RESEARCH ARTICLE
Multi-storey timber construction and bioeconomy – barriers and opportunities
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Multi-storey timber construction has been developed and promoted in Finland since the 1990s. Despite these efforts, the share of timber frames in multi-storey construction has remained very low. Construction business is also very resource intensive and accounts for a large share of greenhouse gas emissions. Increasing the use of renewable materials, mainly wood, in buildings, could make construction more sustainable and a part of bioeconomy. This study aimed at identifying barriers to the adoption of multi-storey timber construction, ways in which wood could compete with established solutions and possibilities for partly integrating construction into bioeconomy. Based on 18 interviews of representatives from the entire value chain, this study presents insights into introducing new solutions into a conservative field. Our results indicate that multi-storey timber construction could offer competitive solutions for more sustainable construction, even though barriers to its adoption still exist.

Keywords: timber construction; multi-storey buildings; bioeconomy; Finland; new products

1. Introduction
Buildings are designed to last for a long time, and partly because of this goal, construction companies are hesitant to try new things which might result in unforeseen problems (Levander 2010). The construction industry prefers to let someone else try new methods of construction, for example, multi-storey timber frames, first (Roos et al. 2010). As a result of this conservatism, the introduction of new solutions in the construction industry tends to be slow and difficult.

This conservative attitude may be the underlying reason why the new solutions developed by the construction industry tend to be only gradual changes from the current practices. Energy efficiency in a building can reduce energy consumption, but its other effects on, for example, residents’ lifestyle are very small (Daniëls 2007). The “new” housing concepts can be quite close to traditional solutions. For example, a townhouse (a terraced single-family house), touted as a new concept in Finland, is quite similar to a traditional detached house, and is common in other countries (Väliniemi et al. 2009). Using unusual recycled materials, such as steel containers or straw panels, in multi-storey construction is a more novel idea, but will probably only be implemented gradually, if at all (Hyvönen et al. 2012). Sustainable construction could be implemented and developed by means of pilot projects, which provide opportunities for learning (Berry et al. 2013).

Technological changes have occurred also in the Finnish construction industry over the past decades. For example, in 2005 about 60–70% of single-family houses were built from prefabricated elements, which is not the traditional way of building (Halme et al. 2005). There have also been programmes devoted to the development of new solutions in the construction industry in Finland. These have, for example, advanced the construction of multi-storey low energy buildings and building information modelling (Tekes 2008). Some new trends might lead to a more innovative construction industry in the future. New, low energy or passive houses could, for example, interact with energy networks (VTT 2012).

The changes in the Finnish construction industry have also included a new role for timber construction. Wood has traditionally been used in the construction of detached houses in Finland, but since the 1990s large-scale timber construction has been promoted as a way to generate new business opportunities for wood product industry.

Two different strategies have been used in promoting timber construction. The first utilised the concept of modern wooden cities, and took inspiration from the older areas of some Finnish towns, for example, from Porvoo, and the dense terraced housing common, for instance, in the UK. The idea was to build single-family houses, which are popular in Finland, while combating urban sprawl. This project was operational from 1997 to 2013, and resulted in 20 completed projects, ranging in...
size from five houses to areas consisting of several blocks of buildings (Puuinfo 2013).

The second approach has promoted the construction of wooden multi-storey apartments and office buildings. The construction of multi-storey timber buildings has required many technical advances, for example, development of better sound insulation between floors (Tekes 2000). So far 37 residential multi-storey timber buildings and four office buildings have been completed in Finland. All of the office buildings are for forestry-related organisations (Puuinfo 2014). Outside Finland, multi-storey timber buildings have been completed, for example, in Austria (Holzforschung Austria 2013), Germany (Henke 2012), Sweden (Roos et al. 2010; Skogsindustrierna 2013) and the UK (Alter 2010).

Despite promotional efforts, the market share of wood in multi-storey construction has increased slowly in Finland. Wooden frames account for only few per cent of the frames of multi-storey buildings, while for wood facades the share is around 5% (Tekes 2011). By contrast, in Sweden, the market share of wooded frames was about 10% of all multi-storey buildings in 2013 (Skogsindustrierna 2013).

In Finland, one reason for the slow increase in timber construction is the concrete and steel industries’ strong position and development expertise, which has made market entry difficult for others (Tekes 2011). However, some of the previous barriers have been removed. The fire safety regulations were changed in 2011 and now permit the building of multi-storey buildings of up to eight floors with wooden frames, if they are equipped with automatic fire-extinguishing systems (Puuinfo 2011). Building regulations regarding the use of wood vary quite widely even in Europe, which partly explains the differences in market shares. For instance, the maximum number of stories allowed for a timber construction without sprinklers varied from over five stories to under two in 2010. (Östman & Källsner 2011)

This study aimed to find out why multi-storey timber construction has increased so slowly in Finland, despite many promotional efforts, and whether bioeconomy might offer new possibilities for advancing multi-storey timber construction. We will answer the following research questions:

RQ1. What are the most important barriers to multi-storey timber construction in Finland?
RQ2. How can multi-storey timber construction compete against established solutions, such as concrete?
RQ3. Could bioeconomy offer new opportunities for multi-storey timber construction?

2. Theoretical background

Buildings account for a large share of greenhouse gas (GHG) emissions; in the EU this share is around 35% (Ruuska & Häkkinen 2012). Using wood instead of other materials could reduce GHG emissions of construction, for example, by reducing the use of fossil fuels during the manufacturing of building components, and by storing carbon in buildings (Sathe & O’Connor 2010).

Using more wood in buildings could also better integrate the construction sector into bioeconomy. Bioeconomy can be defined as the sustainable use and management of renewable natural resources, production of products and services which use those resources and use of biological methods in production (Valtioneuvoston kanslia 2010). Construction sector tends to rely on non-renewable resources, thus increasing use of renewable materials would move it at least partly into bioeconomy.

In Finland, bioeconomy is on the political agenda, as the Ministry of Employment and the Economy is developing a national bioeconomy strategy (Biotalous 2014). The reasons for the government’s interest in increasing the use of wood in construction relate to the changes in global markets that undermine the competitiveness of the traditionally strong Finnish forest industry. The government has an incentive to support possible new avenues for diversifying forest-based production, and multi-storey timber construction has been one focus area (Ministry of Employment and the Economy 2014). It would also make the construction sector more sustainable, which would create more links between construction and bioeconomy.

In this article, we analyse how multi-storey timber construction as an example of new solution could be brought into wider use in the construction industry and whether it could bring the construction sector closer to bioeconomy. One commonly applied model for analysing the spread of technologies is the technology adoption lifecycle. Overview articles of research using this approach include Rogers (1976) and Haider and Kreps (2004). The basic idea of the model is that in general people’s willingness and eagerness to adopt innovations follows a normal distribution, and they can be divided into different categories according to their position in the distribution. These categories are called innovators, early adopters, early majority, late majority and laggards (Haider & Kreps 2004). If the construction industry is more conservative than an average industry, it could be assumed that most companies tend towards late adoption of innovations, and thus it would be more difficult to find construction companies eager to be the first adopters of multi-storey timber construction.

While the diffusion of innovations model has been widely applied, it has some limitations which have to be recognised. These include pro-innovation bias, and ignoring the effect of social structure on communication behaviour (Rogers 1976). Pro-innovation bias means the assumption that the new development is always better than the old one. This is not always the case, which means that sometimes resistance to innovations is sensible. The construction industry in Finland mainly
uses concrete and steel, and because of this social structure, it is more difficult for new materials to enter the field. Another challenge in using the diffusion of innovations model is identifying the appropriate change agents, who can promote the innovation (Haider & Kreps 2004). In this study, we tried to identify actors from different parts of the value chain who could play an important part in increasing multi-storey timber construction.

A similar notion to a change agent is introduced by Schumpeter (2002). He discusses the concept of “entrepreneur” or leader, who is a driver of economic development and crucial to introducing new ideas. The role of a leader is to push new ideas through the economy, despite the probable resistance of other actors who are committed to old solutions. According to this approach, it is important to identify people who can promote change. The timber construction industry in Finland has tried to use this approach in promoting timber construction, but has so far not achieved its stated goals (Tekes 2011).

Barriers can hinder the adoption of new technologies. For multi-storey timber construction, these have been studied, for example, in Sweden and in the USA. The preferences of material selectors can block new construction materials (Roos et al. 2010), particularly if the persons in charge have pre-existing preferences (Hemström et al. 2011). In the case of multi-storey timber construction, these existing attitudes can include doubts about the performance of wood. Lack of information about using wood as a frame material is also a common barrier (Robichaud et al. 2009). Other barriers can include the building code and the cost competitiveness of wood as building material (O’Connor et al. 2004). In this article, we analyse whether these barriers are influential also in Finland. The data cover the value chain more comprehensively than in the studies cited in this paragraph, so the results may differ from the studies cited in this paragraph also for this reason.

The concept of value innovation, as introduced in Kim and Mauborgne (2005), is also relevant to multi-storey timber construction. The idea is that instead of competing heavily in the “red ocean”, where the competitors operate, a company should seek value innovations. These are innovations, which combine utility, price and cost positions. By seeking value innovations, companies are able to create uncontested market space, that is, “blue oceans”. From this perspective, gaining a market share for multi-storey timber construction requires rethinking of the value proposition, trying to stand out from the standard construction companies, and trying to find a more unique competitive position. This might also enable overcoming the existing barriers. Closer connections with bioeconomy could offer one opportunity for value innovations. Wood products industry is already a part of bioeconomy, but if there is demand for more sustainable construction, this could generate more possibilities for multi-storey timber construction.

In sum, it seems that innovations can be introduced through diffusion, through the actions of change agents or by a company identifying a new market space where it can relocate its activities. Barriers influence all these approaches. Our intention is to identify the most important barriers to increasing timber construction in Finland, and try to find ways to compete with established solutions while bridging bioeconomy and construction.

3. Materials and methods
The data for the study were collected by semi-structured interviews. We chose personal interviews because the goal was to get detailed and in-depth information about the experiences and opinions of construction sector actors, instead of more general data from a larger group of respondents. The personal interview method produces more precise data than other interview methods (Groucutt et al. 2004). Semi-structured interviews, in contrast to open interviews, produce data, which can be compared among interviewees, but they still allow for flexibility and a conversational tone in the interview situation (Grönfors 1982).

The data collection process started by listing the companies from the construction sector value chain that we wanted to interview. The initial list was based on desk research about multi-storey construction in Finland, which gave us the idea of key players. After the initial selection, we drafted the interview guide. Two Finnish experts on multi-storey timber construction were consulted for the final selection of the interviewees and design of the interview guide.

The research questions we tried to answer guided the selection of the interviewees. We wanted to gain knowledge across the construction sector value chain and from different levels within corporate hierarchy. The construction companies, companies renting flats and municipalities were selected on the basis of their size, geographical location close to Helsinki metropolitan region and previous experience of multi-storey timber construction. The last condition applied on the level of organisation, which explains why all interviewees did not have experience of timber construction. The wood product companies selected manufacture products for multi-storey timber construction and were chosen to provide a suppliers’ perspective.

The backgrounds of the interviewees are presented in Table 1. As shown, seven interviewees represented construction, seven their customers and four wood product companies. Only four of the interviewees had been involved in many multi-storey timber construction projects. All the construction companies mainly use concrete in their projects. The skewed sex distribution reflects the male-dominated character of the Finnish
construction sector. With the exception of construction company 1 and company which rents flats 3, all companies fall into the category of large companies (EU 2007). Comparable data to determine the size of the operations of the municipal construction organisations were not available.

The interview guide was edited by us and reviewed by our colleagues prior to the interviews. Five main themes were selected for the interview guide: relations with end-users/residents, effect of environmental awareness on construction industry, cost-effectiveness of construction, experiences of multi-storey timber construction and views of the future of multi-storey timber construction. The interview guide consisted of 26 main questions. Most of the questions were open-ended, which allowed the interviewee to further contemplate a given subject. The English version of the guide is available as Supplemental data to this article.

The interviews were conducted in October–December 2012 by the second author. He contacted 24 people and conducted 18 interviews. The interviews lasted between 30 minutes and over one hour. All interviews were recorded, and the discussions were typed afterwards. The interviews were not transcribed in full, as the contents of the answers were of primary interest rather than the transcription of interviews to the letter. All the content from the interviews was typed up. All interviews were conducted in Finnish. The quotes used in this article were translated to English by the first author. They were edited a little to improve clarity, for example, by removing unnecessary filler expressions such as “errr” and “like”, but care was taken to ensure that the content and message remained unchanged.

The data were analysed qualitatively, by searching for themes which emerge from the responses. During this process, we kept in mind the analytical approach, that is, tried to identify barriers, possibilities for improving competitiveness against established solutions and possibilities for integration with bioeconomy. Some sections of the interviews, for example, those focusing on measuring environmental impact of construction and on specific technological developments have been left out to maintain the focus of this article.

4. Results

4.1. Changes in the construction industry and timber construction

To provide some context for the interviewees’ experiences and perceptions of multi-storey timber construction, we asked them to describe how the construction industry had changed from the 1990s to the present. In answers to this question, the wood product companies stand out from the others. Four interviewees stated that the construction industry had not really changed. One of these was construction company 2, and three were wood product companies (1, 2 and 4). This indicates that the wood product companies have a different perspective on the construction industry.

The other interviewees, by contrast, listed numerous changes. Technological changes were a commonly mentioned category and included, for example, improvements in energy efficiency, ventilation and increase in
complexity of construction. This indicates that the construction industry is at least somewhat prepared to adopt new technologies, which could be a positive sign for increasing timber construction. One big change in the Finnish construction industry has been the proliferation of subcontracting:

The operational model has changed dramatically. We finished a project of 70 flats last spring, and just calculated how many subcontracts were involved in the main project. The main contractor had 34 subcontracting agreements, and then these subcontractors had maybe around twenty contracts with e.g. suppliers or kitchen fittings suppliers. A different company came to do the installation. So this means that a building site for 70 flats can include 50 different financial units, who think that their task is to produce their own service as cheaply as possible and sell it as expensively as possible. (Company which rents flats 1)

Some interviewees saw this as one reason for the decline in the quality of construction. If each actor is only responsible for a small share of the building process, the potential for mistakes increases:

Construction has become more fragmented. And I think quality has suffered from it. Although if there is a very good site supervisor it remedies the situation a little. But it’s a little like they’ll do one stage and completely ignore what will happen afterwards, what is the connection between stages. (Company which rents flats 3)

Another interesting change is the increasing internationalisation of the construction industry in Finland. The Finnish market now includes several large construction companies, which originate in Sweden. It is also noteworthy that a couple of interviewees stated that the customers are more demanding than they used to be:

Well, there have been positive changes, the buyers and users of flats have become really demanding, when compared to what was then. There are more demands also for this concrete thing, for flats in general there are now more demands. In that way it has also become more expensive and is no longer so easy to do. Not just anything will do now. (Municipal construction 1)

The interviewees were also asked about the changes that they thought had taken place in timber construction from the 1990s onwards. This helps in identifying barriers to multi-storey timber construction. These comments were classified according to whether the changes were perceived to be positive or negative. Quite a few interviewees were either neutral or uncertain of the impact. Some interviewees gave conflicting responses, that is, responses which contained both positive and negative statements. These were split into both categories to highlight both the positive and the negative developments.

The positive changes in wood construction were mainly technological. The interviewees were pleased that it was now possible to use other kinds of wood than sawn wood, for example, cross-laminated timber (CLT). They also thought it was good that there was now competition between wood product companies in developing better technical solutions for timber construction. Another positive change was the shift of part of the construction work to factories, the main benefit being reduced vulnerability to weather conditions.

The neutral responses were characterised by scepticism about the magnitude of changes that had taken place. These interviewees recognised that technological changes had occurred, and that the building regulations, particularly fire regulations, had changed. Nevertheless, they thought there was not enough experience of multi-storey timber construction, a lack of skills and of broad-enough product selection and some problems with the quality of timber offered.

In the negative responses, the roles of promotional organisations, state actors and regulations were emphasised. They were seen as favouring wood in a way which skews the market, and is unfair to other materials:

Regulations have been removed, that has had a strong impact. But if we think what the wood product industry has done to make it look more interesting from our point of view, then these efforts to standardise have been steps in the right direction, but they are incomplete and the results have probably not been quite what they could have been. There have been no significant triggers which have worked. I think they have focused too much on image, and I dare say, on emotional lobbying. Construction is an engineer dominated field, and we go by euros, kilos, cubic metres and I think they could come to this more objective side more strongly. (Construction company 3)

In my opinion, it’s just the state authorities who have forcefully pushed it forward. It needs to be remembered that when we talk of multi-storey timber construction, quite a big gun fires on a small fly. There are these issues of scale, which are easily overshadowed by this ideology. In my opinion, the construction industry has become resistant to timber construction, because they have tried to force-feed it so powerfully. Town plans have appeared stating that here the houses must be made out of wood. I think it is really skewing [the market]. (Construction company 2)

They thought that the technology had not yet developed enough, and that if timber as a construction material was to be competitive, better solutions needed to be developed, for example, for facade maintenance.

4.2. Cost-effectiveness of multi-storey timber construction

In previous studies, cost-competitiveness of wood has been identified as one barrier for multi-storey timber construction (O’Connor et al. 2004; Roos et al. 2010). This appears to be the case also in Finland. Eight interviewees thought that multi-storey timber construction
was still more expensive than the other solutions. They included Construction companies 2, 3, 4 and 6, Municipal construction 1, Company which rents flats 4 and Wood product companies 1 and 3. The main reason for expensiveness was that there is still less experience of working with wood than with concrete, and as a result, the processes and products are not quite as well-developed as for other materials. The particular aspects of multi-storey timber construction which raised the costs were less efficient processes, requirements for sprinkler systems, sound insulation between apartments and intermediate floors. These two quotes highlight the last two:

So far the problem has been that the load-bearing frame is made out of wood, but we still have to make separate sound insulating dividing walls between flats. With concrete we make the sound insulating dividing walls and they are the load-bearing frame and it is very inexpensive. In addition, concrete doesn’t require any sprinklers or anything like that. My view is that wood is more expensive. (Construction company 2)

It’s the intermediate floor, which is at the moment more expensive. The [concrete] hollow-core slab is such a superior product and so inexpensive that the cost competitiveness of wooden house falls to pieces there. With the hollow-core slab we can fix the sound engineering too, with wood we have to use some gimmicks and put in loads of sheeting. (Construction company 6)

Six of the interviewees were somewhat uncertain about how cost-effective the use of wood in construction is. They included the representatives of Construction company 5, Municipal construction 3, Company which rents flats 1, 2 and 3 and Wood product company 4. Some stated that the costs were the same, while others gave only hesitant estimations of the relative cost effectiveness. A descriptive statement is:

I don’t have much experience of using wood in multi-storey sites, but I have followed the building of a multi-storey timber house almost weekly by driving past the construction site and I assume that the cost benefits are not that great, since they haven’t really been advertised, at least not in public. (Company which rents flats 2)

Four of the interviewees found the cost-effectiveness of wood to be better than that of other materials. The statements of the interviewees from Construction company 7 and Municipal construction 2 were a little vague. Of the others, the interviewee from Wood product company 2 stated that building with wood is faster and as a result more cost-effective, while the interviewee from Construction company 1 cited his experience of building passive houses and said that in these projects wood had been cheaper during construction. The faster building process, if achieved, could be one advantage which forestry industry could build on when creating a competitive edge.

Ten interviewees thought that the cost-effectiveness of wood had nevertheless improved. The interviewees who were of this opinion were Construction companies 2, 4, 6 and 7, Municipal construction 1, 2 and 3, Company which rents flats 1 and 3 and Wood product company 1. The reasons given for improved cost-effectiveness were interesting and varied. Many of the interviewees mentioned changes in building technique, for example, the use of CLT, better availability of ready-made parts, better joints and increased level of prefabrication. Other reasons included less strict regulations, better design skills, faster construction process and more actors in the market. Further development of these aspects could help timber become a more competitive construction material. Two interviewees thought that there had been no clear changes, three could not say and two thought that cost-effectiveness had decreased. The main reason given for lower cost-effectiveness was the increasing price of wood as a raw material.

4.3. The role of customers

In this section, we focus on the answers of the interviewees from construction companies and their customers. This is because the wood product companies mainly do business with other companies, while the other interviewees work more with the users of buildings. If the customers or users can participate in the design process and if they have a preference for wood as a construction material, they could act as change agents and help to bring in new construction methods.

It appears that the people who will use the buildings have only limited possibilities to participate in the design process. Most companies stated that the future users could not participate in the design process, but that they tried to take into account, for example, market trends as indicators of user preferences.

Some companies, by contrast, said that users can participate in the design process to a certain extent. In one case, this consisted of an annual feedback survey for residents, the results of which were used in building development (Company which rents flats 1). Another company stated that the participation depended on the type of customer. If an organisation contracted an entire building, they had better opportunities to participate than if they were merely in the position of a user, who becomes involved at a later stage of the process (Construction company 6). In the case of two other companies, participation was possible in some pilot projects, but was otherwise quite limited.

Only three interviewees included users in the design process systematically. This approach is described by the following statement:

The user is involved. What I represent, we aren’t a real estate developer, but we talk of project development, which means usually, or always, that we have a user during the construction phase. We take the project forward hand-in-hand, so they are completely tailored.
Our sister company, they do actual real estate development and our business park products. In their case the users are involved in the project at the final stage. They can influence the design of their own spaces, but the concept of the building has already been finalised. (Construction company 5)

The low level of customer involvement can be problematic for the introduction of new construction methods. If customers are not involved in the design process, they will not be able to effectively convey their preferences in relation to building materials.

The majority (eight) of interviewees either did not consider users’ experiences of different materials when designing a building, or they thought that users did not have any material preferences. Four of them were interviewees from construction companies, two represented municipal construction and two companies which rent flats. These interviewees thought that other aspects of a building were more important. If these gatekeepers do not think material preferences are important to users, user demand is an unlikely driver for multi-storey timber construction:

We have asked a lot, but have not yet detected any demand for whether it is made out of concrete, steel, wood or what. The residents are more interested in surface materials, plan of the flat, and location. (Construction company 2)

Three interviewees said that they consider the material preferences to some extent, while only one said that customers can influence material choices. Even this interviewee stated that the users mainly do not express any such preferences.

This contrasts interestingly with the fact that six interviewees (four from construction companies and two from municipal construction) had received some feedback from customers regarding materials. An example is:

We do receive feedback on materials, but it is mainly on surface materials, not so much on the material of the load-bearing structure, because it is usually concrete. In one of our timber buildings we made a survey which also asked about the structure. The residents were very satisfied, because it is a very quiet building. (Municipal construction 3)

This feedback about materials could mean that the companies could benefit by taking customers’ preferences into account. Nevertheless, most companies had not received feedback about material use, which suggests that customer preferences towards particular materials are not as strong as preferences relating to other features of a building.

We were also interested in how environmentally aware the customers were thought to be. If customers want more sustainable construction, this could exert pressure to push construction sector towards bioeconomy.

Most interviewees thought that their customers’ environmental awareness had increased. An illustrative quote is:

In residential construction environmental and ecological issues start to be visible to an ever greater extent. In commercial construction environmental issues have been taken into account for a longer time, because investors demand it in different forms. Practical tools investors use are environmental certificates (LEED, etc.), which obligate both the owner and the user to operate according to a particular concept. At present in commercial construction real estate is valued differently according to whether or not it has an environmental certificate. (Construction company 7)

The increased environmental awareness was more connected to general environmental awareness than to details such as construction materials:

I believe environmental awareness is increasing, but that people would require a particular material is a different thing, because it depends a bit on how you calculate. Even concrete is environmentally friendly, when you calculate in a right way. It’s more that people want air proofness, energy efficiency and small heating costs during the building life cycle rather than during the construction process. (Construction company 2)

Nevertheless, some interviewees stated that customers were unwilling to pay extra for environmentally friendly construction, or to forgo other benefits for environmental reasons:

We have to first separate two things. When we ask about values without expecting the consumer to invest even a euro, they are strongly expressed. We all want to save this world; none of us has anything against it. We are more environmentally aware, we e.g. know the importance of built environment in these matters and so on. Then comes the situation when the father and mother have to go to the bank and negotiate the money to get the flat, and I say that so far we are at a base level and the journey is unfinished. Environmental values weigh considerably less. For example, they are not willing to compromise on the amount of square metres in a flat, because more compact living would save the world. (Construction company 3)

Only two of the interviewees thought that environmental awareness had not increased, or was only instrumental to other goals. It seems that customers might be interested in more environmentally friendly construction and might be willing to promote change towards it. If timber construction was proven to be more environmentally friendly than conventional construction, it could lead to increasing its market share. At the moment, there is still uncertainty about the environmental impact of timber construction when it is compared to other construction materials (e.g. Sathre & O’Connor 2010).
4.4. Experiences of timber construction and views on its competitiveness

Lastly, we examine the interviewees’ opinions about how the cost-effectiveness of timber construction could be improved, and their experiences of timber construction. These opinions help in identifying ways of competing against other materials and possibilities for value innovation. In this section, wood product companies are analysed separately because they have different perception of their products than the other companies.

Ten interviewees offered some suggestions on ways to improve the cost-effectiveness of timber construction. We analysed the transcripts from the interviews, and listed all references to ways of improving cost-effectiveness of timber construction. Most respondents mentioned more than one way to achieve this. In total, we got 13 ideas for improving cost-effectiveness. Most of these were introduced by only one respondent.

The most commonly mentioned possibility for developing cost-effectiveness of timber construction was improving the knowhow of timber construction. Three interviewees thought that this would be helpful. Each of the following themes was mentioned twice by different interviewees as possible ways to improve cost-effectiveness: prefabrication, building a greater number of timber buildings, changing building or fire regulations, making a concerted effort to develop timber construction and increasing standardisation. All of these are issues which the Finnish wood product industry has already tried to improve. Some headway has been made, but our interview results indicate this is still not sufficient.

The cost-effectiveness of timber construction could, according to the interviewees, also be improved by optimising the use of wood in the building, building in the shelter of a tent, faster construction, improving the efficiency of the entire supply chain, developing alternatives for concrete hollow-core slabs, reducing the amount of gypsum board used and developing solutions for temporary buildings. These ideas, which the wood product industry in Finland has not yet utilised significantly, offer slightly different opportunities for improving the cost-effectiveness of timber construction. Temporary buildings, e.g. emergency housing, are an underdeveloped area in general, and thus wood construction would face less intense competition in that area. As a result, temporary buildings could be a value innovation, and by increasing the share of renewable materials could connect construction and bioeconomy more closely.

The interviewees from the wood product companies thought that improving cost-effectiveness could be achieved by gaining more experience of timber construction during a longer period in order to convince construction sector of its quality, and by improving prefabrication. The focus on long-time experiences differs a little from the perspectives of other respondents.

The question on interviewees’ experiences of timber construction yielded an even greater number of different issues, a total of 23. The themes were derived from the transcripts in the same way as with cost-effectiveness. When analysing the issues, we divided them into positive and negative experiences. The most commonly mentioned positive experiences were that building with wood is fast and dry, both because there is no need to wait for concrete to dry and because the construction is often done in a tent. Both of these issues were mentioned by six interviewees. Lightness of wood as a material was mentioned four times. It could enable both using larger elements, and building on poor quality soils. Three interviewees also thought that tooling of wood could be easier than with concrete but these comments were somewhat speculative.

The most commonly (eight interviewees) mentioned negative experience of wood construction related to moisture control. They were from interviewees from Construction companies 3, 4, 6, and 7, Municipal construction 1 and 3 and Company which rents flats 1 and 3. Wood was perceived as more vulnerable to moisture during construction, and thus required special solutions for sheltering from the weather. There were differences in how large a problem this was perceived to be, as some interviewees stated that most buildings these days are built under cover. The other negative experiences related to maintenance of facades (five interviewees), more difficult or expensive maintenance (four interviewees) and sound insulation (three interviewees).

Interesting issues, which were introduced by some interviewees, were a more pleasant working environment when using wood, perception of wood as a warm material, and promotion of “hybrid buildings”, where different materials are used where they work best. Some of these could offer possibilities for the creation of value innovations.

The answers differed between respondents according to the levels of experience of timber construction. The clearest difference was that those respondents with experience from many timber construction projects were the most critical ones. They mentioned more negative experiences and problems with timber construction. All three of them stated that wooden facades require more maintenance, and two mentioned problems with the technical solutions related to fire safety. Less experienced respondents mentioned, for example, the lightness, machinability, aesthetic and air quality attributes of wood more often. All groups mentioned fast and dry construction as positive properties of timber construction. Comparisons between groups are somewhat worrying because while timber industry hopes that experiences would further increase timber construction,
these negative experiences indicate that this might not occur.

When asked about experiences of timber construction, the interviewees from wood product companies introduced five new themes. According to their responses, building with wood is quieter, occupational health on the building site is better, fire safety during construction is better, well-being at work is higher and the carbon footprint of transporting elements is smaller because the elements are lighter.

5. Discussion

The first research question concerned the identification of most important barriers to multi-storey timber construction. It seems that at least some of the previous barriers have been removed. For example, fire regulations, which previously were rather restrictive for multi-storey timber construction, have been changed (compare with O'Connor et al. 2004). This is an example of how the positive attitudes of state and municipal actors have created opportunities for multi-storey timber construction in Finland.

Nevertheless, some barriers still remain. Many of these stem from the fact that concrete is still the default option in the construction industry. This probably explains why our interviewees stated that timber products and processes are still not as developed as those for concrete, and why wood is still a more expensive construction material. While timber construction processes might also objectively be less efficient, the gap might appear wider merely because the timber products and processes are different, which can make combining materials difficult. Some of the perceived technical advantages of concrete, for example, those relating to sound insulation, were also seen as very important by many interviewees. These results are quite similar to the results of Roos et al. (2010). In terms of barriers, the perceived higher maintenance costs of multi-storey timber buildings are a particularly difficult issue because the construction sector has been moving towards focusing on life cycle rather than building costs. In other studies, timber has also been seen as having a shorter life cycle than, for example, bricks. (Wang et al. 2014) Thus, the higher maintenance costs could prove to be an important barrier to increasing timber construction. The advantages of wood as a construction material, such as fast and dry construction, have trouble overcoming this resistance. The strong position of the concrete industry also makes adoption of innovations by diffusion rather unlikely.

The second research question aimed at uncovering ways in which wood could compete with other materials. Our results indicate that the new technological solutions, such as the use of CLT, have improved the competitiveness of wood in multi-storey timber construction. While our interviewees stated that there is still not enough experience of larger scale timber construction, experience is slowly accumulating (see Puuinfo 2014). Being aware of changes in regulations and taking full advantage of these and the technological advances could offer ways for wood to compete with established solutions.

Wood could compete with other materials also through the actions of change agents, such as promotional organisations and the public sector. So far these change agents have had some success, but they have also created antipathy among the construction sector. Some interviewees felt that wood was given an unfair competitive advantage, for example, by town plans favouring wooden frames. The change agents have to some extent created more resistance to the adoption of new methods. As a result, there is a need to rethink promotional strategies to improve the competitiveness of wood. Alternative strategies could be based on the needs of the users or the use of the technical language and arguments of the construction sector. Bioeconomy could be one argument for increasing timber construction, but its effective use in promotional activities would probably require the involvement of wood product industries.

Finally, our study identified some possibilities for wood to compete on its own terms by using value innovations. These possibilities include lightness, speed and greater level of prefabrication. These are interconnected, since lightness enables greater level of prefabrication, as it is easier to transport lighter elements. Prefabricated elements in turn make faster construction possible. Less often recognised opportunities revealed in our data are quieter construction and better well-being of workers both on-site and off-site. These newer arguments in favour of wood could provide opportunities for promoting wood construction. For instance, quieter construction could be a desirable proposition in a densely built urban environment. By focusing on these possibilities, multi-storey timber construction could offer a truly different alternative to established methods.

The third research question concerned the possible bridging of construction and bioeconomy by the means of multi-storey timber construction. Forestry is an essential part of bioeconomy in Finland, and the promotion of timber construction is one way in which the state tries to boost bioeconomy. Closer links with bioeconomy could also help to develop value innovations. More sustainable construction could also be a way to move competition towards other aspects than price. If timber construction is also of better quality, it could improve the sustainability of construction. Bioeconomy with its focus on using renewable materials could thus offer a wider context for promoting multi-storey timber construction.

Overall, our study uncovered only limited possibilities for bridging construction and bioeconomy. While users are more environmentally aware, they are not in general ready to pay more for environmentally friendly construction. As a result, it is difficult to see how users...
and their environmental perspectives would offer possibilities for value innovations. A more realistic way to connect construction with bioeconomy would be through influencing construction industry and industrial clients, by getting them to use more wood and other renewable resources in construction. To achieve this, it is important to focus on improving the competitiveness of wood. This might also work better because in commercial construction green construction, for example, green building certificates are increasingly being adopted. Our study also has some limitations. Although the selection of interviewees was representative of the Finnish multi-storey construction actors, the data still consist of only 18 interviews. Thus, the results are of qualitative nature and might not be representative of the entire Finnish construction industry. The general tone of the results is probably still representative, and the in-depth content of the interviews provides information not obtainable in wider surveys. This detailed understanding of experiences and attitudes could be particularly helpful for development of construction industry.

In conclusion, it appears that some earlier barriers to multi-storey timber construction have been removed and there are ways to improve the competitiveness of wood as a building material. It is important to remember that there are still obstacles to increasing the use of wood in construction. One interesting, and from the point of view of wood product industry worrying, finding is that interviewees with most experience of multi-storey timber construction were more critical than those with less experience. This indicates that merely building more from wood and gaining more experience is insufficient to improve the popularity of timber construction. We also found only limited possibilities for connecting construction sector and bioeconomy. The best way to achieve greater use of renewable materials in multi-storey construction would be to focus on improving the competitiveness of multi-storey timber construction. In order to do this, it is necessary to utilise the strengths of timber construction, such as lightness and possibilities for prefabrication, and focus on improving these.

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Supplemental data

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