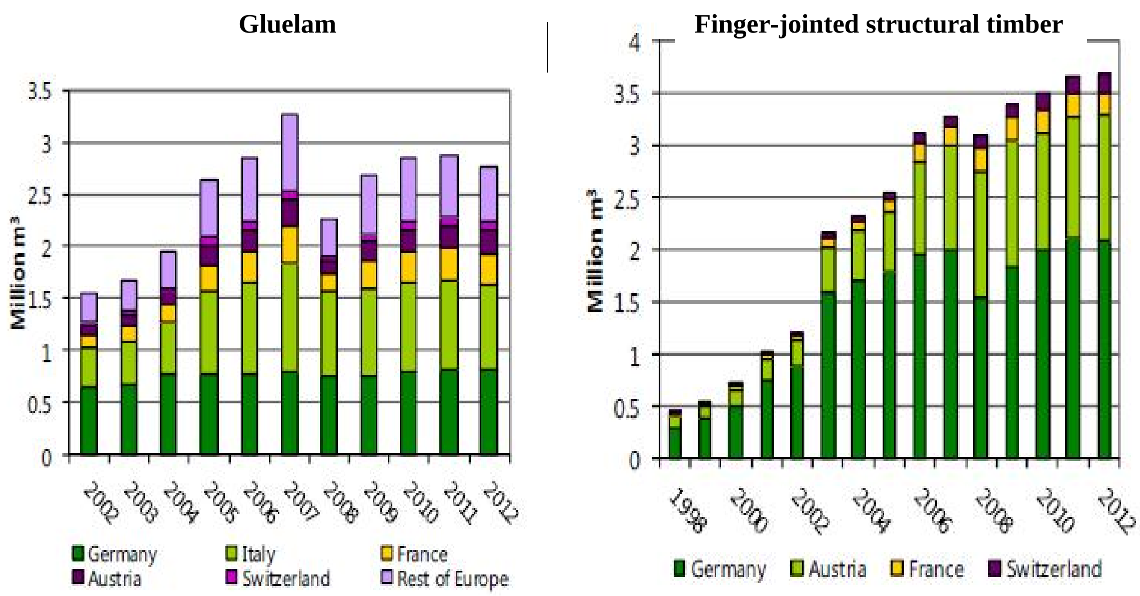

Figure 4. Consumption of gluelam and finger-jointed structural timber products in Europe in 1998–2012 (Figures adapted from Pahkasalo et al. 2013).

The demand for finger-jointed structural timber has also grown remarkably and competes on the same markets as gluelam and traditional sawnwood. The consumption has grown annually about 17 % since 1990s, being currently a bit over 3.5 M m^3 per year in 2012. The main markets are in Central Europe (Figure 4) (Pahkasalo et al. 2013). However, the growth trend stagnated in 2012 due to a prolonged economical downturn and high competition. Still, there are prospects for growth of these markets as well, and many sawmills have already invested in an additional finger-joint capacity in the recent years. Finger-jointed structural timber is notably cheaper than gluelam. The price in 2011 was around 290 €/m^3, when gluelam cost around 403 €/m^3 (Pahkasalo et al. 2012).

Cross-laminated timber is a leading innovation in the group of EWP and has faced high market demand in the construction sector. Despite the economic downturn, the production of CLT has increased rapidly in the last few years (20-30 % per year in Middle Europe since 2008), being currently about 450,000 m^3 per year in Europe (Figure 5). The production is concentrated in Central Europe, especially in Austria, which is the largest producer country with 70 % market share (Timber Committee 2012, Pahkasalo et al. 2012). Most of the CLT products are sold on the domestic markets, although significant quantities are also exported. For example, about 20 % of the total European production is consumed in France and the UK. But, also customers far away, like in Canada and Australia, have shown interest in CLT (Pahkasalo et al. 2012).

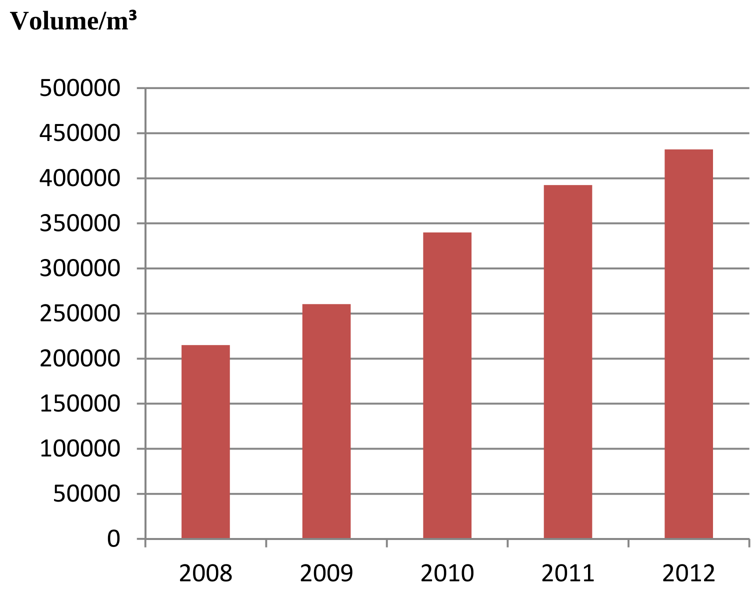

Figure 5. CLT production has increased rapidly in Central Europe (Austria, Germany, Switzerland, the Czech Republic and Italy) 2008–2012, despite the economic downturn (Helamo 2011, Holzkurier 2012, Timber-online 2013).

In 2012, several manufacturers competed for the position of the largest producer (Table 1), but after recent investments Stora Enso has taken the lead. It has two factories in Austria whose production capacity is total of 120 000 m^3. That is approximately equivalent to the amount of CLT needed in two hundred multi-storey buildings (Puu & Tekniikka -magazine 2012). Investments for CLT capacity seem to continue in Europe. For example, CLT manufacturing was started for the first time in France in 2013 where Monnet Seve commissioned a new factory with about 20 000 m^3 capacity per year (Timber-online 2013). CLT manufacturing will begin also in Finland in 2014 where Cross Lam Kuhmo Ltd is erecting a factory with 30 000 m^3 annual capacity (Metsälehti 2014).

Besides large manufacturers, there are also a large number of small CLT manufacturers (“the rest” in Table 1) who have focused mainly on detached houses. This is because the customers in Austria prefer the use of massive wood also in single-family houses. On the other hand, large multi-storey building projects take many years to develop, they include many risks and need large capital investments, which all make it difficult or even impossible for small- and medium-scale (SMS) companies to manage on (Mikkola 2013).

Table 1. The largest CLT manufacturers and total production (cubic metres /m^3) in Europe 2008–2012 (Helamo 2011, Holzkurier 2012, Timber-online 2013).

Manufacturer	**2008**	**2009**	**2010**	**2011**	**2012**
Bilderholtz	30000	45000	-	70000	80000
KHL	52000	58000	-	83000	80000
Mayr-Melnhof	20000	30000	-	48000	45000
Stora Enso	20000	25000	-	60000	75000
The rest	93000	102500	-	131500	152000
Total	**215000**	**260500**	**340000**	**392500**	**432000**

European EWP are consumed mainly in domestic markets. Currently only gluelam is exported in notable volumes from Europe. EWP are manufactured also in North America, but the market differs from Europe. The most important EWP in North America are wooden I-joints and laminated veneer lumber (LVL), whereas the market volume of gluelam is only one tenth compared to Europe. The EWP markets have also similarities between the continents. For example, manufacturing of CLT has already begun in North America, and on the other hand, LVL is manufactured also in Europe. LVL can become a significant competitor to gluelam, but currently, it is produced in much lower quantities and mainly in Northern Europe (Pahkasalo et al. 2012, Pahkasalo et al.2013).

2.3 European construction markets and customs - opportunity or challenge for EWP?

Traditionally the demand for forest products follows the construction activity (Alderman & Shelburne 2012). However, it is interesting that despite the historically low construction rates since the economic downturn after 2007, the consumption of EWP has not dropped dramatically. In spite of the European construction activity having dropped to less than a half of the record year 2006 (2.38 million homes) (Alderman & Shelburne 2012) (Figure 6), the impacts on the EWP market have been quite minor. The previous figures indicate that actually the markets of finger-jointed structural sawnwood and CLT have even increased during the period. The possible growth of construction activity in the future would surely affect positively also the demand for EWP, but more important is to notice that there seems to be also other more essential structural factors in the background.

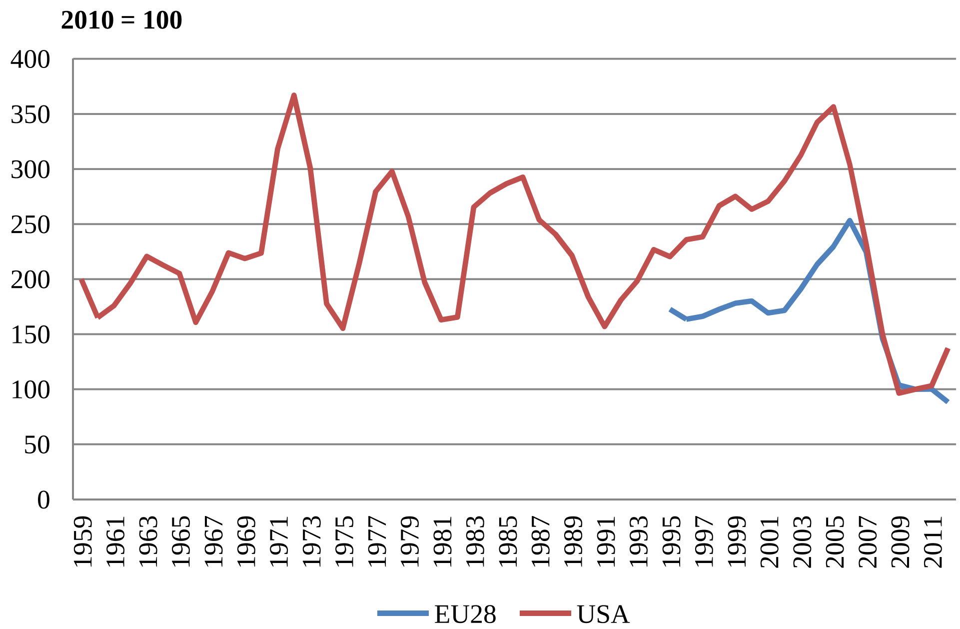

Figure 6. Building permits in the U.S. and Europe in 1959–2012 (United States Census Bureau 2013, Eurostat 2014).

Hurmekoski et al. (2014) found that in several European countries construction activity has not been the only explanatory factor for sawnwood consumption (wood construction). The statistics of construction activity and building material consumption provide interesting findings for example in Finland. The market share of sawnwood increased rapidly during the 1990s, when construction activity plunged, but sawnwood consumption, instead, remained relatively stable (Figure 7). The reasons for rapidly increased sawnwood consumption have been showed a few. For example the increase of single-family housing, public actions for wood favouring and research programmes may have promoted the wood usage (Kimmo 2006, Hänninen et. al 2007).

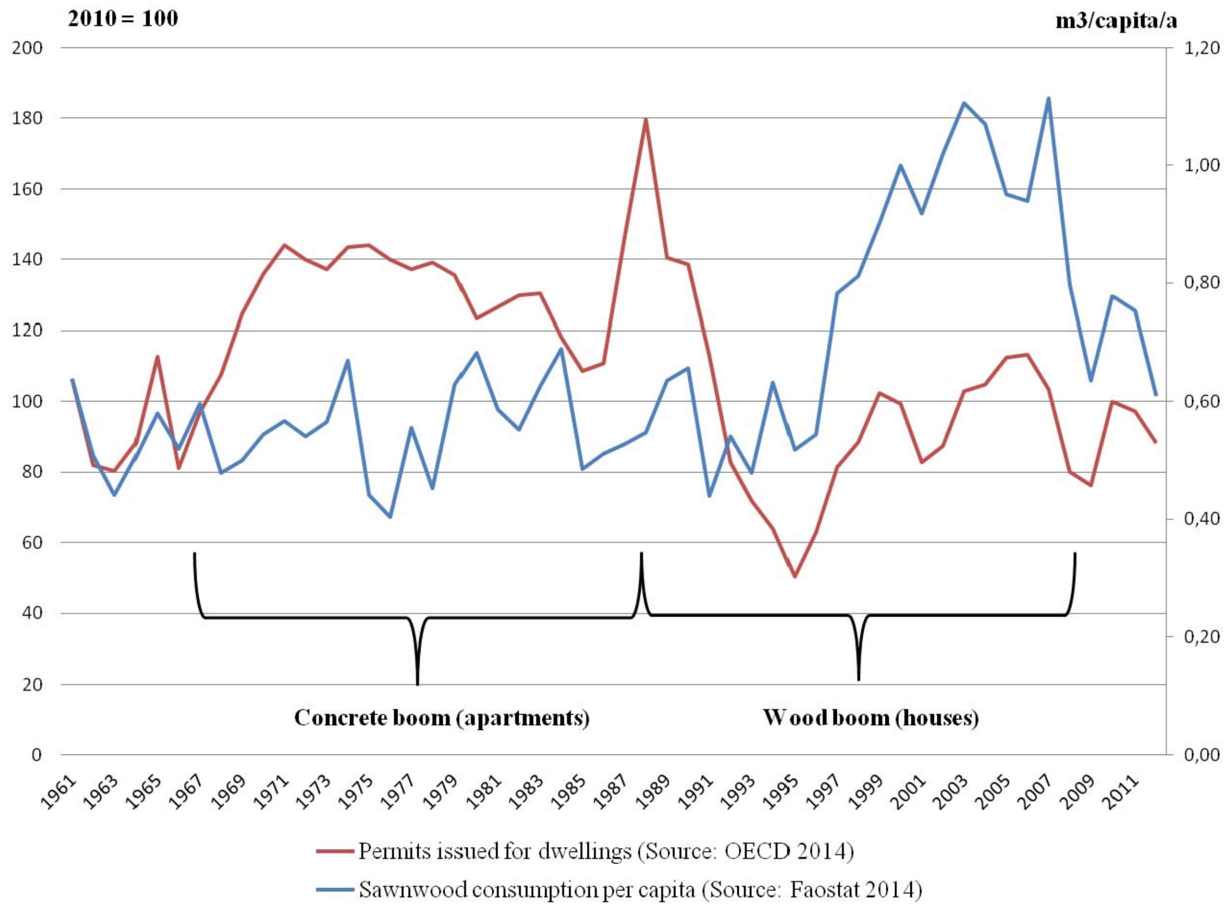

Figure 7. The development of construction activity and sawnwood per capita consumption in Finland 1961–2012 (Figure modified from Hurmekoski et. al 2014).

There are several important issues affecting the long term demand for relatively new EWP, such as country specific construction customs and recent innovations in prefabrication. Considering the conservativeness of the construction sector, it is justifiable to assume that countries that have traditions in wood construction may also be faster to adopt new customs, such as multi-storey buildings, in wood construction (Mahapatra & Gustavsson 2009b, Hurmekoski et al. 2014). The construction methods and practices, especially the share of wood frame buildings of all dwellings, vary a lot in different parts of Europe. Despite the small detached houses not being the main targets for EWP, the country and region specific volumes of wooden single- and two-family houses characterize the traditional customs of different countries in wood construction (Table 2). The Nordic countries have long traditions in wood construction and even 80-85 % of single-family houses are made of wood. The share of wood frame buildings is very different in Western and Middle Europe, with the surprising exception of Scotland (60 %) (Sathre & Gustavsson 2009).

Table 2. Share of wood construction in one and two family house construction in selected countries or regions (Sathre & Gustavsson 2009).

Country	Share of wood construction
USA	90-94%
Canada	76-85%
Nordic countries	80-85%
Scotland	60%
UK	20%
Germany	10%
The Netherlands	6-7%
France	4%

Data on the total share of wood frame buildings (multi-storey and public buildings included) in European countries is not comprehensively available. However, the above data may offer a rough picture of mutual proportion between the countries and regions. In Scandinavia, almost half of all dwellings are made of wood, but in Western and Eastern Europe clearly less than 10 % of all dwellings have a wood frame (Mahapatra & Gustavsson 2009b). However, also examples of recent and rapid changes in traditional construction customs exist. For example, in the UK the market share of wood frame buildings has risen from 8% in 1998 to 25% in 2008, at least partly due to political promotion (Mahapatra & Gustavsson 2009b).

Even though in Scandinavia the total level of wood usage in construction is about the same across different countries, in multi-storey buildings the share of timber frames varies a lot. For example, in Sweden 15 % of all multi-storey buildings were wood-framed in 2008 (Mahapatra & Gustavsson 2009b), but in Finland only about 1 % (Esala et al. 2012). Nevertheless, this situation could change relatively fast. The Finnish Government has defined a goal of having 10% of all new multi-storey buildings wood-framed by 2020 (Metsäalan strateginen ohjelma 2012). Based on the planned construction projects this seems possible (Laukkanen 2013a).

Previous tables and numbers are only showing the aggregate and approximate levels of wood usage and construction. As in Hurmekoski et al. (2014), the outlook of wood construction can be evaluated also by country specific changes in sawnwood consumption per capita. According to Hetemäki & Hänninen (2013), the use of sawnwood has been in the last decade about four times higher in Finland, Sweden and Estonia (also separately in each country) than in Europe on average (Figure 8). The present level of these countries was preceded by a significant growth period which started in the mid-1990s. In other European countries the average wood usage has stayed constant all the time.

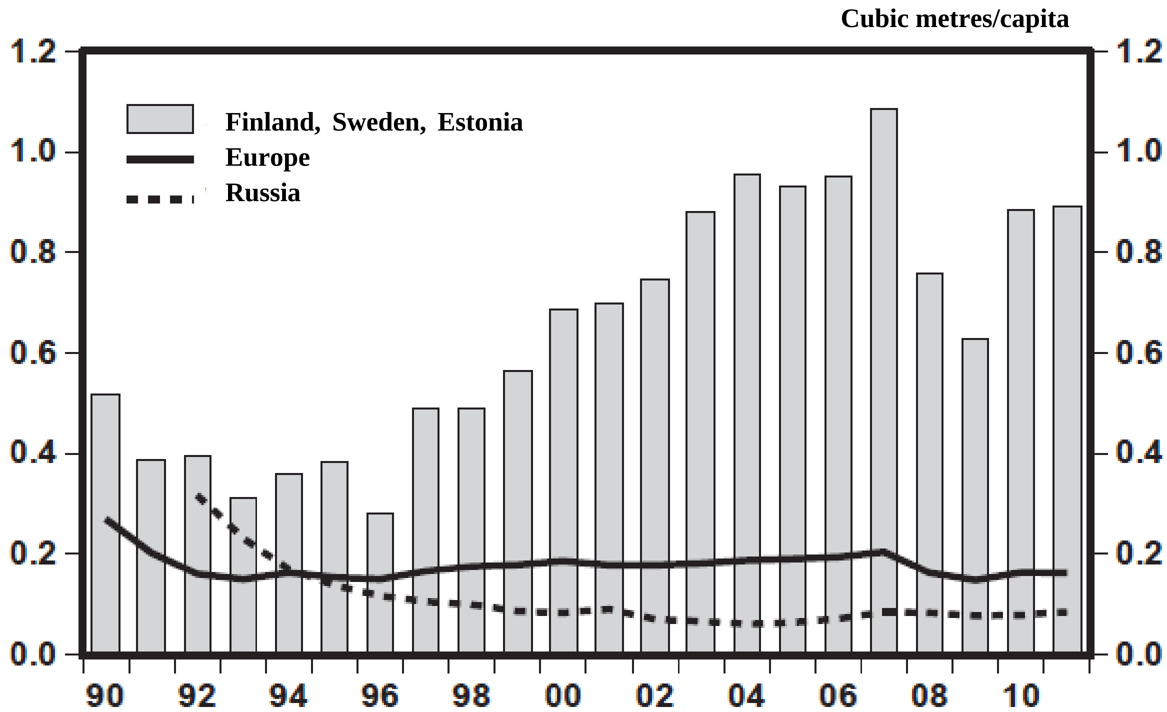

Figure 8. Consumption of sawnwood per capita between 1990–2011 (Figure adapted from Hetemäki & Hänninen 2013).

Hurmekoski et al. (2014) analyze the question whether in the future also other European countries could experience an increase in the sawnwood consumption per capita similar to Estonia, Finland and Sweden, and if so, why? Indeed, in the light of the experience of these countries, it is notable that changes in sawnwood consumption can take place rather fast. If similar changes would happen in the other parts of Europe, the impacts on sawnwood consumption will be significant. According to Hetemäki & Hänninen (2013), the European average sawnwood consumption would double from 105 million cubic metres to 212 million cubic metres in 2020 if the sawnwood per capita consumption in Europe would increase even half of the level currently in Finland, Sweden and Estonia, and the population would grow according to recent population projections made by the United Nations. However, it is important to notice that the countries which have faced rapidly increased sawnwood per capita consumption are relatively small and have large forest resources (Hurmekoski et. al 2014).

The discussion above suggests that there would be potential for a significant increase in sawnwood and EWP markets in Europe. Moreover, the future for wood products has been seen bright in many reviews whose expectations for new innovative products and the market pull of green economy are high in Europe (FAO 2009, UNECE/FAO 2011, Timber committee 2012). For example, EWP is expected to have large potential to benefit from a general trend for more sustainable construction, as energy regulations and environmental consciousness could favour wood. On the other hand, the construction customs varies a lot between different countries and regions in Europe, what might appear as a challenging issue for market development of EWP. However, considering the current favourable moment (e.g. political pressure to decrease the emissions of construction sector) for EWP and their possible ability to provide new value and methods to the construction sector, the market development of EWP would be worthwhile to be reflected considering the theory of diffusion of innovation (Rogers 1983). According the theory, the cumulative adoption of new innovations in a specific area shapes an S-curve, because customers behave in a particular way (Figure 9). On the other hand, when innovation adoption is reviewed as a quantity in relation to the moment, it forms a bell-shaped frequency curve (Figure 9). This is because the adoption of innovations always involves risks which customers take differently. From the perspective of the market success, the period of accelerating growth at the beginning of innovation development is the most critical phase. If “early adopters” consider the innovation worthwhile, and the “critical mass” of customers is achieved, the innovation is able to spread in larger usage in society (Rogers 1983). In other words, in order for an innovation to succeed extensively, a certain number of first customers need to get convinced of its usefulness. Moore (1991) emphasizes this critical period, and calls it with the term “chasm”.

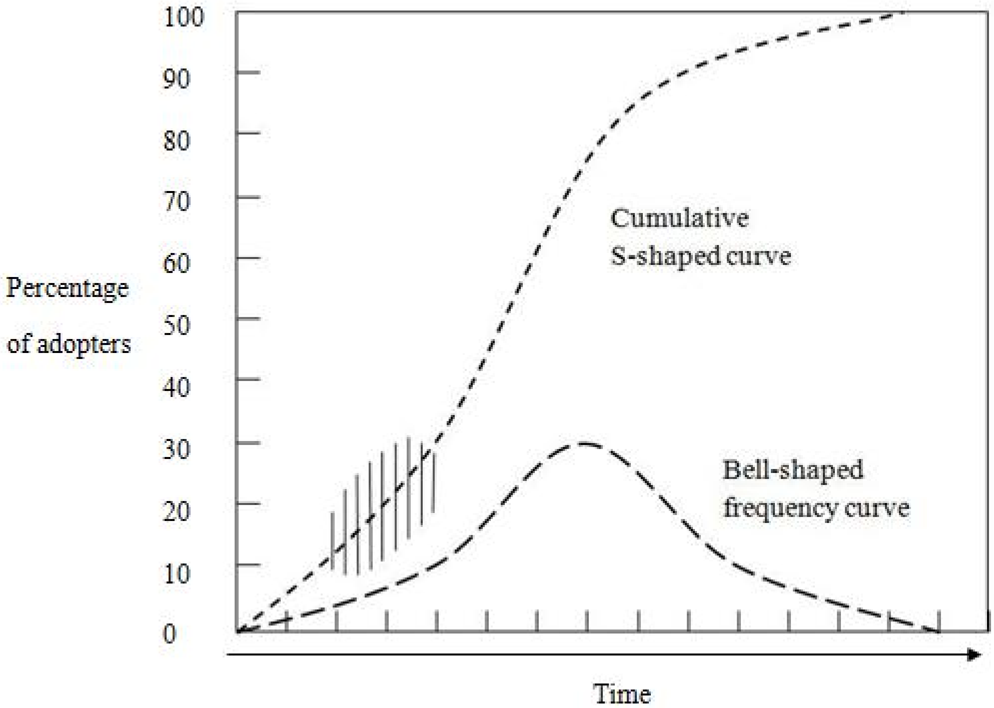

Figure 9. The bell-shaped frequency curve and the s-shaped cumulative curve for an adopter distribution. The critical period is highlighted (Figure modified from Rogers 1983).

An interesting question is whether these innovative EWP and their construction solutions could have potential to establish themselves in the European construction markets, and if so, how would it happen? And, would the development vary in different countries and regions? In this context it is also interesting to reflect, what might be the current phase of EWP markets in the Rogers' theory, and what are the prerequisites to surpass the chasm, and to develop along the theory? Indeed, all these previous questions are essential to the long term outlook for EWP. Would the European construction markets provide an opportunity for positive development of EWP and what kind of challenges it may bring on?

3 METHODOLOGY

3.1 Background of methodology choice for EWP outlook study

Forest product outlook studies (eg. Mantau et al. 2010, UNECE/FAO 2011) have often applied the scenario approach, based on simplified econometric equations with the price and GDP as the determining factors of demand. This type of an approach, however, is currently not helpful for EWP market developments, because of the short history of the products and the consequent lack of data that could be used to estimate the parameters of an econometric equation. Furthermore, the EWP business and markets are still very much in the early development phase, during which major changes are possible in the market structures. Given this, it could be difficult to estimate a robust and stable econometric equation that could describe the markets. Moreover, as indicated in previous chapter the EWP market has been growing very rapidly despite the recession in construction markets, and therefore the usual demand drivers, such as GDP and construction activity are unlikely to capture fully the market development. Especially for the long-term outlook of EWP it is more important to focus on structural factors and questions, and not only on construction activity or other estimations based on historical trends.

In order to analyze and assess the implications of possible structural changes for EWP markets, other approaches are needed than what has been conventionally used. Useful methods will require knowledge of the characteristics of EWP markets and understanding what the major drivers of the market developments are now and will be in the future. The methodology of this study to analyze and provide outlook for EWP markets is based on the following steps. First, literature review on EWP will be carried out in order to establish the current state-of-art in EWP, i.e. synthesis, what we know about EWP and their markets. This is necessary before we can move to make assessments about the possible future outlook for EWP.

Next, due to the problems related to quantitative approaches on EWP markets (c.f. discussion above) and the nature of the research questions, the future outlook will be approached through qualitative methods. For this purpose, the possible major drivers of EWP market development and increase of wood construction will be first identified. After the major drivers or impacting factors will be charted, the possible direction and magnitude of the impacts will be evaluated through detailed analysis of each factor. This analysis is, in turn, based on literature review.

Basically, this means a summation of the research and expert views and how they have seen the factors affecting EWP markets.

3.2 PESTE analysis and outlook for EWP markets

For the purpose to reach overall picture of EWP and the business environment, the PESTE (Political, Economic, Social, Technological and Environmental) analysis is used in this study (Johnson et al. 2008). CIPD (2014) describes it as a useful method to illustrate the present business environment and to identify future trends. It is often used for example in organizations as a tool for strategic or marketing planning. Furthermore, it is also a useful method for helping research on issues where quantitative methods cannot not be used, and for issues that are still very much on the early development phase and for which major drivers (determinants) have not necessarily yet been fully identified. On the other hand it is a worthwhile tool for scenario planning, which could be the next step for to forecast EWP future development. Consequently, a study with PESTE analysis serves possible following researches as well. Even though PESTE analysis appears quite rarely in the literature of research methodology, the technique is often exploited especially in future oriented analyses (e.g. Meristö et al. 2000, Näyhä 2012).

The first step in the PESTE analysis is information gathering from appropriate sources, after which it is analyzed for to find the key driving forces (factors) for the future development. The factors are sorted in five categories according to the name of the method: political, economic, social, technological and environmental issues. That ensures broad perspective and helps to analyze factors comprehensively. As a note, the method could be named also as PESTEL (Legal factors included), STEEP or SLEPT, which differs only from combination of letters and a bit from category emphases. Advantages of PESTE analysis are its simplicity and that it facilitates understanding of the phenomena studied in the wider context. On the other hand, there is a risk for over-simplifying if for example information is gathered too narrowly and some important factors are left out. Indeed, the best result is achieved having several researchers and experts offering different expertise and perspectives (CIPD 2014).

3.3 Data gathering and analysis

EWP are a challenging subject to investigate due to inadequate compilation of statistics. European Community uses industry standard classification system named NACE (European Commission 2013). It classifies forest products into 1: manufacturing of paper products and 2: manufacturing of wood products. The latter is further divided to 2.1: sawmilling and planning of wood and 2.2: manufacture of products of wood, cork, straw and plaiting materials. EWP belong to group 2.2, but large size of the group becomes problematic. Naturally the group is further divided into several subgroups, but it is impossible to separate EWP as its own group. This is mainly due to EWP not being particularly homogenous group, and also because many products are of recent origin.

Publications and data for PESTE were searched from both scientific databases (e.g. Scopus) and more informal sources (e.g. Google Scholar).). Since most of the EWP products are of recent origin and the markets still in the early stage of developing, the information also tends to be quite scattered, and it is difficult to find synthesis and general assessment reports that would directly support the current study. The statistics presented here are mainly gathered from trade journals, industry associations, consulting studies, and informal sources, such as interviews. Obviously, these types of sources do not necessarily fulfil the requirements and quality of official data sources, but it is the only possibility to try to analyze and form view about the EWP markets outlook. For example, the widely used forest data sources, such as FAOSTAT or EUROSTAT do not report EWP data; they are included in more aggregate categories, such as sawnwood.

Earlier literature presents and analyzes some factors directly or indirectly affecting EWP (e.g. FPAC & FPInnovations 2013). As the literature with specific attention to EWP appears to be relatively rare, also the literature related to wood or wooden multi-storey construction is of high interest, since they appear to be very near-related topics. Information searching was expanded also for example on issues such as environmental policies, standardization customs, etc., which were found to be important for future EWP development. The data were analyzed and the most essential factors were identified and simplified to the PESTE framework.

After the PESTE analysis of the driving forces found from literature and some interviews, these factors were finally sorted and analyzed with the mind mapping tool (future wheel)

(Glenn 2009). This helps to illustrate many linkages between the factors that may otherwise appear as separate occurrences. Organizing the factors helps also to find the most essential development paths and possible trends affecting the markets of EWP. It should be stressed that the presented result of mind mapping is only an example of the interactions and possible development paths, and it is based on the author's own analysis. Due to resource constraints, it was not possible to expand the study, for example to stakeholder workshops, which would have been helpful for deepening the analysis and for experimenting with future wheels and similar participatory foresight approaches.

During the analyzing there is constantly the idea of diffusion of innovations (Rogers 1983) in the background when analyzing the factors. It has not been used as an actual method here, but it is rather a framework where the analysis is reflected. Lastly, in the summary of the results of PESTE analysis the possible diffusion of EWP is shortly evaluated according to Rogers' (1983) form of assessment for innovations' innovativeness. Essential characteristics of innovation are evaluated from five perspectives: relative advantage, compatibility, complexity, trialability and observability.

4 RESULTS

4.1 Results from PESTE framework

The most vital expert assessments of factors possibly affecting the demand for EWP are presented in the PESTE table (Table 3). The Factor -column states the present situation or expected trends. The effect and relative magnitude of the factors are classified in the Impact -column. The factors which are likely to support the development of EWP markets or affect them positively are denoted with plus signs (+). On the contrary, the negative factors which are likely to hinder the EWP development or may appear as a barrier for it are expressed with minus signs (-). Some factors are found to be obvious drivers or barriers, but for which the impact and magnitude stay however uncertain. These unspecified impacts are denoted with a question mark. The more you have signs, the stronger the impact is assumed to be. It should be stressed that the classification of this column is quite speculative, but it is still based on the results of the analysis and on the review of earlier literature or expert interviews. Moreover, the segmentation of the different PESTE factor categories is not always obvious, since the drivers may be overlapping (e.g. environmental policy and environmental factors). However, rather than having very accurately defined categorization of the factors, it is more important to have the most important factors included under one of the categories. The factors stated in the PESTE framework are evaluated in detail below.

Table 3. PESTE analysis of factors that may affect the growth prospects of EWP in Europe.

Factor (trend)	Impact on EWP prospects*	Source (for example)
POLITICAL		
Environmental targets (CO_2)	++	Jonsson (2009),(2013)
Lack of education and skills	--	Mahapatra & Gustavsson (2009b), Konttila (2013)
Unequal construction regulations	--	Brequlla et al. (2003)
Diverse interpretation of regulations	--	Brequlla et al. (2003), Konttila (2013)
ECONOMIC		
Cost competitiveness	+++	Mahapatra & Gustavsson (2009b), FPAC & FPInnovations (2013)
Growing need for renovation	++	Kristof, K. (2008), Gaston et al. (2010)
SOCIAL		
Demographics		
- ageing	+	Jonsson (2009)
- growing number of households	+	Jonsson (2009)
Wood favouring attitudes of the public	?	Rice et al. (2006)
Health impacts of construction material	?	Rice et al. (2006), Moser (2010)
TECHNOLOGICAL		
Tough firesafety regulations	--	Lehmann (2012)
High energy efficien-cy of wood	+	CEI-Bois (2011)
EWP innovations (e.g. material combi-nations)	?	Fadai et al. (2012), FPAC & FPInnovations (2013)
Fast construction speed	++	Mahapatra & Gustavsson (2009b), Lehmann (2012)
ENVIRONMENTAL		
Environmentally friendly production	+	Eriksson et al. (2012), Ruuska & Häkkinen (2012) Kuittinen et al. (2013)
Advantage in carbon seguestration	+	

* The magnitude of each factor is evaluated between very positive (+++) and very negative (---)

4.2 Political issues

It seems apparent that the wood construction could, to some extent, benefit from the EU's climate policies. For example, according to Jonsson (2013), the climate change mitigation policies supporting construction by renewable materials could increase the global demand for wood construction. Several European countries, such as Austria, Denmark, Finland, France, Germany, Hungary, the Netherlands, Norway, Sweden and the UK, have implemented some type of green public purchasing (GPP) policies, which also tends to support wood construction. GPP requires public authorities to take into consideration the environmental impacts, such as CO_2 impacts, when making purchasing decisions (UNECE/FAO 2006). In practice GPP may be implemented e.g. through Green Building policies, which is a term used to refer to environmentally conscious construction processes (Knowles & Sinha 2013). Buildings cause 39 % of total CO_2 emissions, which makes it the largest single contributor of global CO_2 emissions (Knowles et al. 2011). That is why countries favour, or at least consider, building materials that help to mitigate CO_2 impacts, and wood is often seen to be such a material (Jonsson 2009).

Green Building is implemented by several different rating systems (e.g. LEED) which aim to reduce environmental impacts of building project through its entire life cycle (Knowles & Sinha 2013). However, the rating systems are voluntary, which weakens their effectiveness. Furthermore, various rating systems used around the world differ significantly, which causes problems for global comparison. Nevertheless, environmental consciousness tends to have positive effects on wood construction. For example, pilot multi-storey CLT building projects are favoured also due to their assumed climate friendliness, and carried out with governmental support in several regions (Timber committee 2012).

Concrete, bricks and stone as framing materials have long traditions in Europe. Due to this, it may be difficult for wood to gain a more prominent role in construction. Also, the fire regulations have been one hindrance for promoting multi-storey wooden buildings. Because of large city fires in the past, regulations and measures related to fire protection were introduced in several European countries during the late 19th century. These discouraged or even prohibited the construction of wood frame multi-storey buildings (Mahapatra & Gustavsson 2009b). The lack of wooden multi-storey construction activity has also led to inadequate skills and wood construction professionals (architects, engineers, consultants and contractors). This lack of educated and experienced wood construction professionals is a major problem that slow down or even prevent the construction activity of wooden multi-storey buildings (Konttila 2013). Because of general lack of expertise in wood construction, the actors who have a key role in material selection might have difficulties to adapt to the new knowledge required for wood construction (Mahapatra & Gustavsson 2009b). Thus, the problem is not (only) a question of attitude, but rather that without major earlier experience and standards, there are no ready design solutions for wooden multi-storey buildings. Consequently, designers' work is more difficult and expensive compared to already familiar building material solutions (Laukkanen 2013b). Both Mahapatra & Gustavsson (2009) and FPAC & FPInnovations (2013) underline that in order to wood construction to gain a more prominent role, especially in the wooden multi-storey buildings, the change must happen firstly in the education and secondly on the attitudes of architects, developers and construction firms. However, this may require a long time to occur in a large scale. After all, due to risks and need for large capital for multi-storey buildings, the large construction companies are the key players, and may have the possibilities experimenting with new materials and innovations, such as EWP (Gaston et al. 2010).

Perhaps somewhat surprisingly, Bregulla et al. (2003) argue there are no direct regulatory barriers which would prevent the use of wood and wood-based products in residential construction in European countries. However, they stress that many regulations can possibly act as indirect barriers for wood usage. In practice this may happen for example in the case, where requirements for wood and wood-based solutions are set at such a high level that fair competition between different construction materials is impossible. Usually these regulations concern fire and acoustic performance, especially in multi-storey buildings. In addition, the number of floors in wood frame buildings may be limited. It is neither unusual that regulations, for example considering of fire safety, are interpreted differentially in various locations, which does not promote standardized production and competitiveness of wood products (Brequlla et al. 2003, Konttila 2013). Some actions have recently been taken in some countries to change e.g. fire regulations to allow more equal treatment between different construction materials, but these changes tend to take long time before having a larger impact on the construction markets.

One concrete measure for harmonizing the services and standards related to the construction sector was European Commission's order to implement the Eurocodes in the EU. These codes consist of regulations of load-bearing structures for all framing materials, timber included.

Internationally parallel standards are implemented in order to improve construction safety and to develop common and standardized design solutions. This also helps communication between the key stakeholders and benefits international business. The Eurocode standards were implemented in 2010 in every EU country, but also some other countries outside of the EU have been interested in this standardization system. To put the Eurocodes into practice countries had to formulate national appendixes (NA), so that possible inconsistencies between national and Eurocode standards could be avoided (Joint Research Centre 2013).

In summary, changes in policies related to construction regulations and resource and energy efficiency can impact in many ways on the outlook for EWP market development in Europe. For example, development of institutional regulations and efforts for increasing wood construction education at all levels, are expected to improve the wider utilization of wood and EWP in construction sector in the future. Also, environmental policies and changes in fire regulations may accelerate this development. However, the changes are likely to be gradual, rather than very rapid, due to other affecting factors, such as the long-lasting customs and traditions in construction and the lack of wood construction professionals.

4.3 Economic issues

Economical benefits of a product are naturally in an essential role in competitiveness. According to Knowles et al. (2011), the most important factors for decision of framing material in building projects are regulatory codes and building costs. Firstly, building projects are designed to meet regulatory codes, and secondly, those are performed as inexpensive as possible. Consequently, for example environmental benefits of structural material are taken into account very rarely in practice and at performing level.

Not only raw material and manufacturing costs of a single EWP are significant, but also costs that arise from the whole EWP construction process and further sustenance of a wooden building. For example, compared to concrete, wood frames are faster to build without need for drying periods (Mahapatra & Gustavsson 2009a). With prefabricated wood element systems, like CLT based ones, the time savings can be even more significant (only a half of the traditional method) (Lehmann 2012). Furthermore, the cost benefits are reached in wood construction because of the material’s light weight which decreases, for example, costs of transportation. In fact, the light weight of wood frame makes the prefabrication and transportation possible. That enables fast standardized manufacturing in factures covered against the weather. In addition, less massive foundation and cranes are needed in construction area. In some cases the ground of construction area restricts the weight of building, thus with light wood frame several storeys and large floor space could still be reached (Mahapatra & Gustavsson 2009a). Particularly in the case of life-cycle costs, wood is very competitive in comparison with concrete and steel (FPAC & FPInnovations 2013).

As stated in section 2.3, construction activity itself is not a very appropriate variable for evaluating EWP market development. Instead of factors affecting the construction activity, such as general economic development, a more significant driver for structural and long-run demand for EWP could be the growing need for repair and renovation of the ageing housing stock throughout Europe (Gaston et al. 2010). Especially in narrow cities the light weight and the fast construction speed of prefabricated EWP solutions could be significant competitive advantages in terms of costs (Kristof 2008). Wooden modular systems with the above mentioned advantages also provide possibilities for building additional floors to existing buildings, which may have a significant role in the future (Mikkola 2013).

The climate friendly properties of wood and EWP might be worthwhile also in economical terms. One possible factor could be energy and carbon taxation systems that would provide a competitive advantage to wooden construction materials, due to their positive climate effects (Sathre & Gustavsson 2007). In the future for example the EU Emissions Trading System (EU ETS) might affect positively the competitiveness of wood construction, because rival energy intensive products, such as concrete, may have to carry the costs for the larger emissions. However, the system has not started to work as hoped due to several problems. Besides, for to avoid the carbon leakage, i.e. the carbon intensive products are bought outside of Europe, the carbon taxation system should be adopted internationally. This kind of progress seems improbable because even the Europe-wide system would need further development. Thus practical benefits for wood products seem unlikely in the near future.

EWP and prefabricated modular systems are just making breakthrough to the larger awareness and as worthy alternatives in multi-storey building. Even though the first pilot building projects have been promising in terms of competitiveness, also further improvements are expected. After the building methods of EWP and modular systems become more familiar, the cost savings will be realized at several levels. Designers' work will become less time-consuming, prefabrication process will become more standardized, assembling on site will happen even faster, et cetera. Not even new innovations are, however, impossible. In summary, further improvements are expected for the economical advantages of EWP, which appears to be one of the most promising factors for the future EWP market development. After the “learning period” is over, the final cost level of EWP construction will be revealed, which is also important for confirming customers’ confidence.

4.4 Social issues

The changes in demography must also be taken into consideration when assessing the future construction prospects. The average population growth is expected to be stagnated in Europe, although variation between countries will exist (UN 2013). Moreover, the old-age dependency ratio is expected to increase at least in Western Europe, which may result to decreasing demand for dwellings, because of higher amount of retired people (Jonsson 2009). On the other hand, ageing population may affect the demand of dwellings positively with more special properties needed for dependent or impaired people in housing. It’s also notable that the demand for small households is increasing at least in Western Europe, which would further increase the already growing number of total households (Jonsson 2009). That is for sure positive for all residential construction.

Health issues are getting more attention in housing, which may profit especially wood construction. Wood is generally considered as a healthy and natural material at least in countries where usage of wood as a construction material is generally familiar. For example in some recent cases in Finland wood has been favoured in new public buildings, such as nursery schools, due to cities’ fatigue for mildew problems. According to Rice et al. (2006) there is a widespread consensus among people that wooden environments affect positively people’s emotional states and psychological health. Wooden rooms are often described as “warm”, “comfortable”, “relaxing”, “natural” and “inviting” spaces. Based on the findings the study also pointed that the manufacture of wood products may achieve a potential competitive advantage from these health issues. Also some quantitative studies have been made of health impacts of wood. For example Moser (2010) discovered that in a classroom with massive wooden walls children’s pulse was six beats per minute lower compared to traditional classrooms.

However, construction regulations especially for fire safety may be inconsistent with the willingness to use wood in inner surface. For example, in Finland, Stora Enso produces CLT based modular elements for multi-storey construction, but the wood as itself is not allowed to use as inner surface. Despite massive wood structures' good resistance to fire, the surfaces are ordered at least to be treated with a fire retardant coating. Stora Enso has solved the problem by coating the walls with gypsum boards, thus the apartments look the same as in concrete buildings (Konttila 2013).

Currently, it seems uncertain if customers are ready to pay more for wood buildings, for example due to positive environmental impacts. Neither current regulation systems promote the comparison with framing materials in terms of environment or health. However, for example the upcoming researches on construction materials' health issues may change the significance of social issues, such as attitudes. Moreover, new researches on health issues may also lead to implementations of more developed institutional regulations. Consequently, social issues and factors are reasonable to consider as opportunities for future development of EWP usage.

4.5 Technological issues

One of the highest concerns of wooden multi-storey building is traditionally related to fire safety. This has been a critical barrier for increase of wooden multi-storey construction. A lot of work has been done to get people convinced of the fire safety of wooden multi-storey buildings. Even though wood is a combustible material, studies have pointed that in load-bearing structures, especially with massive timber solutions, wood has better durability against fire than aluminium or even steel (Lehmann 2012). Naturally, fire engineering must take in a high consideration at the beginning of architectural and structural designing to meet the building requirements. However, wood products still suffer from fire regulations which may often impose tougher restrictions on wood than on other materials (Brequlla et al. 2004, Östmann & Källsner 2011).

One especially determining factor in the positive development of EWP has been the innovative wood construction solutions for wide and large constructions, such as multi-storey buildings. These have improved cost competitiveness insomuch that EWP can be considered as a reasonable substitute or complement for concrete, steel and brick in large building projects. Especially CLT itself is able to replace concrete slabs in the frames of multi-storey buildings.

As stated earlier cost competitiveness is reached by prefabrication and, on the other hand, the natural light weight and strength of wood. These properties enable a standardized manufacturing process and a notably faster construction time on site, which provides cost savings.

Also energy efficiency is one of the wood's excellent advantages. Due to the biological structure, it's 15 times more insulating than concrete and 400 times more insulating than steel (CEI-Bois 2011). Wooden low energy single-family buildings are already familiar in several regions, but with EWP and their solutions the energy advantage of wood could be reached in multi-storey buildings as well.

Generally studies and public interaction are focused on comparison between construction materials, but also composites such as wood-concrete systems can be in a notable role in the future. For example FPAC & FPInnovations (2013) predicts an increasing demand for composite materials. The idea of these materials, e.g. wood-based cement bonded structural elements, is to combine all the good advantages of different materials. The final product may be a competitive prefabricated lightweight element with excellent durability, energy-efficiency and fire resistance. For example, nowadays a cement coating is often added into wooden middle floors to improve sound insulation (Figure 10). However, the composite products are yet at the early stage of development thus they have a long road to reach competitiveness, acceptable building regulations and the customers' confidence before wider usage. (Fadai et al. 2012).

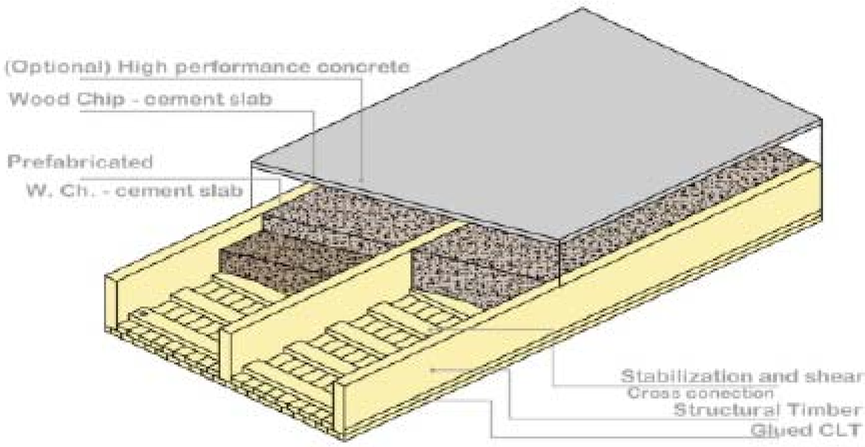

Figure 10. Lightweight wood-concrete slab (Fadai et al. 2012)

At the moment both political willingness and new fireproof solutions (e.g. mass timber) set prospects for a more neutral treatment of building materials and, thus, for better competitiveness for wood frame solutions than earlier. As a summary, the technological innovations for example in modular construction have been very essential in the favourable development of EWP and might continue to so also in the future due to investments in R&D.

4.6 Environmental issues

Sathre & Gustavsson (2009) have summed up the main factors which lead to CO_2 emission reductions by using wood frames instead of concrete or steel frames in buildings: manufacturing of most wood products needs less fossil energy compared to other materials, wood materials store carbon, and the emissions from cement reactions are avoided. Furthermore, the mitigation potential of biofuels such as logging residues produced along with the process replacing the fossil fuels is often emphasized (e.g. Börjesson & Gustavsson 2000, Gustavsson et al. 2006, Gustavsson & Sathre 2006, Sathre 2007). Also some quantitative researches have been made of climate friendly advantages of wood. Eriksson et al. (2012) studied the level of carbon emission reduction which could be reached by increasing the wood construction. Their results showed that if a million apartment flats are built of wood in Europe every year until 2030, it would lead to 0.2–0.5 % annual reduction of total 1990 European greenhouse gas (GHG) emissions. An extreme scenario, where the wood consuming per capita in Europe would be 1 m^3 by 2030, showed more significant effects, but the scenario is not considered realistic.

Ruuska & Häkkinen (2012) found similar results as Eriksson et al. (2012), calculating the carbon reduction potential as a result of increasing wooden multi-storey construction in Finland. The baseline scenario for which the comparisons were made is the current situation in which 2 % of new multi-storey buildings are made of wood and the rest are mainly made of concrete. In other three scenarios the part of wood usage would be 22 %, 52 % or 82 % until 2030. According to the scenarios, the GHG reduction would be quite marginal, accounting for only 0.2–0.5 % of Finland’s total GHG emissions (66 336 thousand tonnes in 2009) However, comparison with total emissions of the country does not necessarily tell the whole truth. On a bit smaller scale the mitigating effects are more impressive, because in the fourth scenario (82 % wood usage) the GHG emissions of new residential multi-storey construction would more than halve the emissions when compared to the baseline. If carbon uptake of wooden buildings is taken into consideration, CO_2 emissions of new residential multi-storey construction would even turn negative, at least in the sense that the buildings do not release the carbon again.

The above presented researches show quite conservative results of wood construction's potential to mitigate the climate change. However, also more optimistic researches exist. For example Kuittinen et al. (2013) found that depending on calculation system the carbon footprint of a four-storey wood frame building is 15–30 % lower compared to an equivalent concrete framed building. This describes well the problem of defining the environmental effects of construction materials and methods. The consensus between construction materials' "greenness" is hard to achieve, due to many differing calculations, methods and results. Furthermore, "green dominance" of wood is not obvious in the future, as a lot of efforts for greenness of competitive construction materials, such as concrete, are also performed (Ali et al. 2011).

Potential of environmental factors to promote EWP usage was already figured previously. It seems apparent that environmental factors barely affect directly the customer's choice between construction materials unless they lower the price. However, countries might have motivation to promote wood construction because of environmental obligations. In other words, EWP are more likely to benefit from environmental policies than its positive impacts to the environment from the customers' point of view.

4.7 Summary of the results

The PESTE analysis with comprehensive examination of various factors affecting EWP development indicates that the future of EWP seems to be bright. Improving cost competitiveness of wooden multi-storey building appears to be one of the most important single factors for the positive development. The high significance of cost competitiveness is justifiable, as already in stage of planning and design of coming construction projects the choice of building and frame material depends a lot on the final costs. Consequently, besides meeting all regulations and codes, wood construction needs to be attractive also in economic terms. Especially key stakeholders consider cost competitiveness one of the most important issues for applying EWP and wooden multi-storey building in practise. In fact, due to EWP innovations wood frame multi-storey construction seems to be competitive compared to concrete and steel framing for the first time. New wood construction business models, for example CLT based module solutions, are just at the beginning of progression, thus also further improvements in several fields are expected. Notable is that also several other factors seem to improve cost competitiveness and usage of EWP. This kind of development paths are presented in Figure 11, which shows an example of possible interactions between different factors.

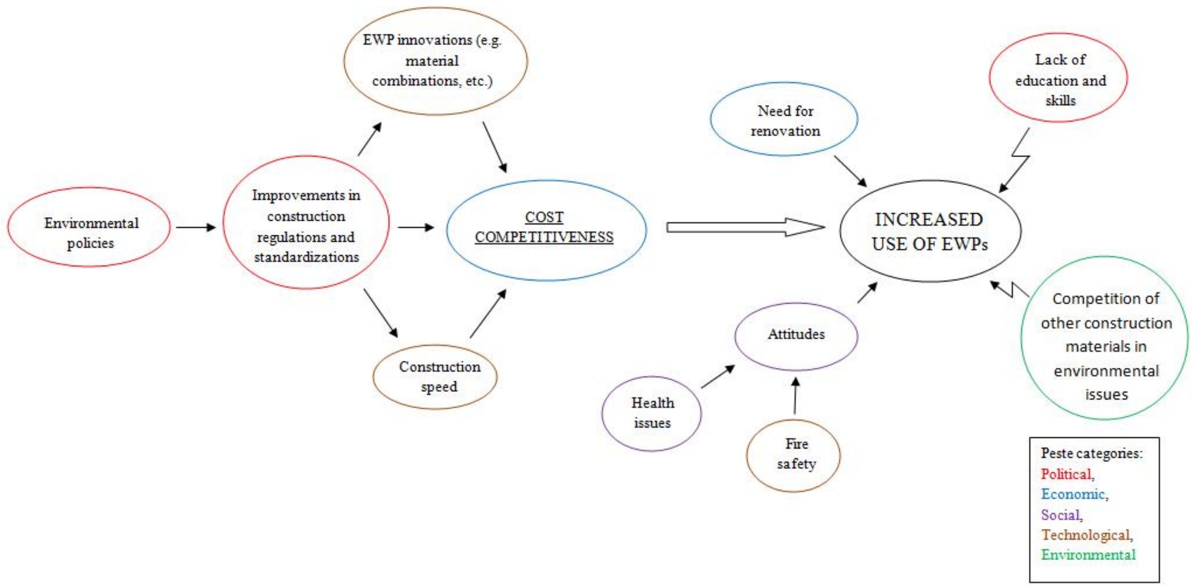

Figure 11. Relationships between major drivers and possible impacts on EWP development in the future.

For example environmental policies may and have already launched institutional changes such as development work for construction regulations and standardization systems. More balanced construction regulations improve naturally also cost competitiveness of EWP usage compared to other construction materials. On the other hand, it may also encourage to develop new innovative EWP, such as composite products, that may further improve their competitiveness. Advanced standardization systems will ease and even more speed up construction with EWP, which is already perceived as one of the EWP benefits. These all affect finally consumers' economy (Figure 11).

PESTE analysis revealed also various other factors affecting the future development of EWP markets. One interesting question for assessing the future development is how the increasing demand for renovation construction will impact on EWP. EWP may provide clever and cost competitive solutions especially in narrow cities, due to their excellence in construction speed and their light weight (Figure 11). New researches of wood's healthy effects and the growing confidence to fire safety of wood frame buildings may improve the attitudes to wood construction, and further increase the demand for EWP. On the other hand, there are not yet enough skilled builders, engineers, architects and other key stakeholders to support rapidly increasing EWP construction (Figure 11). The EWP development would require education at all level, which requires political willingness and time. That is why the lack of skilled labour has been seen as a significant barrier for an increased use of EWP.

Even though the cost competitiveness is emphasized above all, the results show also many other drivers for development of EWP market. The earlier literature provides many positive factors, such as environmental advantages and health issues of wood, which might accelerate EWP usage. However, these would be of more significance for market development if they could also provide some economic value. Moreover, the dominance of wood in environmental issues is not obvious, as greenness of construction materials varies significantly depending on the applied calculation system. Furthermore, for example energy efficiency of concrete manufacturing process may be improved significantly in the future. Either the social issues themselves are unlikely to become the most significant factors for an increased EWP usage.

It is apparent that EWP markets are only at the early stage of development, and EWP key end applications are just spreading to a larger awareness in Europe and elsewhere in the world. Comparing EWP markets to the Rogers' theory of innovation's diffusion (Rogers 1983) EWP may stand at the beginning of the innovations' S-curve, as early adopters are just becoming familiar with them. PESTE analysis indicates that EWP might have good changes to pass the critical chasm, as they seem to be able to meet the most of Rogers' essential characteristics of innovativeness; EWP construction would be cost competitive compared to the traditional construction methods and it might help to reduce the emissions of construction (relative advantage), it would fit to the current attitudes of society (compatibility), and its benefits could be shown as the first construction projects will be completed, and more research results of EWP construction will be achieved (trialability and observability). However, due to some issues, such as the lack of education and skills, the innovation's diffusion may not be very straightforward (complexity).

5 CONCLUSIONS

5.1 Perceptions of EWP future development

Along the study objectives this study provided a systematic analysis of present EWP market situation in Europe, and presented the key end applications of EWP construction. The main question of EWP future prospects was managed to be answered by gathering and analyzing several factors and trends, which may affect the EWP future either positively or negatively. Also relative significance and interdependence between these factors was evaluated for to expand the knowledge of EWP market characteristics. Due to the early stage of EWP development and the uncertain market situation, this kind of qualitative study approach with PESTE analysis provides valid information for future research. It is a useful method when the purpose is to sketch out the complex research topic and investigate the essential factors affecting the future development of EWP. Instead of offering concrete forecasts of volumes of future EWP consumption or such, this study made the obligatory first steps for the future research by evaluating critical factors affecting the EWP development. This kind of an approach is useful, for example, for scenario analyses, which might be worthwhile as a next step for EWP future research.

This study suggests that considering both the positive and challenging factors for EWP prospect, finally the future of European EWP market seems favourable. The most important driver for increasing EWP usage and wood frame multi-storey building seems to be the improved cost competitiveness. Due to many recent innovations, such as modular solutions, wood construction will improve its reliability even in large scale building projects. However, it is very essential to consider that the structural EWP solutions are only at early stage of their life cycle. The study indicated that improvements in cost competitiveness of EWP construction are possible to achieve in many stages.

EWP market development was compared shortly to Rogers' theory of diffusion of innovation (S-curve) (Rogers 1983), where the first steps of innovation adaption are considered the most critical for the further development. EWP construction is of recent origin and not in larger awareness, thus worldwide interest and spreading of the innovative construction methods are expected in the future. Consequently, the future development of EWP is much dependent on the success of the first EWP building projects. These projects are very important for to achieve the confidence of customers and the key actors in the construction sector and to spread a positive image of such new alternatives.

Several positive signals generate prospects for a favourable future of EWP. For example, based on more ambitious targets for climate change mitigation, political willingness to develop institutional regulations, such as fire regulations and standardization systems, in order to promote wood construction and increasing worldwide interest to ample benefits of EWP in construction, EWP may provide a new significant product group for global forest industry and construction sector. That is for sure a positive and encouraging signal for the forest industry in Western countries which is struggling with structural changes in traditional wood product markets.

However, also many uncertainties and barriers appear to hinder the positive development of EWP market, thus it is reasonable to regard with a reserve for EWP prospects. Especially prospects for environmental benefits of wood might be far until providing real competitive advantage. For example, political consensus of climate change mitigation potential of wood construction is not obvious. Moreover, the implementation of a binding and effective international green policy is challenging, because of various differing views of green building rating systems, as an example.

5.2 Criticism of the study and further research needs

One of the main objectives of this study was to provide a synthesis of the current knowledge related to EWP and to evaluate the future prospects of EWP development. This aim was achieved, but it would be possible and necessary to deepen the analysis. For example, each of the factors founded in the study could be investigated in more detail with further studies. In addition, due to confined resources it was not possible to follow a participative approach, such as brainstorming, involving specialists and key stakeholders. It might have been productive to have more different points of view, which would have improved also the plausibility of this study. Some detailed issues of EWP market characteristics would be possible to examine also through quantitative methods. For example, tests of EWP price elasticity and possible substitution effect on other construction materials, or simple correlation inspections between EWP consumption and some other suitable variable would provide new worthwhile information.

However, this kind of quantitative studies will be more meaningful after the properties of EWP market become more stable and familiar.

For the future there are still plenty of important and interesting research questions to study regarding EWP. The study focused mainly on internal markets of Europe, but, however, competition outside of Europe might be very significant in the future. There is certain need to explore what are the possibilities of foreign countries to produce EWP to European and international markets. The competitive situation might be similar as sawnwood markets. On the other hand, European industry is recommended to focus on more value-added products, which might mean for example modular construction. Even if prefabrication were more inexpensive outside of Europe due to the low employment cost, it is unlikely that large bulk products would be profitable to transport long distances, which might restrain global competition (UN 2011). One open question is also that could some other wood species work as a raw material for EWP than that have been currently used, and could it somehow affect the international EWP markets? In summary, many new research questions came up during this study and further research related to EWP would be necessary. However, an initiation to the research of EWP future markets is, at least now, performed.

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