THE ROLE OF BOARD INTERLOCKS IN INCREASING THE USE OF WOOD IN NORWEGIAN CONSTRUCTION

Silje Marie Svartefoss *, Antje Klitkou **

* *Corresponding author,* Nordic Institute for Studies in Innovation, Research and Education (NIFU), Oslo, Norway
Contact details: Nordic Institute for Studies in Innovation, Research and Education (NIFU), Økernveien 9, 0653 Oslo, Norway
** Nordic Institute for Studies of Innovation, Research and Education (NIFU), Oslo, Norway

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Abstract

This paper studies the existence of board interlocks between wood-based firms in the Norwegian construction supply chain and firms in other industries, and their role in enabling increased use of wood in construction. Wood-based construction remains a niche market globally. The literature highlights two main barriers to wood-based construction: 1) lack of expertise with the material, and 2) lack of coordination and collaboration across the supply chain. As a form of interfirm governance structure, board interlocks may promote innovation in construction, such as applying new materials, products and processes, by fostering strategic collaborations. Drawing on resource dependence theory (RDT) and the theory of dynamic capabilities, we explore this through analysis of registry data, interviews and case studies. It was found that the majority of wood-based firms have board interlocks and that a majority of the firms they are interlocked with belong to industries within the construction supply chain. It was also found that the role of these board interlocks is primarily to secure access to immaterial resources, such as knowledge, expertise and skills, which enables the wood-based firms to engage in processes (sensing, seizing, and reconfiguration) that are important for their dynamic capabilities and therefore closely related to their ability to innovate.

Keywords: Wooden Construction, Board Interlocks, Resource Dependence Theory, Dynamic Capabilities

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1. INTRODUCTION

This paper studies a specific type of interfirm governance structure, namely board interlocks or directorate interlocks, which occurs when the same person is a member of the board of directors (BoD) in two different firms (Mizruchi, 1996). More specifically, our research question addresses

the question of whether there exists board interlocking between wood-based firms in the construction supply chain and firms in other industries, and their potential role in enabling increased use of wood in construction.

There is plenty of evidence supporting the substitution effects of replacing the most common building materials with wood-based products (Hurmekoski, 2017; Leskinen et al., 2018; Poljatschenko & Valsta, 2021). At the same time, new solutions have developed, such as wood multi-storey constructions (WMCs) based on cross-laminated timber (CLT) and glulam (Iqbal, 2021; Karjalainen et al., 2021; Lazarevic et al., 2020; Viholainen et al., 2021), and the focus on digitalization of the supply chain has increased (Gharaibeh, Eriksson, et al., 2022; Olawumi & Chan, 2020). Still, wood-based construction is a niche in the European and global construction market (Jussila et al., 2022; Toivonen et al., 2021). In the literature on wood-based construction, two main barriers to increasing the use of wood in construction are highlighted: 1) the lack of material expertise (Gosselin et al., 2016; Karjalainen et al., 2021; Santana-Sosa & Kovacic, 2022), and 2) the lack of coordination and collaboration across the construction supply chain (Gharaibeh, Matarneh, et al., 2022; Gosselin et al., 2021; Jussila et al., 2022).

Drawing on the work by Miozzo and Dewick (2002), who argue that interfirm governance structures may contribute to innovations in construction by establishing strategic partnerships, we study a specific type of interfirm governance structure, namely board interlocks. According to previous studies, board interlocks may give access to the resources of other firms, such as materials, technology, and expertise (Brullebaut et al., 2022; Howard et al., 2017; Lu et al., 2021), and enable coordination and collaboration throughout the supply chain (Gulati & Westphal, 1999; Palmer, 1983).

Moreover, we study board interlocks through the lens of resource dependence theory (RDT) and the theory of dynamic capabilities. RDT allows us to understand why and how organisations, such as wood-based firms, may establish relations with their external environment and, to some extent, the role of such relations. The theory of dynamic capabilities allows us to further elaborate on the role of such relations, especially their role within specific organisations, such as wood-based firms, and how they may be important for innovation through their contribution to firms' dynamic capabilities. These theoretical frameworks allow us to formulate hypotheses for empirical analysis of registry data using social network analysis (SNA), analysis of interview data and case studies.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature and develops hypotheses. Section 3 describes the methodology applied in the study. Section 4 provides the results. Section 5 presents a discussion of the study results. Section 6 concludes the paper by considering its limitations and charting directions for future research.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

This section initially reviews the literature on the use of wood in construction and the main barriers to increasing the use of it in construction, which forms the basis for our research question. Second, we present our theoretical framework for the study and formulate hypotheses regarding the results of the analysis.

2.1. Theoretical background

The construction sector has considerable economic and social importance and is a sector with a major environmental impact. If we include the whole lifecycle of buildings, the global construction and building sector stands for 42% of total energy consumption, 35% of total greenhouse gas emissions, 50% of extracted materials and 30% of water consumption (Hurmekoski, 2017). Improving resource efficiency and sustainability in the building sector has thus become an important climate policy goal in the European Union (EU) and in the Nordic countries (Antikainen et al., 2017; European Commission, 2011, 2012, 2014, 2018). In this context, an increased use of wood is seen as having large potential as a substitute for more energy-intensive and non-renewable materials (Ramage et al., 2017). There is plenty of evidence supporting the substitution effects of replacing the most common building materials with wood-based products (Hurmekoski, 2017; Leskinen et al., 2018; Poljatschenko & Valsta, 2021). Studies on the mitigation potential of wood use in buildings and furnishing have shown that wood products have lower greenhouse gas emissions than the alternatives, considering the complete life cycle of the product (Food and Agriculture Organization of the United Nations [FAO], 2016). Furthermore, it is superior to common construction materials, such as concrete and steel, when considering all performance indicators (Abed et al., 2022). Increasing the use of wood in construction is also important because of the possibilities for recycling materials and enabling a transition to the circular economy (Rakhshan et al., 2021).

Previous literature about the sustainability transition of the construction sector in general has targeted low-energy houses or passive houses (Nykamp, 2017), while the literature on the wooden construction industry has been mainly technical and focused on qualities of construction materials and assembling techniques (Buck et al., 2015; Di Bella & Mitrovic, 2020; Grynning et al., 2019; Ramage et al., 2017; Rose et al., 2018) or on specific projects and the used materials and assembling techniques (Abrahamsen, 2017; Koronaki et al., 2021). However, in recent years, a body of literature has developed concerning the role of WMCs in the sustainability transition of the construction sector, as the need for such a transition has become increasingly apparent. Research on new solutions, such as designs using CLT or glulam, has developed (Iqbal, 2021; Karjalainen et al., 2021; Lazarevic et al., 2020; Viholainen et al., 2021). In addition, there has been an increased focus on digitalization of the supply chain (Gharaibeh, Eriksson, et al., 2022). Even though wood-based construction is gaining momentum (Maniak-Huesser et al., 2021), it is still a niche in the European and global construction markets and so there is a potential for expansion beyond the niche (Jussila et al., 2022; Toivonen et al., 2021).

The literature highlights several barriers to the increased use of wood in construction, and lack of material expertise among actors in the supply chain (e.g., consultants, architects, construction engineers and contractors) has previously been highlighted as one of the main barriers (Mahapatra & Gustavsson, 2009). Gosselin et al. (2016) further confirmed this finding in a review of the scientific literature on major construction projects that used wood. More recently, an interview study in Finland, which interviewed 21 key professionals with experience in tall timber residential construction, concluded that the lack of construction expertise was considered one of the major obstacles (Karjalainen et al., 2021). Santana-Sosa and Kovacic (2022), in their study which includes a review of the literature and expert interviews, also highlighted the need for material expertise to increase the use of wood in construction.

However, lack of material expertise is not the only barrier to the increased use of wood in construction. Previously, Mlecnik (2013) showed how the project-based approach may hinder innovation within the construction sector, and how enhanced coordinated collaboration may enable better conditions for innovation. Gosselin et al. (2018) studied fifteen wooden construction projects in nine different countries, using a mixed methods approach. They showed how the increased use of wood is obstructed by the complexity of the supply chain relationship, and that partnerships along construction supply chains rarely reach outside the project level. A more recent study by Gosselin et al. (2021) further supports the need for collaboration and tighter relations along the supply chain. Furthermore, Santana-Sosa and Kovacic (2022) recommend that experts on wood construction should be included in the early stages of the design phase to avoid re-design, cost, and time overruns. Gharaibeh, Matarneh, et al. (2022) present a similar finding when studying the implementation of building information modelling (BIM) in wood construction projects. Finally, the review by Jussila et al. (2022) on WMCs market development calls for more research on forms of collaboration within the construction supply chain.

The outlined barriers to the increased use of wood in construction call for further research on this issue. Miozzo and Dewick (2002) argue that interfirm governance structures can constitute a path towards innovations in construction, such as applying new materials or products based on new materials, by establishing strategic partnerships. A specific type of interfirm governance structure is board interlocks or directorate interlocks, which occurs when the same person is a member of the BoD of two different firms (Mizruchi, 1996). Several studies have shown that board interlocks secure access to resources from other firms, such as materials, technology, expertise and information (Brullebaut et al., 2022; Howard et al., 2017; Lu et al., 2021; Shropshire, 2010). Palmer (1983) has also shown that multiple board interlocks increase the likelihood of collaboration through joint ventures. Gulati and Westphal (1999) also found that board interlocks may be influential in forming strategic alliances, which enables collaboration, depending on the context of the board interlocks. The literature also suggests that board interlocks positively influence firms' innovation performance (Ahuja, 2000; Helmers et al., 2017; Teng et al., 2021). Still, the studies linking board interlocks and innovation primarily rely on quantitative data, which makes it unclear exactly what role board interlocks have played in creating this link. As a result, we believe it is necessary to investigate this link further to unpack the relationship between the two.

Based on the literature review, we formulate the following research question:

RQ: To what extent do board interlocks exist between wood-based firms and firms in other industries, and what role do they have in enabling increased use of wood in construction?

By answering this research question, we aim to contribute to the two streams of literature, wood-based construction and board interlocks, mainly in two ways. First, by investigating if board interlocking is a viable interfirm governance structure for overcoming the barriers to increased use of wood in construction. Second, by unpacking what role board interlocks have had in creating a link between firms with board interlocks and innovation.

Following the formulation of our research question, we now outline the theoretical framework of the study that we use to formulate hypotheses for findings in the empirical analysis.

2.2. Research framework

Resource dependence theory (RDT) and the theory of dynamic capabilities form the basis of our theoretical framework. RDT contributes to our understanding of why and how organisations, such as wood-based firms, may establish relations with their external environment and, to some extent, the role of such relations. It is also a particularly relevant framework in this context because it considers the characteristics of the external environment of the organisations (Davis & Adam Cobb, 2010), in this case, the construction sector, which has been highlighted as important to consider in recent studies of corporate governance (Kempner-Moreira et al., 2020). The theory of dynamic capabilities allows us to elaborate on the role of such relations, especially within a specific organisation and how they may be important for innovation through their contribution to firms' dynamic capabilities.

The premise of RDT states that the environment surrounding organisations is uncertain, and that the organisations try to gain control over this uncertain environment, and avoid dependence, because they need a persistent and reliable flow of resources (Mizruchi, 1996). The source of uncertainty is the existence of interdependencies, which describes a situation where "one actor does not entirely control all of the conditions necessary for the achievement of an action or for obtaining the outcome desired from the action" (Pfeffer & Salancik, 2003, p. 40). Furthermore, a central assumption of RDT, which separates it from ecological and institutional perspectives, is that managers within an organisation have discretion, which entails the ability to actively manage the uncertainties of the external environment (Oliver, 1991). Another important distinction is that resources are not simply material but may also be immaterial resources such as expertise or specific skills (Barringer & Harrison, 2000; Davis et al., 2003).

Malatesta and Smith (2014) present three main strategies for reducing uncertainty and dependence: 1) mergers, 2) alliances, and 3) co-opting or board interlocking (hereafter, board interlocking). The choice of strategy depends on how much control over resources the focal organisation views as necessary (Finkelstein, 1997). The strategies can be viewed as a part of a continuum because they require varying degrees of coordination and loss of autonomy (Malatesta & Smith, 2014). Furthermore, the control gained by applying these strategies is highly dependent on the characteristics of the organisation's environment. The literature suggests that board interlocking is the most likely strategy for gaining control in environments characterised by low concentration and high levels of competition (Malatesta & Smith, 2014; Pfeffer & Salancik, 2003). A study by Boyd (1990) showed that the number of board interlocks is greater in such environments. The assumption is that through board interlocks, the focal organisation trades sovereignty to an organisation on which the focal organisation is dependent, which in turn establishes self-interest in the focal organisation's development and survival (Davis & Adam Cobb, 2010). The literature characterises the construction sector as a highly competitive sector with low concentration (Ball et al., 2000; Bremer & Kok, 2000; Lowe, 2011; Staniewski et al., 2016). Therefore, we expect wood-based firms to use board interlocks as a strategy for gaining control and reducing their dependency on the environment. As a result, the first hypothesis can be formulated as follows:

H1: A majority of wood-based firms will have board interlocks with other firms.

Another relevant characteristic of the construction sector is the complexity of the supply chain relationship within the construction sector (Gosselin et al., 2018, 2021; Mlecnik, 2013). A construction supply chain encompasses architects, engineers, builders and suppliers (Gosselin et al., 2021; Vrijhoef & Koskela, 2000). Papadopoulos et al. (2016) describe how the construction supply chain differs from the manufacturing supply chain because of the frequent changes in product, production, and location. Board interlocks may enable better coordination with the environment because they establish a channel for communication between firms (Hillman, 2005; Malatesta & Smith, 2014; Schoorman et al., 1981). Given the need for coordination, we expect the wood-based firms to have board interlocks with actors across the construction supply chain. As a result, we formulate the following hypothesis:

H2: The wood-based firms have board interlocks with actors across the construction supply chain.

We rely on both RDT and the theory of dynamic capabilities to understand the role of board interlocks. Within RDT, board interlocks are viewed as a way to secure access to material and immaterial resources (Hillman, 2005; Malatesta & Smith, 2014). Wood-based firms are particularly dependent on access to wood and wood-based materials. This dependency suggests that wood-based firms will be more likely to have board interlocks with firms that may supply the necessary material, due to the potential to secure a persistent and reliable flow of resources (Mizruchi, 1996). As a result, the third hypothesis is formulated as follows:

H3: Wood-based firms use board interlocks to secure access to material resources.

Board interlocks also have the potential to function as transfer channels for immaterial resources such as knowledge, expertise and skills between organisations (Barringer & Harrison, 2000; Haunschild & Beckman, 1998; Pfeffer & Salancik, 2003). However, the role of immaterial resources within an organisation and their potential relation to innovation is less clear within RDT. Teece (1997) developed the theory of dynamic capabilities, which he defines as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (p. 516). In more recent work, Teece (2007) disaggregates dynamic capabilities into three processes: 1) sensing, 2) seizing, and 3) reconfiguration. Sensing entails identifying opportunities in the environment which requires market understanding, and seizing entails addressing the identified opportunity which often requires new knowledge and skills. Finally, reconfiguration entails restructuring assets, priority setting and organisational structures to address environmental changes. Therefore, reconfiguration demands business and management skills and strategic focus. Additionally, Teece (2007) suggests that the ability of firms to engage in these processes forms the basis of their dynamic capabilities which is closely connected to their ability to innovate. As board interlocks have the potential to function as a transfer channel for the necessary knowledge, expertise, and skills needed in these processes, we suggest that they will be used to secure access to these immaterial resources. As a result, we formulate the following hypothesis:

H4: Wood-based firms use board interlocks to secure access to immaterial resources such as knowledge, expertise, and skills.

3. RESEARCH METHODOLOGY

This paper builds on three types of data: registry data, interview data and case studies. These types of data are used in combination because while the registry data allows for investigation into if, and to what extent, there exist board interlocks between wood-based firms and firms in other industries, it does not contribute to the understanding of the role of these potential board interlocks. For this purpose, we also need qualitative data. In the following, we will outline how the data was collected and which methods we applied to analyse the different types of data, but we will first turn to our motivations for selecting Norway as a case.

3.1. The case of Norway

To understand the motivations for selecting Norway as a case, we must understand the national context for corporate governance. Davies (2005) defines corporate governance as "the structures, processes, and institutions within and around organizations that allocate power and resource control among participants" (p. 143). A part of this is, therefore, corporate law. La Porta et al. (1997) have pointed out that laws in different countries are typically transferred from a few traditions, and countries originating from the German and Scandinavian civil law tradition are intermediate in terms of shareholder and creditor protection. Furthermore, a more recent work by Sjåfjell and Kjelland (2013)

describes Norwegian corporate governance laws as international and heavily influenced by the EU because of the European Economic Area (EEA) agreement. Norway is also not very different from other European and Scandinavian countries in terms of international and private ownership of firms, but there is a higher share of public ownership in Norway compared to other European and Scandinavian countries (De La Cruz et al., 2019). Thus, Norway could be seen as a typical case according to Gerring and Cojocaru's (2016) classification, even though Norway is different from other countries in some aspects.

La Porta et al. (1998) state that the German and Scandinavian civil law countries have the highest quality of law enforcement. Furthermore, in addition to the other Scandinavian countries, Norway has a tradition of strong owners and supervisory boards that mainly consist of non-executive BoD members (Sinani et al., 2008). A comparative study of actual BoD behaviour of privately held small and medium-sized enterprises (SMEs) in Norway, Belgium and the Netherlands, found that Norwegian boards had a significantly lower score on advice and counsel tasks that typically have an internal focus, which may indicate a tendency towards an external and strategic focus (Voordeckers et al., 2014). Norwegian firms are also required to have employee representatives on the BoD if it is requested by the majority of employees in a firm with less than 200 employees and if a firm has 200 employees or more, a corporate council or employee representatives on the BoD is required (Grosvold et al., 2007). These additional aspects that characterize Norway make it an interesting case to study, as they relate to important dynamics of how the BoD functions.

3.2. Registry data

We collected the data for this study in February 2022 from the Central Coordinating Register for Legal Entities (CCR), a registry of all firms in Norway. To collect the data, we used the R software and web scraping. Each firm registered in Norway is given a unique identifier upon registration in CCR. We then used the unique identifier to access and collect information about each firm. The information we collected for each firm was the NACE (Nomenclature of Economic Activity) code, the number of employees and information about the BoD members (name, role in the BoD, and date of birth), if the firm had a BoD. At the time of data collection, 1,068,320 firms were registered in CCR. Of these, 549,449 registered firms had boards of directors.

A central issue after data collection is the reliability of the data. The reliability of registry data in Scandinavian countries is generally viewed as high. However, to verify this we estimated the Jaccard similarity coefficient (Jaccard index) for individuals with the same date of birth and through this procedure we identified only 353 cases that needed to be inspected manually and only for 10 of these cases, we questioned whether it was the same individuals but with slightly different names. Given our sample size, this is a marginal percentage, and we consider the data reliable. To collect data on which firms in the construction supply chain use wood-based materials in their products, we gathered information on firms that were members of the primary industry organisations in Norway[1] for the promotion of wood-based products. This led to a list of 357 firms.

For the analyses we created a two-mode network, using the data collected from CCR and the list of wood-based firms. A two-mode network connects firms through persons. The two-mode network allowed us to create a projection of a one-mode network of firms connected to firms from the two-mode network. To get an overview of how connected wood-based firms are to other firms in the network, we calculated the distance from the wood-based firms to all other firms in the network. By only considering directly connected firms (distance = 1) and their NACE-codes, we get an overview of to what extent wood-based firms are interlocked with firms in other industries.

It should also be noted that one firm may be registered with several NACE-codes, which may question the reliability of our analyses based on NACE-codes. We consistently used the first NACE-codes of each firm. In addition, most firms are only registered with one NACE-code (Brønnøysundsregistrene, 2022). Finally, in the remainder of this paper, we will use the term "industry" when we refer to the NACE section[2].

3.3. Interview data

Our interview data was collected between June and October 2022. An attempt was made to select potential informants using the network created from the registry data, but this method proved unsuccessful. Around 40 requests were sent by email and followed up by telephone calls; most of these remained unanswered or were answered with a decline to participate in an interview.

Due to the lack of success with our purposive sampling, we had to change our strategy to something more similar to the snowballing method. This is a non-probability sampling technique where the initial sample suggests relevant informants who have the relevant characteristics or experience (Bryman, 2016). This entailed that we reached out to persons we knew or collaborated with in the industry and asked them to recommend informants. In some instances, they made the first request, and we followed up with a more formal request. We made sure that most of these informants were BoD members of wood-based firms, and that they had connections, through board interlocks, to firms in other relevant industries. This strategy led to interviews with seven informants. We also conducted two additional interviews: 1) an interview with someone who served on the BoD of several real estate development firms, but not a wood-based firm, and 2) an interview with an informant who served on the BoD of several firms. This informant also had extensive knowledge of the legal and operational aspects of BoDs.

Table 1 shows information about which industries the firms our informants are connected to through the BoD belong to. Our informants are well distributed across industries.

[1] These are Treindustrien, Norske Trevarer, Byggevareindustrien and Treforedlingsindustrien.

[2] NACE-codes have a hierarchical structure with four levels, where the fourth level is the most differentiated. At the first level firms are divided into 21 NACE sections. It is these 21 NACE sections we refer to as industry in this paper.

Table 1. Information about the informants and their affiliated industries

ID	*The industries of the firms*	*BoD member of wood-based firm*
1	C — Manufacturing	Yes
2	A — Agriculture, forestry, and fishing	Yes
3	C — Manufacturing, A — Agriculture, forestry, and fishing	Yes
4	M — Professional, science, and technical activities, A — Agriculture, forestry, and fishing	Yes
5	C — Manufacturing	Yes
6	C — Manufacturing	Yes
7	N — Administrative and support service activities	Yes
8	L — Real estate activities, F — Construction, S — Other service activities	No
9	F — Construction, S — Other service activities, N — Administrative and support activities, M — Professional science, science, and technical activities	No

The interviews were semi-structured, and we used an interview guide as the starting point for each interview (see Table A.1 in Appendix). We also adapted our questions depending on the background of the informant and topics that came up during the interview. In the interview guide, we listed several probes that we used if a topic we were interested in was not raised or discussed by the informants themselves. The interviews were all recorded and transcribed.

To analyse the interviews, we developed a codebook (see Table A.2 in Appendix) and used NVivo to code the interviews. The interviews were coded by one person, which can question the reliability of the coding. However, the interviews were conducted as part of a larger research project and two persons jointly conducted all of the interviews and discussed the coding and findings, which increases the reliability.

3.4. Case studies

Although we managed to recruit a group of informants, it was necessary to supplement the interview data with case studies of three types of firms which are involved in different segments of the wood-based construction sector: construction contractors, manufacturers of wooden construction material, and construction engineering consultancies. For each of these segments, two typical firms were selected.

The information for these case studies was retrieved from different sources: if available annual reports published by the firms; economic data and data about the steering boards from Proff.no (https://proff.no/) were retrieved in 2023; background information from the press media and interviews. All information was anonymised.

The case firms are described as follows. Each firm is given its industrial specialisation based on Standard Industrial Classification (SIC 2007), and the size in terms of the number of employees. We avoid giving exact numbers to keep the anonymity of the firms. Therefore, we group the firms according to number of employees:

1) small firms (less than 50 employees);
2) medium-sized firms (less than 250 employees);
3) large firms (more than 250 employees).

Finally, we assess the economic development in terms of trends for the development of operating income over the last three years (see Table 2). Then, we analyse the composition of the BoD for each firm, and the role of the BoD in the development and realisation of the firms' strategic objectives, especially regarding sustainability. Only the larger firms have published regular annual reports where the firms wrote about their strategies, corporate governance, environmental goals, and the role of the BoD. Reports were available for *Alpha* and *Beta*, and recently also for *Zeta*. For *Epsilon, Tau* and *Omega* we used press media, interviews and the websites of the firms.

Table 2. Information about the six case studies

ID	*Size of the firm*	*Economic development*	*NACE code (SIC 2007) and specialisation*
Alpha	Large	Stagnation	41.200: Construction of residential and non-residential buildings
Beta	Large	Decreasing	41.200: Construction of residential and non-residential buildings
Epsilon	Medium-sized	Increasing	16.23: Manufacture of builders' carpentry and joinery
Zeta	Medium-sized	Increasing	16.21: Manufacture of veneer sheets and wood-based materials
Tau	Small	Decreasing	71.121: Construction engineering consultancy
Omega	Small	Increasing	71.121: Construction engineering consultancy

4. RESEARCH RESULTS

The results from the analysis of the different types of data are presented thematically to inform about the results related to each of the four hypotheses. We first present the results associated with the first two hypotheses, which address the first part of our *RQ*, which concerns the extent of board interlocks, before we continue with the results related to the last two hypotheses which address the second part of our research question and concerns the role of board interlocks.

4.1. The extent of board interlocks

Regarding *H1*, our quantitative analysis of the register data showed that of the 357 firms in our list of wood-based firms 81% (N = 289) were connected to other firms through board interlocks. The wood-based firms were interlocked with 3,113 other firms. Of these 3,113 firms, 84% (N = 2,629) were unique firms. The case studies analysed three different groups of firms, and in all three groups, the boards had board interlocks with other firms. However, this was most prevalent for large construction firms. For the medium-sized manufacturers, it was primarily the chairman of the BoD who had board interlocks with other firms and not the BoD members. The small construction engineering consultancies have smaller BoDs, meaning they have less BoD members, but both of these firms had BoD members with board interlocks to other firms.

Regarding *H2*, the results from the analysis of the registry data show that wood-based firms are

interlocked with firms in all industries. However, there is a great deal of variation regarding the degree of interlocks to each of these industries (see Table 3). A majority of these interlocked firms are found within the following industries: real estate (24%), construction (13%), manufacturing (7%), and professional, science and technical activities (7%). Only 3% of the firms that the wood-based firms are interlocked with are within the industry of agriculture, forestry of fishing, where the wooden resources come from. Still, the wood-based firms have board interlocks with actors across the construction supply chain.

Table 3. Distribution of firms that the wood-based are connected to through board interlocks, according to industry

Industry	*N*	*Percentage*
L — Real estate activities	734	24.0
F — Construction	405	13.2
S — Other service activities	264	8.6
C — Manufacturing	217	7.1
M — Professional, science, and technical activities	216	7.1
G — Wholesale and retail trade; repair of motor vehicles and motorcycles	214	7.0
K — Financial and insurance activities	131	4.3
R — Arts, entertainment, and recreation	114	3.7
H — Transportation and storage	95	3.1
A — Agriculture, forestry, and fishing	85	2.8
N — Administrative and support service activities	85	2.8
J — Information and communication	78	2.6
Q — Human health and social work activities	59	1.9
D — Electricity, gas, steam, and air conditioning supply	53	1.7
B — Mining and quarrying	35	1.1
I — Accommodation and food service activities	28	0.9
P — Education	24	0.8
E — Water supply; sewerage, waste management, and remediation activities	22	0.7
T — Activities of households as employers; undifferentiated goods-and-services-producing activities of households for own use	13	0.4
O — Public administration and defence; compulsory social security	6	0.2
Z — Not listed*	185	6.0
Total	**3063****	**100.0**

*Note: * These are firms which are listed with no NACE-code; ** 50 of the firms that the wood-based firms are connected to are missing information about the NACE-code.*

The case studies analysed three different groups of firms, which behave a bit differently regarding board interlocks with actors across the construction supply chain.

For the large construction firms, it can be said that they have board interlocks with other firms in the construction sector, but not for the production of wooden construction materials. For the medium-sized manufacturers of wooden construction material, we did not find evidence for board interlocking with the construction sector or wooden material production, but more to investment firms and the retail sector. Regarding the small construction engineering consultancies there is diverging evidence: while *Tau* has very limited board interlocking, especially with relevant actors in the supply chain, *Omega* is interlocked with many relevant actors in the supply chain, such as forestry producers of wooden construction material and industry clusters specialised in exploiting wooden resources.

4.2. The role of board interlocks

The second part of our research questions addresses the role of board interlocks. Our two hypotheses stated that they would be used to secure access to both material and immaterial resources. We first present the results related to the hypothesis on material resources before we continue with the results related to the hypothesis on immaterial resources. Finally, we highlight some potential issues related to using board interlocks in a strategic way that is of relevance to both potential roles of board interlocks.

4.2.1. Secure access to material resources

We interviewed several informants with various connections to other firms in other industries through board interlocks. However, when we asked them about how these interlocks were used few suggested that they used them to secure access to material resources, such as wood or more advanced wood-based products, or even thought of it as a possibility. Informant 2, who was on the BoD of a carpenter firm and a firm supplying forest plants for planting after trees had been cut down, alerted us to the large difference between the businesses each firm was in. The products of the forest plant firm would not become usable lumber for the carpenter firm until several decades have passed. Informant 5 suggested that firms might use interlocks in this way, but added that, in most cases, firms would select the material most suited for a specific purpose, and that this consideration would be given substantial weight in the decision on material selection.

Furthermore, a board interlock might not be a strong enough connection between firms for it to function as a way to secure access to material resources. Informant 1, who was interlocked with several firms across the supply chain because of ownership through a parent firm, describes the interlocks as something reassuring, in light of the uncertainty caused by the recent pandemic, in the supply of material resources. At the same time, it is also noted by the informant that they are mindful not to make this too big of an advantage.

Even so, our interviews show that this should not be interpreted as the only motivation for parent firms to have interlocks with firms they have

ownership shares in. Several informants (1, 6, 7 and 8) noted that ownership shares were one of the main motivations for interlocks. Informant 6 explained that this is not because of the parent firms' interest in securing access to material resources, but because of having made investments and wanting to influence and have information about the development of the firm. However, this finding lends more support to our hypothesis about immaterial resources. Across the six case studies, there was little evidence for securing access to material resources, except for the small construction engineering consultancy *Omega*, which has board interlocks with suppliers in the forestry sector. Even so, this does not indicate that the board interlock is used in this way, only that there is a potential for such use.

4.2.2. Secure access to immaterial resources

Our results show that board interlocks were used to secure access to immaterial resources and further that they are used mainly to secure access to two specific immaterial resources:

1) knowledge, as well as expertise, and skills related to market and business management;
2) contributions to strategic development.

Knowledge, expertise, and skills related to the market and business management

The interviews show that board interlocks function as a way to secure access to immaterial resources such as knowledge, expertise, and skills. We asked the informants about why they were appointed to the BoD of the various firms. Several informants (2, 6 and 8) noted that knowledge and experience from wood-based firms were important. Informant 1 also noted that they were actively seeking potential BoD members with such knowledge and experience, but that they are hard to come by. Additionally, many of the informants (2, 3, 4, 6 and 9) also had previous work experience from firms that worked with wood as a material.

Many informants (1, 2, 3, 4, 5, 7 and 9) stressed knowledge and experience from business management, as well as skills that enable them to understand how the market develops, as important for their appointment as a BoD member. Informant 3 described how the informant was recruited to the BoD of a wood-based firm because the firm was facing economic struggles, and that they were subsequently recruited to other firms when the economic situation was improved. Informant 4 described the importance of having BoD members who understand the firm's business model and elements that influence the firm's failure or success.

The importance of experience from business management and market understanding seems to be related to how the informants perceive the role of the BoD. Many of the informants (2, 3, 5, 6, 7 and 9) view the role of the BoD as particularly responsible for the long-term development of the firm. They describe how the BoD should be a partner for the chief executive officer (CEO) in thinking about the future development of the firm. Moreover, they should try to have a more long-term perspective, than the operative management, focusing on future development opportunities, but at the same time, be a supporting actor for the short-term development. Most of the informants (1, 2, 3, 4, 6, 7 and 8) also said that they had experience from previously being on a firm's BoD.

In the case studies, data about the knowledge, expertise, and skills of the BoD members is limited. Mostly, only information about the competence of the chairman can be found on the homepage of the firm, in annual reports or in the press media. Here, especially the large construction firms, but also one of the medium-sized manufacturers can be mentioned. For *Alpha,* it can be said that the chairman is experienced, the BoD members have varied backgrounds, and the BoD is composed to safeguard the interests of the community of shareholders and the firm's need for expertise and capacity. Something similar could be found about one of the manufacturers, *Zeta*, the BoD is made up of people with different experiences and professional competencies, so that it can in the best possible way ensure good management of the firm and follow up the administration. For the small engineering consultancies, there was no detailed background data about the skills and competencies of the BoD members, just about their engagement with BoD membership in other firms.

Boards and strategic development

In the interviews, it was also suggested by Informant 5 that a board interlock might give some influence on the future development of the interlocked firms. This informant is on the BoD of a firm that often functions as a contractor in larger construction projects and of a smaller firm that builds private houses and prefabricated elements. Informant 5 explains how the additional element of a customer relation between the contractor firm and the smaller firm enables the contractor firm to provide input on future development, highlighting elements worthy of consideration.

The case studies addressed the development of strategic objectives of the firms by the BoD by analysing different annual reports and information on the firms' objectives stated on their home pages.

Only the large construction firms have published regular annual reports where such information can be found. At *Alpha*, for instance, the BoD has the overall responsibility for managing the firm on behalf of the owners, including ongoing supervision of the group's management and operations. The BoD must participate in the design of strategies, plans, budgets, and guidelines for operations, and ensure that the firm has an organisation that can implement the strategy and follow up that the business is run in accordance with the guidelines and the adopted strategy. The most recent strategy includes for the first time, targets related to climate and the environment: by 2030, the firm must halve greenhouse gas emissions and unsorted waste and contaminated masses that go to incineration or landfill. The BoD has the ultimate responsibility for ensuring that climate and environment-related threats and opportunities are handled satisfactorily. Something similar has been stated in *Beta*'s long-term environmental strategy for how the environment should be safeguarded and continuously improved in its projects. In line with the climate target and the United Nation's Sustainable Development Goals (SDGs) towards 2030, *Beta* has

chosen in its environmental strategy to focus specifically on reducing the use of resources, cutting greenhouse gas emissions, promoting local ecology, and eliminating hazardous substances. As a contribution to the realisation of these goals, *Beta* has actively engaged in many wooden construction projects promoting the innovative use of CLT, for schools, childcare, residential buildings, office buildings, etc.

Both manufacturing firms have recently developed sustainability or environmental strategies. *Epsilon*, for instance, has developed an environmental strategy that is focused on promoting the choice of glulam and CLT in all parts of a building project where it is feasible. *Epsilon* is certified by the Programme for the Endorsement of Forest Certification (PEFC). This means that the forest from which the timber comes is managed and operated sustainably. For the CLT production, the firm only uses slow-growing, high-quality Norwegian spruce that is PEFC-certified. *Epsilon* has provided CLT for many construction projects. *Zeta* developed in 2022 a sustainability report where the objectives of the firm are summarised, combining social, environmental, and economic sustainability.

The two construction engineering consultancies do not publish annual reports or environmental strategies, but they state their objectives on their homepages: *Tau* aims to work for the increased use of wood in the Southern region of Norway and has collaborated with student organisations for the construction of wood-based student residences in several cities. *Tau* is also collaborating with public authorities to realise its aims. By increasing the competence among the participants in the value chain, including architects, consulting engineers for all disciplines, contractors and subcontractors, *Tau* wants to develop a sense of security through specific construction projects and form the basis for changing practice. In the case of *Omega,* the firm is focussing on finding research and development-based solutions for the industrial processing of wood waste to support the circular economy and to facilitate the reuse of wood as construction material.

4.2.3. Potential issues related to using board interlocks in a strategic way

Throughout the interviews, the informants also mentioned some issues related to the role and use of board interlocks. The first issue relates to the qualification of the BoD members in making decisions which may benefit the firm of the BoD member. Some informants (8 and 9) mentioned that in these situations the BoD member in question would be disqualified from taking part in the decision. The task of the BoD member is to act in the best interest of the firm in question. This is also in accordance with the legal regulations (Lov om aksjeselskaper, 1997).

This is seemingly not only a legal issue, but it may also be seen as an unfair advantage by the outside world. Informant 1, who had owned several wood-based wholesale firms previously, mentioned this issue. They described how builders became sceptical towards their business and suspected that the sawmill might sell their materials at a cheaper price to their wholesale firms compared to external builders. According to the informant, ownership increases the need to conduct business in a transparent manner. Another Informant 3, who moved from interest organisations to industry, had to cut ties with the former to avoid being suspected of having one foot in each camp.

Another aspect which might make it difficult to use boards strategically is that there may be election procedures in place for the selection of BoD members, especially in larger firms. Informant 3 suggested that the possibility of appointing a strategically important member to the BoD might be difficult since the election committee might not think of or be aware of the possibility. Another Informant 7 suggested that the committees might resort to selecting the person who is next in line, because it is the most convenient, instead of considering the firm's needs.

The final issue relates to competition among firms. Informant 1 mentioned that they tried to collaborate with other firms, but that it was difficult because of the competition. Moreover, collaboration often leads to conversations about acquisitions or mergers. This informant also mentioned that the price is of course an important factor for deciding which material to use. This was also repeated by another informant (5). This suggests that it might be difficult to select materials or products that a firm is interlocked with if the price is not competitive in the market.

5. DISCUSSION

According to RDT, board interlocks allow the focal firm, in case of interdependencies with other firms in the environment, to trade sovereignty for self-interest in the focal firm's development and survival (Davis & Adam Cobb, 2010; Pfeffer & Salancik, 2003). In contrast to other methods for reducing interdependencies and thereby uncertainty of the focal firm, such as mergers and alliances, establishing board interlocks involves less coordination and loss of autonomy, it is also viewed as the most likely strategy in environments with low concentration and high levels of competition (Malatesta & Smith, 2014; Pfeffer & Salancik, 2003). In the literature, the construction sector is characterised as a highly competitive sector with low concentration (Ball et al., 2000; Bremer & Kok, 2000; Lowe, 2011; Staniewski et al., 2016). We, therefore, expected that a majority of the wood-based firms would have board interlocks with firms in other industries. Our results, based on the analysis of registry data, show that of the 357 wood-based firms 81% (N = 289) are interlocked with other firms, which supports our hypothesis. This was also confirmed by the case studies. However, our data does not cover the prevalence of mergers and alliances among wood-based firms. This means that we are not able to conclude that board interlocking is the most likely strategy for wood-based firms.

The second hypothesis (*H2*) relates to another characteristic of the construction sector which is the complex supply chain. A construction supply chain encompasses architects, engineers, builders, and suppliers (Gosselin et al., 2021; Vrijhoef & Koskela, 2000). The complexity of the supply chain also increases because of the frequent changes in product, production, and location (Papadopoulos et al., 2016). We expected that this complexity of the supply chain would lead to wood-based

firms having board interlocks with actors across the construction supply chain, based on the potential for needed coordination board interlocks provides by establishing communication channels between firms (Hillman, 2005; Malatesta & Smith, 2014; Schoorman et al., 1981). Our results show that wood-based firms have board interlocks with industries across the construction supply chain and our hypothesis is supported. However, some industries are more prominent than others, and the extent of board interlocks is quite limited on the supply side, especially within the forestry industry, an important industry considering its role as the main supplier industry. The case studies have also shown that the interlocking with actors across the wooden construction supply chain is limited especially regarding the supply side. Some interlocking could be traced down the value chain with the retail sector. However, there was also an important exception of the small construction engineering consultancy *Omega*, which interlocks with many relevant actors in the value chain.

The third hypothesis (*H3*) stated that wood-based firms use board interlocks to secure access to material resources. Wood-based firms are especially dependent on one type of material. We expected them to be more likely to have board interlocks with firms that may supply the necessary materials, due to board interlocks having the potential to secure a persistent and reliable flow of resources (Mizruchi, 1996). However, our results show that this does not seem to be the case. This is supported by the fact that the main supplier industry — agriculture, forestry, and fishing — is among the industries which few of the firms that the wood-based firms are interlocked with are found within, compared to other industries in the construction supply chain. In the interviews, one informant highlighted the fact that there may be a large difference between the materials and products a firm produces and the materials and products a firm needs, even if there exists a board interlock between the two firms. It also became clear that material selection must be based on a consideration of what the best material is for a specific purpose. This suggests that even if there exists a board interlock between a wood-based firm and a construction firm, wood might not be viewed as the best material for a specific purpose, and so another material is used. One implication of this is that it may be difficult to use board interlocks in this way because it creates an expectation between firms that may be difficult to fulfil. Another important aspect is that board interlocks may be too weak of a connection. Based on the interviews, it seems like stronger connections, such as ownership, are needed to secure access to material resources. However, this should not be interpreted as the only motivation for parent firms to have interlocks with firms they have ownership shares in. The interviews highlighted that an important motivation for board interlocks, in the case of ownership, is to have control over the parent firms' investments, receive information, and have influence over the future development of the firm. Additionally, the informants described how using board interlocks in this way may be difficult because of the issue related to disqualification and things may appear to the outside. As a result, it does not seem like board interlocks have the role we expected in terms of securing access to material resources. This conclusion is also confirmed by the case studies.

The fourth hypothesis (*H4*) was related to the use of board interlocks as a method for securing access to immaterial resources, such as knowledge and skills. In the literature, it is suggested that board interlocks have the potential to function as transfer channels for immaterial resources (Barringer & Harrison, 2000; Haunschild & Beckman, 1998; Pfeffer & Salancik, 2003). Teece (2007) describes how such immaterial resources are important for the dynamic capabilities of a firm which involve sensing, seizing and reconfiguration. Our informants highlighted knowledge and experience from wood-based firms as a reason for becoming BoD members, and several of them had work experience with firms that use wood as a material even though they did not mention this explicitly as a reseason for becoming a BoD member of a wood-based firm. Moreover, they stressed the need for experience, knowledge, and skills related to business management as well as market understanding, which seem to relate to the role of the BoD as having a special responsibility for the long-term development and future opportunities for the firm. It was also supported by the case studies that a varied composition of the BoD is crucial for the possibilities to access immaterial resources such as knowledge, expertise, and skills. Here larger firms have a clear advantage. The case studies have shown that the active participation of BoD in strategy development supports the professionalisation of management and the increased focus on sustainability. Here, also smaller firms can be active, but it depends on the knowledge, expertise, and skills of the BoD members. Thus, our hypothesis about the use of board interlocks as a method for securing access to immaterial resources seems to be supported. It also seems like they contribute to all aspects of Teece's (2007) theory of dynamic capabilities: sensing, through their understanding of the market; seizing, through their knowledge and experience concerning new opportunities; and reconfiguration, through their business and management skills. Thus, board interlocks seem to provide essential input in the wood-based firms' ability to engage in these processes, and thereby constitute an important contribution to firms' dynamic capabilities, which is closely linked to their ability to innovate. At the same time, the interviews have shown that there are some issues that might hinder the use of board interlocks, such as the qualification of the BoD members in making decisions which may benefit the firm of the BoD member, legal issues, election procedures, and competition with other firms. Nevertheless, we find support for our hypothesis that wood-based firms use board interlocks to secure access to immaterial resources.

A final question that remains is how our findings relate to the two gaps highlighted in the literature that we aimed to address. The first gap focused on whether board interlocking is a viable interfirm governance structure for overcoming the barriers to increased wood in construction. In this respect, we believe that our findings suggest that board interlocks seem to be a viable interfirm governance structure to overcome the first barrier related to the lack of material expertise among actors in the supply chain. However, based on our

findings we are not able to say if board interlocking is enough to overcome the barrier related to lack of coordination and collaboration across the supply chain. Although we now know that wood-based firms have board interlocks with firms across the construction supply chain, this does not necessarily imply increased coordination and collaboration. Furthermore, since board interlocks are not used to secure access to material resources due to the weak connection as well as legal and worries about how it might appear as an unfair advantage to the outside world (which might have established more long-lasting collaborations), it seems that other interfirm governance structures such as strategic alliances and mergers are needed to overcome this barrier. The second gap is focused on the potential for unpacking the role that board interlocks could have for innovation. Our results suggest that this is due to the input that enables wood-based firms to engage in the processes that are important for a firm's dynamic capabilities, which is closely related to their ability to innovate (Teece, 2007). This needs to be explored further as we are not able to connect these two parts empirically within the limits of this paper.

6. CONCLUSION

This paper contributes to the understanding of the role of board interlocks in increasing the use of wood in construction. Through analyses of registry data and case studies, we show that board interlocks exist between wood-based firms in the construction supply chain and other firms. Furthermore, the firms that the wood-based firms are interlocked with belong to industries across the construction supply chain. Most importantly, the additional analyses of the interview data and case studies allow us to nuance our understanding of the role of such board interlocks.

We do not find support for our hypothesis that board interlocks function as a way to secure access to material resources. However, they do have an important role in securing access to immaterial resources, such as knowledge, expertise and skills, but also in strategy development. More specifically, knowledge and experience from using wood as a material, business and management skills, and market understanding are all important. These immaterial resources accessed through board interlocks seem to provide essential input into the wood-based firms' ability to engage in sensing, seizing, and reconfiguration processes. Thereby, this constitutes an important contribution to firms' dynamic capabilities, which are closely linked to their ability to innovate. These findings lead us to conclude that board interlocking is a viable interfirm governance structure for overcoming one of two barriers to increased use of wood in construction, namely lack of material expertise among the actors in the construction supply chain. Furthermore, we suggest board interlocks through their access to specific immaterial resources enable the wood-based firms to engage in processes that are important for a firm's dynamic capabilities. These processes are, subsequently, closely related to their ability to innovate, and that creates the link between firms having board interlocks and innovation.

There are certain limitations to this study. The comprehensive registry data allows for a very broad analysis, but it also limits our ability to study the data in a detailed manner. In addition, the selection of wood-based firms in the construction supply chain is probably not complete. There may be wood-based firms that have not been included. However, other methods may have been too broad in terms of inclusion or required an extensive amount of time and resources. Furthermore, historic registry data was not available, which does limit us to studying data collected at one point in time. This means that we were not able to discuss development over time. Just the case studies provided some insights, by looking at the development of strategic objectives and economic results. Regarding the interview data, more interviews would have been preferable, but due to the difficulties involved in recruiting informants, this was not possible in the time available.

Future research could focus on further exploring the role of board interlocks in increasing the use of wood in construction. In particular by connecting the role of board interlocks to innovation, not only theoretically, but also empirically. Future studies may also consider board interlocks and their relation to alliances and mergers which has not been addressed in this paper. Finally, we suggest that studying firms who have made a transition from just concrete-based construction or are in a transition towards the use of more wood-based materials may be an important avenue for future research.

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APPENDIX A

Table A.1. Interview guide

Q1	Could you please tell us about your experiences with being a board member of firms in the construction industry and the forestry industry? Which type of firms are these mainly? ○ Forestry/logging ○ Producer of building/construction materials ○ Builder ○ Architect ○ Contractor ○ Other
Q2	What is your contribution to the work of the board of directors in these firms? ○ Knowledge about using wood as a construction material ○ Knowledge about other areas (economics, corporate governance, etc.) ○ Connections/contacts with other relevant firms ○ Experience from being a board member of other firms ○ Other
Q3	How did you become a member of these boards of directors? ○ Knowledge about using wood as a construction material ○ Knowledge about other areas (economics, corporate governance, etc.) ○ Connections/contacts with other relevant firms ○ Experience from being a board member of other firms ○ Other
Q4	What is your impression of why firms use or do not use wood-based materials/construction materials? ○ Risk related to changes in customer base and expectations from investors ○ Lack of competence ○ Attitudes ○ Path dependencies/lock-ins ○ Lack in demand ○ Uncertainties regarding access to materials
Q5	What is your role or the board members' role in facilitating more use of wood-based materials/construction materials? ○ Knowledge about relevant firms that could supply materials ○ Knowledge/experience from similar transitions/processes in other firms ○ Knowledge about using wood as a construction material ○ Experience with public builders
Q6	What do you think will be decisive for increasing the use of wood-based materials/construction among firms in the future? ○ Knowledge/competence in the firms — employees/leaders ○ Knowledge/competence in the board of directors/among board members ○ Collaboration among the board of directors across the supply chain ○ Improved framework conditions — authorities

Table A.2. Codebook used for coding of interviews

Code	***Description***
Background of the informant	What kind of background does the informant have (previous work and board experience, education, etc.)?
The role of the board of directors	What role does the board of directors have in relation to the firm?
Reason for board interlocks — material resources	Material — resources or sale of products.
Reason for board interlocks — immaterial resources	Immaterial — knowledge, expertise and skills/competencies.
Issues related to board interlocks	Qualification/disqualification, appearance to the outside, competition, election procedures, etc.
Other forms of connections	Ownership, mergers and alliances