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Managing the complexity of green innovation

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Abstract

Purpose – Green innovation can promote both environmental sustainability and economic growth. However, its development and implementation can be complex due to the need to align innovation activities within and across companies. In this study, the authors examined how this complexity can be managed by analyzing how individual companies combine different innovation activities to develop green innovation, and how companies along the value chain align to implement these innovations.

Design/methodology/approach – The dataset comprises both interviews and a survey of senior executives from the Swedish wood construction industry. These data were first analyzed by using fuzzy set qualitative comparative analysis (fsQCA) to identify innovation activity configurations at the level of the individual company. The interviews were then analyzed to identify alignment mechanisms enabling the implementation of green innovation along the value chain.

Findings – At the company level, the authors found three innovation activity configurations with varying levels of complexity: (1) systemic innovation by proactive companies, (2) process innovation by reactive companies and (3) inaction by technology-independent companies. On the value chain level, the authors found three alignment mechanisms that facilitate the implementation of green innovation along the value chain. These mechanisms promote cooperation by increasing efficiency, opening up new market opportunities and increasing the level of servitization.

Originality/value – This paper analyzes the complexity of green innovation and provides novel insights into how complexity is managed at the level of both the individual company and the value chain.

Keywords Complexity, fsQCA, Green innovation, Innovation, Sustainable development, Value chain

Paper type Research paper

1. Introduction

High levels of industrialization and increased consumption have contributed to growing the economy, at the cost of environmental degradation. A recent report by the International Panel on Climate Change (IPCC) warns that only drastic reductions in CO_2 emissions can prevent severe climate breakdowns (IPCC, 2021). These types of wake-up calls, together with increasing pressure from customers and stakeholders, have spurred companies into searching for cleaner ways to operate along their value chains (Albort-Morant *et al.*, 2016; Aldieri *et al.*, 2019; De

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Medeiros *et al.*, 2014). There is growing hope that developing green innovation can provide solutions to this challenge by mitigating environmental risks and providing more sustainable production and consumption alternatives (Machiba, 2011; Wu *et al.*, 2019).

Although green innovation is a promising avenue of increased sustainability, it is riddled with complexity stemming from the difficulties and uncertainties surrounding how to align activities both within and across companies to make green innovation possible (Afeltra *et al.*, 2021). At the level of the individual company, green innovations can take multiple forms, including the development of "products (goods and services), processes, marketing methods, organizational structure, and new or improved institutional arrangements" that lead to "a reduction of the environmental impact in comparison with alternative practices" (OECD, 2010, p. 2). Therefore, individual companies have a complex set of options at their disposal when it comes to developing green innovation (Iñigo and Albareda, 2016). Simultaneously, the successful implementation of green innovation requires coordination at the value chain level (Hong *et al.*, 2009). This creates complexity due to the need to involve multiple actors and activities in order to implement innovations (Kim and Wilemon, 2003), also requiring that actors find a shared strategic direction (Dougherty, 2017). Since complexity can significantly slow down the rate of innovation diffusion (Rogers, 1983), we need to understand how it can be managed in the context of green innovation.

This study aims to develop our understanding of the complexity of green innovation by analyzing how individual companies develop such innovations, and how these innovation activities are aligned along the value chain. To study this, we focused on the Swedish construction industry and how new engineered-wood solutions are developed and implemented. Our data consist of both interviews and a survey of 24 senior managers in the development of engineered-wood solutions. The data were first analyzed using fuzzy set qualitative comparative analysis (fsQCA) (Ragin, 2000; Fiss, 2011), which allowed us to outline reoccurring innovation patterns along the value chain. The interview data were then analyzed in order to understand how innovations along the value chain are aligned in order to implement green innovation.

Our study makes three main contributions. First, we show how individual companies combine different innovation activities to create green innovation. These configurations include: *systemic innovation* by proactive companies to reap synergistic benefits, *process innovation* by reactive companies only adapting to new situations to make a profit and *inaction* by technology-independent companies not needing to focus on innovation in order to be sustainable since sustainability does not bring them any new business value.

Second, we found three alignment mechanisms that facilitate the implementation of green innovation by accounting for the heterogeneous innovation activities and business potential of green innovation for different companies. These mechanisms focus on *increasing efficiency* (less time, workforce, construction noise and optimized logistics along the value chain), *creating new market opportunities* (building new types of multistorey buildings and attracting new customers) and *increasing the level of servitization* (changing the mindset from volume to value).

Third, we found that being motivated to implement green innovation was not primarily related to a desire to solve environmental problems. Instead, it relates to a need to address the industry-related problems that companies face in their day-to-day work, such as increased competition, low productivity, saturated markets and the dominant role played by existing actors (Del Río *et al.*, 2016). This means that green innovation needs to respond to industry-specific problems to successfully mobilize different actors along the value chain.

2. Theoretical background

2.1 Green innovation

Green innovation can be understood as a type of innovation that benefits the environment (Afeltra *et al.*, 2021), having been referred to as *eco-*, *ecological* or *environmental innovation*

(Schiederig *et al.*, 2012). Green innovation is a subset of the more inclusive concept of *sustainable innovation*, which includes environmental, social and economic dimensions (Boons *et al.*, 2013). Although green innovation is a relatively young research field (Bigliard and Bertolini, 2012; Díaz-García *et al.*, 2015), it is growing in popularity due to its significant impact on environmental and economic performance (Afeltra *et al.*, 2021; Oduro *et al.*, 2021). Specifically, green innovation is the development of "products (goods and services), processes, marketing methods, organizational structure, and new or improved institutional arrangements" that result in "a reduction of the environmental impact in comparison with alternative practices" (OECD, 2010, p. 2). This can range from incremental changes to radical shifts (Del Río *et al.*, 2016) implemented during the manufacturing phase or provided to end-customers as a product (Costantini *et al.*, 2017).

Given that green innovation can differ in terms of type and novelty, companies have various reasons to develop it. Major drivers of green innovation are primarily related to regulations and market pull (De Medeiros *et al.*, 2014; Albort-Morant *et al.*, 2016; Hojnik and Ruzzier, 2016). However, other drivers also include increasing efficiency (Horbach *et al.*, 2012), expanding market share (Green *et al.*, 1994) and cooperating with a wider range of stakeholders (De Marchi, 2012), as well as changes in the technological environment at the industry level (Oltra and Saint Jean, 2009). Although green innovation becomes part of the DNA of some companies and a cornerstone of their competitive advantage (Bocken *et al.*, 2014), other companies limit their focus to complying with environmental regulations in order to gain legitimacy (Li *et al.*, 2018).

Despite its promise, green innovation can pose several challenges. First, its various forms range from incremental to radical and systemic change (Carrillo-Hermosilla *et al.*, 2010). This can create complexity at the individual company level (Petruzzelli *et al.*, 2011) due to the need to align and coordinate different innovation activities (Kim and Wilemon, 2003). This kind of complexity can make innovations hard to understand, negatively influencing their diffusion (Rogers, 1983; Martínez-Vergara and Valls-Pasola, 2020). Second, collaboration between companies plays a crucial role in developing and implementing green innovation (Hong *et al.*, 2009; Szekely and Strebel, 2013) because the actors along the value chain must be aligned in order to deliver value to their customers. This can create inter-organizational complexity and require cooperation between organizations to create opportunities for sharing knowledge, resolving conflicts, learning and maintaining relationships (Kim and Wilemon, 2003; Poutanen *et al.*, 2016). Failure to cooperate can hamper innovation diffusion by creating competition between companies (Huhtala *et al.*, 2014), while a lack of communication can make it hard to understand what value new innovations bring (Goldenberg *et al.*, 2010). Next, we examine the two forms of complexity in more detail in order to orient this paper further.

2.2 The complexity of green innovation at the individual organization level

Pursuing green innovation can require diverse activities at different organizational levels. Successful management necessitates coordination since activities can span multiple functional groups and geographical locations, and may be embedded within diverse structures (Kim and Wilemon, 2003; Iñigo and Albareda, 2016). This generates a high level of organizational complexity, creating the need to identify and align different innovation activities in order to successfully manage them (Chapman and Hyland, 2004; Sihvonen and Pajunen, 2019).

Existing research provides multiple classifications for identifying different innovation activities (e.g. Chapman and Hyland, 2004; Damanpour *et al.*, 2009). These classifications generally distinguish between the development of new products and services, creating and improving processes, changing how offerings are perceived through repositioning and innovating the organization's business model (Abernathy and Utterback, 1978; Jayanthi and Sinha, 1998; Francis and Bessant, 2005; Khazanchi *et al.*, 2007; Torres and Augusto, 2020).

Following on from this, we distinguished between four major types of innovation activities in this study: (1) product innovation, (2) process innovation, (3) positioning innovation and (4) business model innovation. Table 1 provides a working definition, along with key references related to each innovation type.

Although combining different innovation types generates complexity, multiple studies have argued for understanding the interdependence of different innovation types in order to simultaneously implement them (Baregheh *et al.*, 2014; Snihur and Wiklund, 2018). The main motivations for pursuing complex innovation activities relate to both potential synergistic benefits (Damanpour *et al.*, 2009) and achieving competitive advantage by successfully executing activities that are costly, require dedication and are difficult to duplicate (Kim and Wilemon, 2003). Although the need to manage different activities, and their interdependencies, creates complexity, it can simultaneously generate significant benefits.

2.3 The complexity of green innovation at the value chain level

Green innovation projects can span multiple actors and require a systemic view of innovation activities (Chadha, 2011; Dangelico *et al.*, 2017). This entails aligning actors as regards cooperation in order to make innovation possible (Chadha, 2011; Prajogo *et al.*, 2014). The challenge of managing such complexity lies in defining new roles for organizations, roles that can break traditional firm-customer dyads and form new interdependencies and cooperation patterns (Horbach, 2008; De Marchi, 2012; Poutanen *et al.*, 2016). This creates a layer of complexity that requires a specific focus on maintaining and managing relationships, keeping alliances and partnerships intact, and finding a strategic direction shared by all parties (Kim and Wilemon, 2003; Dougherty, 2017).

An inability to coordinate and align activities can result in the slower implementation and diffusion of innovation (Sihvonen and Pajunen, 2019), poor unit-cost outcomes (Tatikonda and Rosenthal, 2000), and unforeseen shifts in relationships and power balances between actors (Kim and Wilemon, 2003). Conversely, the successful management of value chain complexity can strengthen relationships between stakeholders (Kim and Wilemon, 2003), enhance cooperation when all parties are complementary (Nightingale, 2000), and improve learning and the development of new organizational capabilities (Nightingale, 2000; Chapman and Hyland, 2004). Therefore, managing complexity at the value chain level is crucial to successful innovation.

3. Methodology

We chose the construction industry as our research context, focusing on engineered wood as an emerging segment that concentrates on developing green infrastructure using wood instead of concrete. The construction value chain consists mainly of project-based organizations using temporal collaboration patterns, with actors in the value chain

Innovation type	Definition	Key references
Product innovation	New goods or services commercialized in the marketplace	Utterback and Abernathy (1975), Damanpour (1991)
Process innovation	New elements and methods of improving production or service delivery	Utterback and Abernathy (1975), Damanpour (1991)
Positioning innovation	Redefining the positioning of the product or service in the eyes of the customer	Francis and Bessant (2005)
Business model innovation	Innovation of the business model elements and their linkages	Foss and Saebi (2018)

Table 1. Different innovation types, their definitions and key references

including material and equipment producers, architects, engineers, contractors, installers and suppliers. These characteristics fit well with the goal of this study since individual actors develop their own innovations and their activities must be aligned in order to implement construction projects. In addition, studying the construction industry is highly important since it is a major source of CO_2 emissions, according to the United Nations Environment Programme [1].

Given that this research aims to develop our understanding of the complexity of green innovation on both the company and value chain levels, we needed an approach that helps us to explore both individual companies and their interrelationships on the value chain level. To do this, we combined two analytical techniques to enable ourselves to first examine individual companies' innovation activities and then study how these activities are aligned on the value chain level. First, we selected QCA as a method of studying innovation activities on the individual company level. This method helped us to systematically compare companies' innovation activities, identify reoccurring patterns and explain how different configurations of activities lead to sustainable outcomes. Previously, Torres and Augusto (2020) used this approach to study the complementarity of different forms of innovation. Second, to understand how individual companies' innovation activities are aligned on the value chain level, we used within- and cross-case analysis techniques (Eisenhardt, 1989). This helped us to gain deeper knowledge of alignment mechanisms that facilitate cooperation and the implementation of green innovation by aligning actors in order for them to achieve joint goals. In the following section, we provide a more detailed explanation of our data collection and analysis procedures.

3.1 Data collection

We collected data focusing on the Swedish construction industry, particularly the segment that develops and implements engineered-wood solutions. Here, engineered wood refers to the segment of the construction industry that constructs multistorey wood buildings. This distinguishes it from how wood is more commonly used in smaller buildings, such as the town houses that are common in the Nordic countries.

We collected data between 2019 and 2020, focusing on companies that had recently implemented new technology for building multistorey wooden buildings. We identified 24 CEOs and senior managers along the construction value chain and asked them about their willingness to participate in our research. All agreed to participate in an interview (see Table 2 for a full list of participants). The interviews were semi-structured and lasted between 40 and 150 min. Face-to-face interviews were conducted with three of the participants, while 21 of the interviews were conducted using digital meeting tools due to restrictions related to the coronavirus disease 2019 (COVID-19) pandemic. According to the preferences of the interviewees, eight interviews were conducted in English and the other 16 in Swedish. All of the interviews were recorded and transcribed, providing us with a deep understanding of how engineered-wood technology functions and how various activities contribute to green innovation.

We supplemented the interviews with a survey in which we asked the same participants to evaluate which innovation activities (product, process, position and business model innovation) are required to develop engineered-wood offerings and also to rate the impact that engineered-wood products have on business value and sustainability. All the questions were based on a 7-point Likert scale and the questions are presented in Table 3. We received a total of 24 responses to our survey. The next section will explain how these data were analyzed.

3.2 Analyzing green innovation complexity at the company level

To analyze how individual companies develop green innovation, we used fsQCA, which is grounded in Boolean algebra and case comparison (Ragin, 2000). This method assumes

Interviewee #	Firm's role in the construction industry	Market focus	Firm size (employees)	Interviewee's position at the firm
Interviewee 1	Materials manufacturer	International	26,000	Vice-president Strategy
Interviewee 2	Materials manufacturer	International	26,000	Business Developer
Interviewee 3	Materials manufacturer	International	26,000	Program Manager
Interviewee 4	Materials manufacturer	International	26,000	Product Manager
Interviewee 5	Materials manufacturer	International	26,000	Head of a business unit
Interviewee 6	Materials manufacturer	International	26,000	Senior Vice-president Supply Chain
Interviewee 7	Materials manufacturer	International	26,000	Digital Advisor
Interviewee 8	Materials manufacturer	International	26,000	Head of a business unit
Interviewee 9	Architects and engineers	Domestic	5	CEO
Interviewee 10	Product manufacturer	Domestic	61	CEO
Interviewee 11	Contractor	Domestic	14	CEO
Interviewee 12	Contractor	Domestic	30	Co-owner
Interviewee 13	Product manufacturer	Domestic	491	CEO
Interviewee 14	Contractor	International	6,447	Head of Department
Interviewee 15	Contractor	Domestic	85	CEO
Interviewee 16	Service provider	Domestic	4	CEO
Interviewee 17	Contractor	Domestic	20	Head of Human Resources and Finance
Interviewee 18	Architects and engineers	International	605	Chief Architect/ Operations Manager
Interviewee 19	Architects and engineers	International	605	Chief Architect/ Operations Manager
Interviewee 20	Architects and engineers	Domestic	25	Project Manager
Interviewee 21	Materials and equipment supplier	Domestic	50	CEO
Interviewee 22	Service provider	Domestic	18	CEO
Interviewee 23	Contractor	Domestic	179	Section Manager
Interviewee 24	Contractor	Domestic	23	CEO/Co-owner

Table 2. List of interviewees

causal complexity and makes three main assumptions relating to *conjunctural causation* (an outcome is usually generated by a combination of conditions), *equifinality* (different combinations of conditions can lead to the same outcome) and *causal asymmetry* (a condition can have a positive, a negative or no effect on the outcome depending on the configuration that it is a part of) (see Fiss, 2011; Misangyi *et al.*, 2017). These characteristics make fsQCA a suitable method for studying how complex combinations of activities lead to an outcome (Sihvonen and Pajunen, 2019). In practice, we used the fsQCA 3.0 software to perform our analyses (Ragin and Davey, 2016), following the best practice guidelines of Greckhamer and colleagues (Greckhamer *et al.*, 2018).

First, the survey variables were calibrated into conditions. We used the *direct calibration method* (Ragin, 2000) to specify qualitative anchors that corresponded to the set membership scores of being *fully in* the set (1), at *the crossover point* (0.5) and *fully out* of the set (0). We examined and individually calibrated each condition and outcome (see Table 3). Full membership corresponded to 7 on the Likert scale, while full non-membership corresponded to the minimum point on the scale. The crossover point corresponded to the point of central tendency (mean value). Values above/below the crossover point indicated the differences in kind between the high and low levels of importance of each factor, in relation to the average value (Rubinson *et al.*, 2019).

Second, we examined whether the presence or absence of a single condition was necessary for the outcome to occur. Using the software, we analyzed the *consistency* and *coverage* scores.

Condition "*High importance of . . .* "	Question/measure "*In my organization, engineered wood products . . .* "	Type	Max (full membership)	Mean (crossover point)	Min (full non-membership)
Product innovation	. . . require innovation of the products themselves	Condition	7	5.3	3
Process innovation	. . . require changes in the way we create and deliver them	Condition	7	5.1	3
Positioning innovation	. . . require changes in how customers perceive our offerings	Condition	7	5.1	2
Business Model Innovation	. . . require innovation of the business model	Condition	7	4.1	2
Business value	. . . increase our market share . . . provide stable growth . . . generate sufficient revenues	Condition	7	5.3	3
Sustainability	. . . contribute to sustainability and reduce environmental impact	Outcome	7	5.9	4

Table 3. Calibration of conditions as fuzzy-sets

This analysis revealed no necessary conditions, suggesting that the outcome was created by configurations of conditions.

Finally, we performed a truth-table analysis to identify configurations that were sufficient to produce high sustainability. We applied a consistency threshold of 0.80 and a frequency threshold of at least two cases (Greckhamer *et al.*, 2018). The configurational chart (Table 4) shows the configurations of conditions resulting in high sustainability. The configurations are accompanied by consistency and coverage scores for the intermediate solution, as well as our interpretation of the meaning of these configurations, against the backdrop of our qualitative data.

3.3 Analyzing green innovation complexity at the value chain level

We analyzed individual interviews to outline companies' reasons for collaborating with other value chain members in order to understand how they both collaborate and implement engineered-wood solutions. Then, we compared these reasons across the interviews to find recurring themes. These procedures correspond with the logic of within- and cross-case analyses (Eisenhardt, 1989), and they enabled us to identify three frequently recurring reasons for collaboration. We labeled these reasons as alignment mechanisms since they bring together heterogeneous actors to execute joint projects. In doing so, they follow the mechanism logic by explaining how individual actors' activities function together at a more abstract level (Sihvonen *et al.*, 2021).

4. Findings

We present our findings in two stages to develop an understanding of the complexity of green innovation and how it is managed. We first shed light on how individual companies manage

Table 4. Configuration chart for the outcome of high sustainability*

Configurations	High sustainability 1	2	3
Conditions			
Product innovation	●		⊗
Process innovation	●	●	⊗
Position innovation	●	⊗	⊗
Business model innovation	●	⊗	⊗
Business value	●	●	⊗
Qualitative interpretation of the configurations	Becoming sustainable through systemic innovation (proactive)	Adapting to changes through process innovation (reactive)	Business as usual (inactive)
Consistency	0.81	0.90	0.83
Raw coverage	0.36	0.35	0.29
Unique coverage	0.19	0.13	0.08
Solution consistency		0.78	
Solution coverage		0.62	

Note(s): *Black circles indicate the presence of a condition, while circles containing an "X" indicate its absence and blank spaces indicate that the presence or absence of the condition does not matter to the configuration. The configuration chart illustrates the intermediate solution, while large circles indicate the core conditions of the parsimonious solution

the complex set of innovation options at their disposal. Thereafter, we analyze how alignment mechanisms enable different companies to jointly cooperate and implement green innovation. This provides an understanding of how the complexity of green innovation is managed at both the company and value chain levels.

4.1 Green innovation at the individual–company level

To analyze green innovation complexity at the company level, we used fsQCA to uncover how individual companies combine different innovation activities. This revealed three configurations that led to high sustainability. Table 4 presents the configurations and our qualitative interpretation of each one. In the following section, we analyzed these configurations further, with the help of qualitative data.

4.1.1 Systemic innovation by proactive innovators. Configuration one includes all the different types of innovation activities. It also includes high business value and results in high sustainability. Companies in this group include materials and products manufacturers and material suppliers. For these companies, green innovation constitutes a major change in all aspects of their business. One senior vice president explained the rationale behind the broad range of innovation activities:

> I would say we are trying to look in all areas for innovation. We are currently working a lot in process innovation and business model innovation [. . .] we see a lot of opportunities for us. (Interviewee 4)

This innovation approach is characterized by a proactive strategy for scaling up new technology and leading the sustainability trend in the construction industry. This logic was well summarized by one informant, who explained the importance of wood construction and its role in propagating this trend:

> We, as a player that is connected to building with wood, have created a lot of interest in the last couple of years in the construction industry. So, there is a kind of trend, taking place at the moment . . . [It is] creating a lot of tailwinds for construction with wood, which is also influencing the construction industry. (Interviewee 5)

In addition to companies' proactive stances, the wide range of innovation activities can also be explained by the key role of material manufacturers and suppliers as frontrunners in developing the construction industry. As one head of the business unit explained:

> . . . with our size we have certain responsibilities for the market. And we definitely see us in a role of a forerunner and consequently we also hope to be in a role of a game changer. (Interviewee 5)

In this way, material producers act as proactive catalysts in spreading new and sustainable technology that forms the core of their businesses. Overall, configuration one illustrates that green innovation can be viewed as a systemic innovation that involves innovation in all business areas. This is accompanied by a proactive stance, since these actors provide green technologies for the rest of the value chain.

4.1.2 Process innovation by reactive innovators. Configuration two includes process innovation and high business value as the two preconditions for high sustainability. It also does not include position nor business model innovation. Companies in this group include material and product manufacturers, as well as contractors and builders. These companies perceive engineered wood to be an opportunity to develop processes that accommodate new construction materials. They tend to emphasize the importance of internal process innovation in improving their own businesses toward sustainability. As one informant noted:

> The biggest need is in the internal processes, for example, how should the CAD system be managed? [. . .] What we can do is to digitalize production. (Interviewee 7)

This approach to green innovation can be characterized as reactive since these companies adapt by developing new processes. They see the value of working with new technology and they respond to it by innovating their established processes. The response by contractors and builders to the emerging trend of green innovation is simply a reaction to ongoing development. Their focus is not on spreading new technology along the value chain, but on changes that will maximize benefits for them and their customers. One contractor explained:

> We want to develop the internal processes that simplify things for us and our customers. (Interviewee 14)

Configuration two shows that, for some companies, green innovation is only an opportunity to develop new processes and to reap business value from them. This approach is characteristically reactive since these companies focus on adapting to the changes in the value chain that accompany the introduction of new and sustainable building materials.

4.1.3 Inaction by technology-independent actors. Configuration three has no innovation activities or added business value, yet it still leads to high sustainability. Companies in this group include architects and engineers, and certain contractors. The introduction of new and sustainable technology does not require a high degree of innovation, or bring any added business value to these actors. This might sound counterintuitive at first, but these companies are applying existing knowledge and processes in adopting green technology. This means that high sustainability does not require a high degree of innovation or provide added business value, since working with wooden materials just constitutes one possible way of operating. One project manager explained this logic in the following way:

> Often the customer may decide on a particular material that they want. Those times that they want to build using wood, they usually want an environmental profile, and the interest for wooden constructions is increasing. Concrete is often cheaper and we are more familiar with it, especially when it is about noise and fire [. . .] But there is no difference in our ways of working that would depend on the material. (Interviewee 3)

This configuration describes actors that are mainly involved in designing products, where engineered wood is merely one potential material. These actors can easily adapt to different construction materials, whether or not they come from new and sustainable technologies. Therefore, this approach to green innovation is characterized by inaction since these companies' work is largely independent of technological change. However, they still play an important role in the value chain by incorporating green technology into final products. Overall, this configuration illustrates the fact that, for some companies, green innovation is just a tool for conducting day-to-day business. Therefore, when actors along the value chain work with highly customized offerings, their use of different materials already forms part of their day-to-day business and does not require any additional innovation activities.

4.2 Alignment of green innovation at the value chain level

The first part of our analysis uncovered a variety of ways in which individual companies approach and develop green innovation. Yet, these companies still need to cooperate in order to implement green construction projects. By analyzing our interview data, we identified three alignment mechanisms that help to manage complexity associated with involving heterogeneous actors in green construction projects. These are: (1) *increasing efficiency*, (2) *opening up new market opportunities* and (3) *increasing the level of servitization*. Next, we will elaborate on these mechanisms in more detail.

First, *increasing efficiency* is associated with reduced project time, a smaller workforce and better working conditions due to reduced noise levels at the construction site. Engineered wood is also lighter than steel and concrete, which reduces logistics costs. One senior manager, working for a materials producer, explained how these factors motivate companies to use engineered wood:

> I think the value is that we provide a solution, which allows [our] customers to build efficiently on the construction site. We are delivering sustainable products with incredible CO2 footprint in comparison to concrete and steel. We are delivering high quality products to them. What we also deliver is speed, which means that they are quickly able to build with this material. With multi-storey building projects, you can build faster, which allows investors to bring it quicker to the people who will rent the flat and thus have earlier return of investment. (Interviewee 6)

These benefits enable material producers to supply other actors with the means of improving their processes and creating higher value for their end customers. This helps align different actors in order to implement green innovation. However, increased efficiency also involves enhanced coordination, as one manager explained:

> Today, we see that the value chain is a little bit scattered and there is no optimization from the building order to the material supply and that is what we are going to change. There will be optimized value chain for our products that provide efficiency to the whole chain, so that ultimately, the building would be cheaper to construct and our products would increase the value. (Interviewee 1)

Therefore, increasing efficiency provides the means of improving processes and enhancing coordination. This motivates companies to cooperate and implement green innovation. However, these benefits hinge on proactive material producers since they develop the key technologies that more reactive or inactive parties adapt to.

Second, *opening up new market opportunities* is another key driver of companies becoming a part of the green innovation value chain. One CEO said the following about these opportunities:

> We've started working with actors and entrepreneurs and our idea is to tell them that we're now able to build taller houses. Where you can use [engineered wood] and dare to build higher. We need more

> knowledge about this. Architecturally, we can draw it, but we haven't yet produced this kind of taller building. (Interviewee 11)

Here, we see how implementing green innovation depends on having multiple actors in the value chain. While the proactive material producers play a key role in instigating the use of engineered wood, involving other parties in the value chain brings in knowledge that enables the construction of new types of buildings. This can unlock new market opportunities for the companies involved, as one contractor explained:

> One subject where we need more knowledge is detailed solutions for beams and load-bearing walls. Procedures for electrification, ventilation and sewage. There are detailed solutions for the traditional construction, but not so much for wood . . . (Interviewee 15)

Although involving multiple actors in the value chain can increase the level of complexity, due to the need for coordination, it can also simultaneously open up new market opportunities. This enables companies to expand their portfolios and attract new customers by providing new types of buildings in a trending market.

Finally, engineered wood also creates opportunities for *increasing the level of servitization*. This means a shift of mindset away from selling volume toward delivering value to the customer. To exemplify this idea, one senior manager working for a materials producer told us the following, as regards the importance of servitization:

> [We are] moving from volume business to customer service, [. . .] we have to improve our understanding what the customer actually wants, what they need. We need more resources in communication with the customers. Also, it is a shift in salespeople's mind-set, so that we are not driven by a volume, but more driven by the value we can provide. (Interviewee 1)

Increased servitization enables the rearranging of the value chain by aligning it better with customer needs. Rather than using standardized products and relying on traditional construction processes, buildings that use engineered wood can be adapted to customers' design preferences and built in less accessible locations in a shorter timeframe. This means that engineered wood not only provides new market opportunities, in terms of what can be built, but also enables meeting customer needs in a more efficient way by tailoring the offerings available.

5. Discussion and conclusion

The aim of this study was to understand the complexity surrounding the development and implementation of green innovation, and how this can be managed. We approached this by first analyzing how individual companies use different innovation activities to develop green innovation. Thereafter, we identified alignment mechanisms enabling cooperation at the value chain level. These analyses provided us with a number of key insights.

At the company level, we found three innovation activity configurations explaining how different companies approach the complex set of innovation options at their disposal. These configurations focus on: *systemic innovation* by proactive companies combining multiple innovation types in order to scale up green technology and to lead the sustainability trend in the construction industry, *process innovation* by reactive companies only adapting to the new environment to make a profit, and *inaction* by technology-independent companies not needing to focus on innovation in order to be sustainable and not gaining new business value from sustainability. For some actors, green innovation is thus directly aligned with both their business objectives and how they perceive their competitive advantage (Bocken *et al.*, 2014), explaining why they are conducting more complex innovation activities. However, other actors find green innovation more of a response to pressure to be legitimate (Li *et al.*, 2018), and as a form of ethical visibility that does not affect their current way of doing business. Therefore, these companies are less likely to conduct more complex innovation activities.

At the value chain level, we analyzed how companies collaborate in order to implement green innovation. This is because green innovation requires intense engagement between multiple actors (De Marchi, 2012), with complexity emerging from the need to form new cooperation patterns that create opportunities for resolving conflicts, sharing knowledge and maintaining relationships (Horbach, 2008). We found three alignment mechanisms that facilitate the implementation of green innovation: *increasing efficiency,* which can be achieved by reducing key variables (time, workforce required and noise levels) and by optimizing logistics, *opening up new market opportunities* by building new types of multistorey buildings, and *increasing the level of servitization* by a change of mindset away from volume toward value. These mechanisms create collective motivation that keeps alliances and partnerships intact (Kim and Wilemon, 2003; Dougherty, 2017) since they provide a shared strategic direction grounded in economic performance that aligns multiple actors for participating in the development and implementation of green innovation (Del Río *et al.*, 2016). Furthermore, servitization also involves a change in mindset since it entails a shift of focus away from selling standardized products toward combining products and services in an attempt to tailor offerings to better meet customers' needs (Lightfoot *et al.*, 2013). Understanding these three alignment mechanisms in the wood construction industry might offer opportunities to accelerate the adoption of new technology by different types of actors along the value chain (Rogers, 1983; Halila and Rundquist, 2011). Opinion leaders (Rogers, 1983) can also use these means to expedite the diffusion of green innovation.

These findings also extend our understanding of the drivers of green innovation. At the company level, our findings confirm the fact that companies engage in green innovation to increase efficiency (Horbach *et al.*, 2012; Asni and Agustia, 2021), or to change how they operate (Bocken *et al.*, 2014). However, our findings are unique because the value chain drivers have not been studied previously. Although efficiency and new market opportunities have been shown to drive individual companies into developing green innovation (Green *et al.*, 1994; De Marchi, 2012; Horbach *et al.*, 2012; De Medeiros *et al.*, 2014; Asni and Augusta, 2021), our findings show that this also applies at the value chain level. In addition, our findings show how developing green innovation is also driven by servitization that causes a shift of mindset away from volume toward value in order to become more responsive to customer needs.

The aforementioned drivers also highlight the fact that environmental dimensions are not perceived to be the main motive for developing green innovation (see also Bossle *et al.*, 2016). Rather, developing and implementing green innovation rests on its ability to address industry-related problems that actors face in their day-to-day work (Del Río *et al.*, 2016). These problems relate to increasing competition, low productivity, saturated markets and the dominant role of existing actors. Therefore, the driving force behind green innovation in the construction industry is not a desire to reduce the environmental footprint but a desire to address existing issues within the industry and to ensure a profitable future.

5.1 Managerial implications

Managing green innovation requires the execution of innovation activities within the company and collaboration between multiple actors with differing motivations and roles. This dynamic has three primary ramifications. First, when developing green innovation, the level of complexity that one has to deal with should be matched with the desired level of effect that one wants to achieve. In particular, if the goal is to achieve large-scale change, a more complex approach, using different innovation activities, makes sense. Conversely, if the goal is to take a more reactive stance, then a simpler approach would be suitable.

Second, when it comes to managing collaboration, a clear understanding of the various actors' roles along the value chain, in relation to new and sustainable technology, is important. Adopting a value chain perspective and understanding the various roles of the actors along the value chain can also help in creating collaboration among the actors that drives the implementation of green innovation on a larger scale. Failure to understand these roles may result in a competitive rather than a collaborative mindset, which can hamper the implementation of green innovation (as shown by Huhtala *et al.*, 2014).

Finally, for companies that assume a more proactive stance and try to become opinion leaders, aligning different actors in order to implement green innovation is best achieved by showing how green innovation can improve efficiency, open up new market opportunities and increase servitization. This helps anchor the benefits of green innovation in solving existing industry problems and opening up new opportunities, rather than replacing existing materials with a greener alternative. It is therefore essential that actors driving green innovation clearly communicate how green innovation can create value for other actors along the value chain, and not just focus on the promotion of sustainability. The construction industry has a high level of project orientation that requires operational and financial improvements to be clearly indicated in order for different actors to adopt new and sustainable technology and to engage in the diffusion of green innovation.

5.2 Limitations and suggestions for further research

As with any study, ours has certain limitations. First, fsQCA is sensitive to small changes in calibration and choices of cut-off values regarding frequency and consistency (Greckhamer *et al.*, 2018). To mitigate this, we examined different thresholds and calibration alternatives, and we also used qualitative data to bring depth to our analysis. Future research should further examine how individual companies configure their innovation activities to take advantage of green innovation opportunities. Second, this study was performed in the context of the Swedish construction industry, with a particular focus on the emerging technology of engineered wood. Although parallels with other types of green innovation can be drawn, we wish to underline the context-specific nature of our study. Future studies could examine these dynamics in other contexts.

Note

1. https://www.unep.org/news-and-stories/press-release/building-sector-emissions-hit-record-high-low-carbon-pandemic

References

Abernathy, W.J. and Utterback, J.M. (1978), "Patterns of industrial innovation", *Technology Review*, Vol. 80 No. 7, pp. 40-47.

Afeltra, G., Alerasoul, S.A. and Strozzi, F. (2021), "The evolution of sustainable innovation: from the past to the future", *European Journal of Innovation Management*, Vol. ahead-of-print No. ahead-of-print.

Albort-Morant, G., Leal-Millán, A. and Cepeda-Carrión, G. (2016), "The antecedents of green innovation performance: a model of learning and capabilities", *Journal of Business Research*, Vol. 69 No. 11, pp. 4912-4917.

Aldieri, L., Carlucci, F., Vinci, C.P. and Yigitcanlar, T. (2019), "Environmental innovation, knowledge spillovers and policy implications: a systematic review of the economic effects literature", *Journal of Cleaner Production*, Vol. 239 No. 2019, 118051.

Asni, N. and Agustia, D. (2021), "The mediating role of financial performance in the relationship between green innovation and firm value: evidence from ASEAN countries", *European Journal of Innovation Management*, Vol. ahead-of-print No. ahead-of-print.

Baregheh, A., Hemsworth, D. and Rowley, J. (2014), "Towards an integrative view of innovation in food sector SMEs", *International Journal of Entrepreneurship and Innovation*, Vol. 15 No. 3, pp. 147-158.

Bigliardi, B. and Bertolini, M. (2012), "Green innovation management: theory and practice", *European Journal of Innovation Management*, Vol. 15 No. 4, pp. 400-420.

Bocken, N.M., Short, S.W., Rana, P. and Evans, S. (2014), "A literature and practice review to develop sustainable business model archetypes", *Journal of Cleaner Production*, Vol. 65 No. 2014, pp. 42-56.

Boons, F., Montalvo, C., Quist, J. and Wagner, M. (2013), "Sustainable innovation, business models and economic performance: an overview", *Journal of Cleaner Production*, Vol. 45 No. 2013, pp. 1-8.

Bossle, M.B., De Barcellos, M.D., Vieira, L.M. and Sauvée, L. (2016), "The drivers for adoption of eco-innovation", *Journal of Cleaner Production*, Vol. 113 No. 2014, pp. 861-872.

Carrillo-Hermosilla, J., Del Río, P. and Könnölä, T. (2010), "Diversity of eco-innovations: reflections from selected case studies", *Journal of Cleaner Production*, Vol. 18 Nos 10-11, pp. 1073-1083.

Chadha, A. (2011), "Overcoming competence lock-in for the development of radical eco-innovations: the case of biopolymer technology", *Industry and Innovation*, Vol. 18 No. 3, pp. 335-350.

Chapman, R. and Hyland, P. (2004), "Complexity and learning behaviors in product innovation", *Technovation*, Vol. 24 No. 7, pp. 553-561.

Costantini, V., Crespi, F., Marin, G. and Paglialunga, E. (2017), "Eco-innovation, sustainable supply chains and environmental performance in European industries", *Journal of Cleaner Production*, Vol. 155 No. 2, pp. 141-154.

Damanpour, F. (1991), "Organizational innovation: a meta-analysis of effects of determinants and moderators", *Academy of Management Journal*, Vol. 34 No. 3, pp. 555-590.

Damanpour, F., Walker, R.M. and Avellaneda, C.N. (2009), "Combinative effects of innovation types and organizational performance: a longitudinal study of service organizations", *Journal of Management Studies*, Vol. 46 No. 4, pp. 650-675.

Dangelico, R.M., Pujari, D. and Pontrandolfo, P. (2017), "Green product innovation in manufacturing firms: a sustainability-oriented dynamic capability perspective", *Business Strategy and the Environment*, Vol. 26 No. 4, pp. 490-506.

De Marchi, V. (2012), "Environmental innovation and R&D cooperation: empirical evidence from Spanish manufacturing firms", *Research Policy*, Vol. 41 No. 3, pp. 614-623.

De Medeiros, J.F., Ribeiro, J.L.D. and Cortimiglia, M.N. (2014), "Success factors for environmentally sustainable product innovation: a systematic literature review", *Journal of Cleaner Production*, Vol. 65 No. 2014, pp. 76-86.

Del Río, P., Peñasco, C. and Romero-Jordán, D. (2016), "What drives eco-innovators? A critical review of the empirical literature based on econometric methods", *Journal of Cleaner Production*, Vol. 112 No. 2016, pp. 2158-2170.

Díaz-García, C., González-Moreno, Á. and Sáez-Martínez, F.J. (2015), "Eco-innovation: insights from a literature review", *Innovation*, Vol. 17 No. 1, pp. 6-23.

Dougherty, D. (2017), "Taking advantage of emergence for complex innovation eco-systems", *Journal of Open Innovation: Technology, Market, and Complexity*, Vol. 3 No. 3, p. 14.

Eisenhardt, K.M. (1989), "Building theories from case study research", *Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Fiss, P.C. (2011), "Building better causal theories: a fuzzy set approach to typologies in organization research", *Academy of Management Journal*, Vol. 54 No. 2, pp. 393-420.

Foss, N.J. and Saebi, T. (2018), "Business models and business model innovation: between wicked and paradigmatic problems", *Long Range Planning*, Vol. 51 No. 1, pp. 9-21.

Francis, D. and Bessant, J. (2005), "Targeting innovation and implications for capability development", *Technovation*, Vol. 25 No. 3, pp. 171-183.

Goldenberg, J., Libai, B. and Muller, E. (2010), "The chilling effects of network externalities", *International Journal of Research in Marketing*, Vol. 27 No. 1, pp. 4-15.

Greckhamer, T., Furnari, S., Fiss, P.C. and Aguilera, R.V. (2018), "Studying configurations with qualitative comparative analysis: best practices in strategy and organization research", *Strategic Organization*, Vol. 16 No. 4, pp. 482-495.

Green, K., Mcmeekin, A. and Irwin, A. (1994), "Technological trajectories and R&D for environmental innovation in UK firms", *Futures*, Vol. 26 No. 10, pp. 1047-1059.

Halila, F. and Rundquist, J. (2011), "The development and market success of eco-innovations: a comparative study of eco-innovations and "other" innovations in Sweden", *European Journal of Innovation Management*, Vol. 14 No. 3, pp. 278-302.

Hojnik, J. and Ruzzier, M. (2016), "What drives eco-innovation? A review of an emerging literature", *Environmental Innovation and Societal Transitions*, Vol. 19 No. 2016, pp. 31-41.

Hong, P., Kwon, H.B. and Roh, J.J. (2009), "Implementation of strategic green orientation in supply chain: an empirical study of manufacturing firms", *European Journal of Innovation Management*, Vol. 12 No. 4, pp. 512-532.

Horbach, J. (2008), "Determinants of environmental innovation—new evidence from German panel data sources", *Research Policy*, Vol. 37 No. 1, pp. 163-173.

Horbach, J., Rammer, C. and Rennings, K. (2012), "Determinants of eco-innovations by type of environmental impact—the role of regulatory push/pull, technology push and market pull", *Ecological Economics*, Vol. 78, pp. 112-122.

Huhtala, J., Mattila, P., Sihvonen, A. and Tikkanen, H. (2014), "Barriers to innovation diffusion in industrial networks – a systematic combining approach", in Woodside, A., Pattison, H. and Marshall, R. (Eds), *Field Guide For Business-To-Business Case Study Research (Advances in Business Marketing and Management)*, Emerald, Bingley, Vol. 21.

Iñigo, E.A. and Albareda, L. (2016), "Understanding sustainable innovation as a complex adaptive system: a systemic approach to the firm", *Journal of Cleaner Production*, Vol. 126 No. 2016, pp. 1-20.

IPCC (2021), "Climate change 2021: the physical science basis", Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Press, C. U., available at: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf (accessed 25 September 2021).

Jayanthi, S. and Sinha, K.K. (1998), "Innovation implementation in high technology manufacturing: a chaos-theoretic empirical analysis", *Journal of Operations Management*, Vol. 16 No. 4, pp. 471-494.

Khazanchi, S., Lewis, M.W. and Boyer, K.K. (2007), "Innovation-supportive culture: the impact of organizational values on process innovation", *Journal of Operations Management*, Vol. 25 No. 4, pp. 871-884.

Kim, J. and Wilemon, D. (2003), "Sources and assessment of complexity in NPD projects", *R&D Management*, Vol. 33 No. 1, pp. 15-30.

Li, D., Huang, M., Ren, S., Chen, X. and Ning, L. (2018), "Environmental legitimacy, green innovation, and corporate carbon disclosure: evidence from CDP China 100", *Journal of Business Ethics*, Vol. 150 No. 4, pp. 1089-1104.

Lightfoot, H., Baines, T. and Smart, P. (2013), "The servitization of manufacturing: a systematic literature review of interdependent trends", *International Journal of Operations and Production Management*, Vol. 33 Nos 11/12, pp. 1408-1434.

Machiba, T. (2011), "Eco-Innovation for enabling resource efficiency and green growth: development of an analytical framework and preliminary analysis of industry and policy practices", in Bleischwitz, R., Welfens, P.J.J. and Zhang, Z. (Eds), *International Economics of Resource*

Efficiency: Eco-Innovation Policies for a Green Economy, Physica-Verlag HD, Heidelberg, pp. 371-394.

Martínez-Vergara, S.J. and Valls-Pasola, J. (2020), "Clarifying the disruptive innovation puzzle: a critical review", *European Journal of Innovation Management*, Vol. 24 No. 3, pp. 893-918.

Misangyi, V.F., Greckhamer, T. and Furnari, S. (2017), "Embracing causal complexity: the emergence of a neo-configurational perspective", *Journal of Management*, Vol. 43 No. 1, pp. 255-282.

Nightingale, P. (2000), "The product–process–organisation relationship in complex development projects", *Research Policy*, Vol. 29 Nos 7-8, pp. 913-930.

Oduro, S., Maccario, G. and De Nisco, A. (2021), "Green innovation: a multidomain systematic review", *European Journal of Innovation Management*, Vol. 25 No. 2, pp. 567-591.

OECD (2010), *Eco-Innovation in Industry: Enabling Green Growth*, OECD Publishing, Paris.

Oltra, V. and Saint Jean, M. (2009), "Sectoral systems of environmental innovation: an application to the French automotive industry", *Technological Forecasting and Social Change*, Vol. 76 No. 4, pp. 567-583.

Petruzzelli, A.M., Dangeliro, R.M., Rotolo, D. and Albino, D. (2011), "Organisational factors and technological features in the development of green innovations: evidence from patent analysis", *Innovation*, Vol. 13 No. 3, pp. 291-310.

Poutanen, P., Soliman, W. and Ståhle, P. (2016), "The complexity of innovation: an assessment and review of the complexity perspective", *European Journal of Innovation Management*, Vol. 19 No. 2, pp. 189-213.

Prajogo, D., Tang, A.K.Y. and Lai, K.H. (2014), "The diffusion of environmental management system and its effect on environmental management practices", *International Journal of Operations and Production Management*, Vol. 34 No. 5, pp. 565-585.

Ragin, C.C. (2000), *Fuzzy-Set Social Science*, University of Chicago Press, Chicago.

Ragin, C.C. and Davey, S. (2016), *Fuzzy-Set/Qualitative Comparative Analysis 3.0*, Department of Sociology, University of California, Irvine, Vol. 1, pp. 1-62, No. 2016.

Rogers, E.M. (1983), *Diffusion off Innovation*, 3rd ed., Free Press, New York.

Rubinson, C., Gerrits, L., Rutten, R. and Greckhamer, T. (2019), "Avoiding common errors in QCA: a short guide for new practitioners", *Sociology*, Vol. 9 No. 2019, pp. 397-418.

Schiederig, T., Tietze, F. and Herstatt, C. (2012), "Green innovation in technology and innovation management–an exploratory literature review", *R&D Management*, Vol. 42 No. 2, pp. 180-192.

Sihvonen, A. and Pajunen, K. (2019), "Causal complexity of new product development processes: a mechanism-based approach", *Innovation*, Vol. 21 No. 2, pp. 253-273.

Sihvonen, A., Luoma, J. and Falk, T. (2021), "How customer knowledge affects exploration: generating, guiding, and gatekeeping", *Industrial Marketing Management*, Vol. 94 No. 2021, pp. 90-105.

Snihur, Y. and Wiklund, J. (2018), "Searching for innovation: product, process, and business model innovations and search behavior in established firms", *Long Range Planning*, Vol. 52 No. 3, pp. 305-325.

Szekely, F. and Strebel, H. (2013), "Incremental, radical and game-changing: strategic innovation for sustainability", *Corporate Governance*, Vol. 13 No. 5, pp. 467-481.

Tatikonda, M.V. and Rosenthal, S.R. (2000), "Technology novelty, project complexity, and product development project execution success: a deeper look at task uncertainty in product innovation", *IEEE Transactions on Engineering Management*, Vol. 47 No. 1, pp. 74-87.

Torres, P. and Augusto, M. (2020), "Understanding complementarities among different forms of innovation", *European Journal of Innovation Management*, Vol. 23 No. 5, pp. 813-834.

Utterback, J.M. and Abernathy, W.J. (1975), "A dynamic model of process and product innovation", *Omega*, Vol. 3 No. 6, pp. 639-656.

Wu, W., Liu, Y., Zhang, Q. and Yu, B. (2019), "How innovative knowledge assets and firm transparency affect sustainability-friendly practices", *Journal of Cleaner Production*, Vol. 229 No. 2019, pp. 32-43.

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