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Innovation systems for sustainability: insights from wood construction businesses and land use planning in Finland

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Academic dissertation

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ABSTRACT

Innovation is widely recognized as a key driver of economic growth and development, yet sustainability-oriented innovations have received comparatively less attention. This dissertation adopts the Regional Innovation System (RIS) perspective to explore the relationship between innovation and sustainability, while acknowledging the importance of financial performance for ensuring companies' success.

Article I present a systematic literature review aimed at assessing the current state of scientific literature on RIS for sustainability with a particular focus on regions situated between two or more adjacent nation states—referred to as Cross-Border Regional Innovation Systems (CBRIS). The findings highlight a notable absence of sustainability considerations in CBRIS literature and a lack in understanding regarding the factors that facilitate or hinder the integration of such systems.

Articles II and III are empirical studies that apply RIS framework in the context of land-use planning and construction in Finland. The data for these studies are based on, respectively, a survey targeting Finnish municipal civil servants involved in land-use planning and adjusted annual financial data from forest-based companies. The findings of Article II indicate that in urban municipalities, innovation-related actors and institutions play a more prominent role in land-use planning, with an emphasis on sustainable building objectives. In contrast, other municipalities tend to prioritize ecosystem service objectives. Article III examines the financial performance of Finnish sawmills and wood element producers as distinct stages in the wood construction value chain during 2012-2021. The results reveal a declining trend in the solvency of wood element producers and a wide variation in profitability. Overall, while differences in financial development and performance were found between the two production stages, the findings reflect characteristics of typical manufacturing industries.

While innovation and agglomeration are often closely linked in current discourse, regions with lower levels of agglomeration have received comparatively less attention. The findings of this dissertation highlight this imbalance, particularly in cross-border and rural regions, which hold plenty of potential for sustainability-oriented path development, such as in the bioeconomy. Consequently, the dissertation emphasizes the importance of regional focus and need to consider different geographical levels in innovation research and policy design.

Keywords: sustainability-oriented innovation, regional innovation system, industrial path development, land-use planning, wood construction

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TIIVISTELMÄ

Innovaatio nähdään yleensä talouskasvun ja -kehityksen moottorina, mutta sen rooli kestävyyshaasteiden ratkaisemisessa on saanut vähemmän huomiota. Tämä väitöskirja tarkastelee innovaatioiden ja ympäristön kestävyyden välistä suhdetta alueellisen innovaatiojärjestelmän (RIS) viitekehyksen kautta, huomioiden samalla taloudellisten realiteettien merkityksen, erityisesti yritysten toimintamahdollisuuksien kannalta.

Artikkelissa I hyödynnetään systemaattisen kirjallisuuskatsauksen menetelmää tarkasteltaessa tämänhetkistä tieteellistä kirjallisuutta alueellisten innovaatiojärjestelmien ja kestävyystavoitteiden välisestä suhteesta. Erityishuomio kohdistuu järjestelmiin ja alueisiin, jotka ulottuvat kahden tai useamman valtion rajojen yli (CBRIS). Tulokset osoittavat, että kestävyysnäkökulma ei esiinny lähes ollenkaan CBRIS-kirjallisuudesta, ja ymmärrys niistä tekijöistä, jotka edistävät tai estävät näiden järjestelmien yhteensovittamista, on edelleen puutteellista.

Artikkelit II ja III tarkastelevat alueellisten innovaatiojärjestelmien rakenteita Suomessa sekä niiden suhdetta kestävyystavoitteisiin maankäytön suunnittelussa ja rakentamisessa. Artikkeli II:n aineisto perustuu kyselyyn, joka kohdistettiin kuntien virkamiehille, jotka työssään osallistuvan maankäytön suunnitteluun. Kyselyssä selvitettiin eri toimijoiden ja tavoitteiden merkitystä kuntien maankäytön suunnittelussa ja rakentamisessa. Tulosten mukaan urbaanien kuntien innovaatiojärjestelmissä korostuvat tutkimusorganisaatiot ja epämuodolliset suunnittelumekanismit, ja painopiste on kestävän rakentamisen tavoitteissa. Sen sijaan muissa kuin urbaaneissa kunnissa korostuvat ekosysteemipalveluihin liittyvät tavoitteet. Artikkeli III:ssa tarkasteltiin suomalaisten sahojen ja puuelementtivalmistajien oikaistuja, vuosittaisia tilinpäätöstietoja vuosilta 2012–2021. Tulokset osoittavat, että puuelementtivalmistajien vakavaraisuus on heikentynyt tarkastelujaksolla, ja yritysten kannattavuutta kuvaavissa tunnusluvuissa esiintyy huomattavaa vaihtelua. Rakentamisen arvoketjun eri vaiheita edustavissa yritysjoukoissa on havaittavissa valmistavalle teollisuudelle tyypillisiä piirteitä, kuten materiaali ja työntekijäkustannusten merkittävä negatiivinen vaikutus taloudellista suorituskykyä kuvaaviin muuttujiin, kun taas arvonlisällä on niihin selkeä positiivinen vaikutus.

Samalla kun innovaatiot ja aluerakenteelliset keskittymät nähdään nykykeskustelussa toisiaan tukevina ilmiöinä, vähemmän keskittyneet alueet ovat jääneet vähäisemmälle huomiolle. Tämän väitöskirjan tulokset osoittavat samansuuntaisia havaintoja, tuoden esiin rajaseutujen ja ei-urbaaneiden kuntien innovaatiojärjestelmien erityispiirteitä verrattuna urbaanien alueiden järjestelmiin. Huomioiden ei-urbaanien kuntien merkityksen kestävyyssuuntautuneilla kehityspoluilla, kuten biotaloudessa, tämä väitöskirja korostaa erilaisten alueiden huomioimista ja eri maantieteellisten tasojen välistä yhteistyötä innovaatiotutkimuksessa ja -politiikassa.

Asiasanat: kestävyyssuuntautunut innovaatio, alueellinen innovaatiojärjestelmä, teollisuuden kehityspolku, maankäytön suunnittelu, puurakentaminen

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LIST OF ARTICLES

Article I:
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Article II:
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Article III:
Revised and re-submitted: **Koskivaara, A.**, Lähtinen, K., & Toppinen, A. (2025). Longitudinal analysis of financial performance of sawmills and wood construction element producers in Finland.

Division of labor in co-authored articles

	I	II	III
Concept and design	AK, JK, AM, NY, TM	AK, KL	AK, KL, AT
Data collection	AK, JK, AM, NY, TM	KL	AK
Data analysis	AK, JK, AM, NY, TM	AK, KL	AK, KL, AT
Writing manuscript	AK, JK, AM, NY, TM	AK, KL	AK, KL, AT
Overall responsibility	JK	AK	AK

AK – Atte Koskivaara, JK – Jaana Korhonen, AM – Arttu Malkamäki, NY – Natalya Yakusheva, KL – Katja Lähtinen, AT – Anne Toppinen, TM – Teemu Makkonen.

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GLOSSARY

Innovations are new or improved products, processes, production methods, services, markets, organizational forms, or the acquisition of new resources. Innovation is commonly categorized as product, process, service, administrative, organizational, conceptual, policy, systemic, or social innovation.

Sustainability-oriented innovation extends the definition of innovation with an aim to foster environmental and/or social benefits in addition to economic ones, without exclusively focusing on a single aspect. It also considers the whole physical life span of innovation including manufacture, use and end-of-life, emphasizing that simply developing technically improved or completely new products is insufficient to solve fundamental sustainability problems.

Regional innovation system (RIS) is a localized innovation framework that highlights the role of regional actors, institutions, and infrastructure in fostering innovation. RIS consists of elements such as firms, universities, research organizations, policymakers, and support institutions that interact within a specific geographical area, facilitating knowledge exchange, and collaboration. The system-based perspective emphasizes that innovation is not an isolated process but emerges through networks and actor interaction.

Cross-border regional innovation system (CBRIS) places the RIS framework in cross-border settings which consist of adjacent areas that belong to more than one nation state. Thus, it emphasizes the role of transnational interactions, institutional collaboration, and knowledge exchange across borders, which abreast with nation-states may relate to smaller entities such as municipalities or other in-state regions.

Bioeconomy emphasizes the utilization of biological resources from land and sea to develop and commercialize goods and services to replace fossil-based materials, with biotechnology and innovations driving the process.

1. INTRODUCTION

1.1. Innovation systems for sustainability in land-use planning and construction

Many public and private sector decision-makers at national, regional, and city levels, as well as within individual companies, aspire to harness innovation to drive economic development and growth (Shearmur 2012). However, given the pressing environmental and social challenges such as climate change, environmental degradation, rising inequality, and poverty, this traditional emphasis in innovation research and policymaking seems overly limited in scope (Uyarra et al. 2019; Raven and Walrave 2020; Tödtling et al. 2022). Subsequently, a growing body of scientific approaches have recently emerged that discus innovation orientation including new concepts such as green regional industrial path development (Trippl et al. 2020), mission-oriented (Mazzucato 2018; Hekkert et al. 2020), challenge-oriented (Raven and Walrave 2020) and transformative innovation (Schot and Steinmueller 2018). However, more systematic empirical research is advocated for to explore how territory-specific actor roles, networks (Martin et al., 2023), and institutions influence sustainability transformation (Hansen and Coenen 2015), particularly in varying regional (Pino and Ortega 2018) and national (Fernandes et al. 2022) contexts.

Although research on innovation(s) has spanned for more than a century, a precise and universally accepted definition of innovation remains a work in progress (Taylor 2016). Austrian economist Schumpeter (Schumpeter, 1911, p. 66) broadly defined innovation as "new combinations" involving new or improved products, processes, production methods, markets, organizational forms, or even the acquisition of new resources. He also made a distinction between invention and innovation: invention refers to the initial creation of something new, while innovation occurs only when that invention is successfully adopted and implemented in markets. Across disciplines, innovation is commonly categorized as product, process, service, administrative, organizational, conceptual, policy, or systemic innovation (Gault, 2018, p 619). Among these, social innovation represents a distinct category, referring to innovative activities and services primarily aimed at addressing social needs and diffused through organizations with a social mission rather than profit-driven motives (Mulgan 2006). While business innovation seeks profit, social innovation prioritizes societal impact, though their boundaries often overlap.

The widely adopted innovation systems framework (Lundvall et al. 1988; Nelson 1993; Edquist 1997) highlights that innovation takes various forms and emerges from the interactions and interdependencies between actors with diverse knowledge-bases and resources (Asheim et al. 2016). The innovation systems concept was primarily developed as a policy tool for national contexts (National Innovation System) (Lundvall et al. 1988; Nelson 1993) for governments to form and implement policies to influence innovation processes (Jacobsson and Bergek, 2011). Subsequently, the uneven geographical distribution of innovation has led to the development of the Regional Innovation System (RIS) approach (Cooke 1992; Asheim 1995; Autio 1998; Doloreux 2002).

Different technologies and geographical regions display varying structural profiles because of their varying stage of development regional preconditions (Dewald and Truffer 2011; MacKinnon et al. 2019). Thus, to encourage industries and regions toward low-carbon development with a minimal environmental impact, they should be considered individually. The RIS framework recognizes the importance of regional institutions and actors for developing innovation and thus enables regionally differentiated approaches (Braczyk et al.

2003). It has been extensively utilized across regions, nations, and within the European Union to guide place-based policy strategies aimed at fostering innovation-driven economic growth and strengthening the competitiveness of the corporate sector (Isaksen et al. 2022). Subsequently, an increasing number of studies highlight the need and potential for the RIS approach to explore issues related to environmental challenges such as climate change and environmental degradation (Coenen and Morgan 2020; Tödtling et al. 2022).

Additionally, the academic focus on studying regional innovation is increasingly on the processes through which new industries emerge and evolve. This stream of literature is commonly referred to as regional industrial path development (Hassink et al. 2019) and it has been utilized to explore areas such as the industrial path development in different types of RISs (Isaksen and Trippl 2014). Furthermore, different forms of path development have been introduced by innovation scholars (Tödtling and Trippl 2013), including the more recent growth in interest toward a transformation addressing grand challenges and the green transition, for example (Trippl et al. 2020). Tackling these challenges requires transformative change, placing new demands on the direction of innovation and necessitating a more critical examination of its normative aspects. This shift expands the traditionally economy-oriented goal-setting to include broader social and environmental considerations (Weber and Rohracher 2012).

Building on Schumpeter's broad definition of innovation, sustainability-oriented innovation is extended with the aim to foster environmental and/or social benefits in addition to economic ones, through the physical life-cycle of the innovation (Buhl et al. 2019). As innovation is essential for both the development and competitiveness of companies and the large-scale renewal of industries towards achieving sustainable societies (Köhler et al. 2019) scholars have called for more attention toward regional industrial path development and transformation processes of RIS themselves (Isaksen 2015; Asheim et al. 2016).

Transformation from a fossil-based economy to a bioeconomy is one example of sustainability-oriented path development that has a potential to contribute to replacing fossil-based materials with bio-based materials and thus leading to a fossil-free society (European Commission 2019). The bioeconomy is one key concept in sustainability research and it proposes to adapt to or transform the current economy towards a more sustainable one, however, implying economic growth based development (D'Amato et al. 2017). For example, the construction industry is characterized by high emissions and it has great potential to reduce carbon emissions globally (Churkina et al., 2020; Labaran et al., 2022) and in Finland (Kuittinen and Le Roux 2017). This aligns with the objectives of bioeconomy transformation by integrating bio-based products and building systems into construction (Churkina et al., 2020). Especially in the Nordic countries, forest-based value creation is considered one of the main paths toward the emerging bioeconomy (Klitkou et al. 2019). Martin et al., (2023) suggest that in the forest-based bioeconomy, such a renewal would likely necessitate the engagement of new actor networks and expanded roles and responsibilities for key actors within RISs. These new actor roles and responsibilities include influencing the direction of change and providing legitimacy for renewal. For forest-industry companies this would complement the technological knowledge exploitation focus to serve a new direction and increasingly focus on discussions around societal development (Martin et al. 2023). Additionally, regional authorities have been found to have important roles in demand articulation and market creation in this context (Martin et al. 2023).

As sustainability is becoming an increasing priority in the construction industry through its carbon emissions (Churkina et al. 2020) and land use impacts (Rinne and Primmer 2016), companies are under growing pressure to improve their sustainability performance by

radically reducing environmental damage and climate warming (Kinnunen et al. 2022). These shifts impact the global construction industry as a whole (Holt 2013) and the development of construction business ecosystems has been identified as a potential avenue for new opportunities in the industry (Pulkka et al. 2016), and investments in sustainability improvements have been found to lead to the creation of economic value (Kajander et al. 2012), for example. Like other industries, construction companies rely on innovation to secure projects, boost profitability, and enhance competitiveness, which in this field can involve advancements in technical capabilities, operational efficiency, and positioning as a technologically progressive player (Blayse and Manley 2004). However, the industry is often characterized with low R&D levels (Dulaimi et al. 2002).

The construction industry is characterized by building practices based on the use of subcontractors to implement delimited tasks and phases in individual projects (Gann and Salter 2000). Previous literature suggests that construction industry business networks have an emphasis on collaborating during a singular project and disband after finalization (Dubois and Gadde 2002; Blayse and Manley 2004). This type of operation is considered to favor companies' short-term productivity but slow down innovation and learning on a broader scale (Dubois and Gadde 2002) and limit knowledge transfer from project to company-level, restricting continuous learning and knowledge accumulation (Kadefors 1995; Drejer and Vinding 2006; Toppinen et al. 2019; Viholainen et al. 2021) thus leading to low levels of innovation (Mokhlesian and Holmén 2012). Collaboration within networks is a commonly emphasized mean in business literature (Anderson et al. 1994) to control complex and risky projects, such as construction (Matinaro and Liu 2017; Toppinen et al. 2019). To handle the complexity, actors' roles within the construction industry have become highly routinized and standardized (Segerstedt and Olofsson 2010) making its dynamics and culture difficult to change (Rohracher 2001).

Emissions related to building materials can be lowered by increasing the building density (reducing the floor area per capita), extending building lifespans, utilizing lighter structures and low-carbon materials such as wood, minimizing construction waste, reusing structural components, and recycling building materials (Hertwich et al. 2019). Using wood as the main building material can significantly reduce carbon dioxide emissions as wood product manufacturing typically consumes less fossil energy, and the processing of wood generates by-products that can serve as biofuel substitutes for fossil fuels. Wooden materials also function as carbon storage compared to conventional building materials such as concrete and steel (Sathre and Gustavsson 2007).

At the interface of RIS and societal goals for sustainability-driven change lie decisions which affect land-use management in different types of localities. Land-use planning has a central role in advancing sustainability in the built environment (Stokes and Seto 2019), which is commonly understood to encompass buildings, infrastructure, and other physical components, including green spaces, that form human settlements (Barton 2009) through sustainable construction (Persson 2013; Salmi et al. 2022) and enhancing ecosystem services (Rinne and Primmer 2016). In Europe, for example, local land-use planning plays a crucial role in managing urban-rural development (Le Bivic and Melot 2020), addressing place-based conditions (Solly 2021), and fostering sustainability-oriented innovations (Huang-Lachmann and Lovett 2016). This places growing demands on municipalities to enhance their land-use governance (Carina et al. 2012). However, in Finland regional strategies, which serve as central policy instruments for regional development, are still primarily economy-oriented rather than advancing the broader goals of sustainable innovation policy (e.g., including ecological and social aspects) (Rinkinen et al. 2016).

In the Nordic context, local politicians and municipal civil servants play a crucial role in governing land-use planning and influencing businesses and citizens in systemic collaboration (Karhinen et al. 2021), which has been identified as a key factor in advancing sustainability goals (Rönkkö and Aarrevaara 2017; Boehnke et al. 2019; Palermo et al. 2020). In Finland, local politicians and civil servants have a lot of power in land-use planning through local planning monopolies (Peltonen and Sairinen 2010). Urban planners are civil servants responsible for conducting land-use planning. In their work they collaborate with multiple actors including businesses, local politicians, citizens, and research institutions. Additionally, through their role of simultaneously operating as information gatekeepers, communicators, preparers and introducers of plans (Puustinen 2004) they have the capability to affect systemic change, for example, as regional innovation initiators (Blayse and Manley 2004; Lähtinen et al. 2019). An important statutory element for directing construction in Finland is the new Building Act which was introduced in January 2025. It is a reform from the former Land Use and Building Act (Land use and building act, 1999) and is designed to tackle modern challenges by emphasizing aspects such as low-carbon construction. A key sustainability feature in the new Building Act is the introduction of carbon footprint assessments, ensuring that construction practices align with Finland's climate targets (Building Act, 2023).

1.2. Aim of the dissertation

This dissertation examines innovation systems within diverse territorial contexts, particularly in urban, rural, and cross-border regions; where institutional settings and actor-based dynamics shape regional development in distinct ways (Tödtling and Trippl 2005). The aim of the study is to provide knowledge on the specific characteristics of varying regions and their system set-ups that contribute to the development of sustainability-oriented innovation, and to assess the realized development trajectory of wood building businesses as a proxy of developments in the construction industry.

The dissertation starts by reviewing earlier literature concerning the level of integration and the role of sustainability for innovation systems located specifically in cross-border contexts. Empirically, it next examines land-use planning and the construction industry through the RIS framework, emphasizing actors' and institutions' roles in advancing sustainable construction. It further examines and compares different regional contexts on an urban–rural scale, to explore the role of key actors and institutions, their interconnections, and the ways in which sustainability objectives are integrated into regional settings. Furthermore, it examines the formation and development of financial performance in the wood construction value-chain, at both the firm level and across industry stages. Article-specific research questions are presented in Table 1.

Table 1. Article-specific research questions.

	Article I	Article II	Article III
Research questions	• What is the general status of the evidence base regarding cross-border regional innovation system (CBRIS) integration? • What drives and constrains CBRIS integration? • How are sustainability goals reflected in the literature on CBRIS integration? • What do we know about the resilience and sustainability of CBRIS?	• Based on the regional innovation system (RIS) framework, what are the structures of municipalities' land-use planning? • What is the interaction between RIS subsystems and sustainability objectives? • Are there regional differences between RISs?	• Does a focus on primary or secondary processing in wood product industry influence the financial performance of firms? • How do costs, value creation, and investment activities influence the financial performance of different types of companies, as measured by various financial measures?

2. CONCEPTUAL BACKGROUND

2.1. Regional innovation systems as lenses for sustainability-oriented innovation

This dissertation stresses that regional innovation should be pursued in a way that enables regions to progress toward more sustainable future pathways. The processes behind innovation are inherently uncertain, with outcomes and impacts remaining unpredictable (Hall et al. 2011). Thus, a sustainability-oriented innovation sees sustainability as a direction guiding the process rather than as a fixed result (Hansen and Grosse-Dunker 2012). Subsequently, the RIS concept has also been harnessed to explore regionally specific issues related to local and global sustainability challenges (Coenen and Morgan, 2020; Tödtling et al., 2022).

Based on Makkonen and Rohde (2016), RIS consists of four distinct elements: *the regional policy subsystem* (e.g., local public authorities), *the knowledge generation and diffusion subsystem* (e.g., research institutes, educational and technology transfer organizations), *the knowledge application and exploitation subsystem* (e.g., companies) and *the socio-institutional factors* (e.g., formal and informal institutions). Additionally, external

influences, such as originating from other RISs (e.g., systems functioning in adjacent localities within one country or neighboring countries), or international institutions and national innovation systems, affect the functioning of RIS, through funding schemes or innovation policies, for example (Autio, 1998).

Figure 1 presents the RIS framework modified from Makkonen and Rohde, (2016) and illustrates how individual sub-studies in dissertation articles I-III have their specific focus on the different subsystems, socio-institutional factors, and different regions. The subject areas of *Articles I* and *II* cover all RIS subsystems, as well as socio-institutional factors, with *Article I* also including considerations of the national level, through its focus on cross-border regions. In *Article III,* the RIS subsystem focus was on *Knowledge application and exploitation* and *Knowledge generation and diffusion subsystems*. Additionally, related to industry development, the *Article III* also examined the realized development trajectory of wood building businesses as a proxy of developments in the construction industry.

In addition to what is presented in Figure 1, international institutions affect regional innovation dynamics together with national innovation system, which both shape the overall innovation environment. From the perspective of characteristics of different localities with varying structural set-ups, for example in rural and urban regions, municipalities may develop distinct innovation strategies based on their specific resources and institutional capacities. Individual companies operating in a particular industry both influence the RIS, but are also affected by other actors, institutions, and knowledge flows in the system. To adapt system structures to better enable sustainability change, it is essential that RIS actors strengthen their roles in providing legitimacy for change, influencing the direction of innovation, fostering market creation, and enabling the development and diffusion of knowledge (Martin et al. 2023).

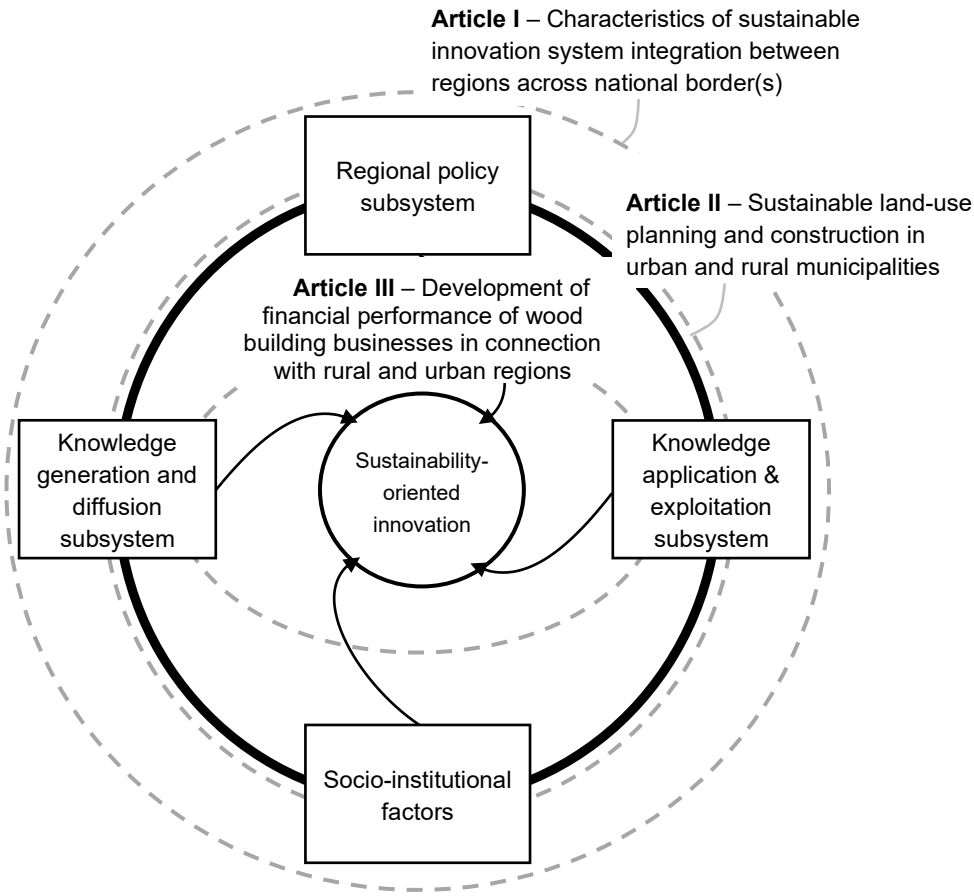

Figure 1. Regional innovation system subsystems and socio-institutional factors driving sustainability-oriented innovation. The solid black line indicates RIS boundaries, and fields marked with dashed lines indicate the positioning of individual sub-studies in articles I-III, within the RIS framework (modified from Makkonen and Rohde, 2016).

The RIS framework has received criticism because of its static view (Doloreux and Gomez 2018) and for not considering the role of agency (Bandura 2006) to describe the systems ability to change, and thus neglecting the inclination of new path development (Miörner and Trippl 2019). To build a comprehensive understanding of temporal development of e.g., an industry or technology, merely understanding the current structure of innovation systems is insufficient (Hekkert et al., 2007). Therefore, to enable a more dynamic view, regional innovations have recently been complemented with the industrial path development approach (see e.g., Binz et al., 2016; Martin et al., 2023).

The important and active roles of actors and institutions in the theoretical RIS literature (Autio 1998) have been similarly highlighted in the regional path development processes (Hassink et al. 2019). A key element in industrial path dependency and lock-in is that past

events tend to influence the probability of future events, and regional preconditions will similarly determine the likelihood of specific types of industrial path development (Martin 2010; Grillitsch and Hansen 2019). A lock-in refers to a region, industry, or system, which continuingly and self-reinforcingly steer along one path rather than other (Martin 2010). In addition, RIS structures provide enabling or constraining conditions for regional path development, also when pursuing sustainable development (Grillitsch and Hansen 2019).

2.2. Variation in regional innovation systems for sustainability

By incorporating a spatial dimension into the innovation system framework, as in the RIS concept, a more regionally differentiated approach is made possible (Tödtling and Trippl 2005). RIS highlights the significance of geographical proximity and supportive institutional settings for innovation activities (Trippl 2010). Thus, the RIS approach covers many possible spatial scales, and the term region has been applied to different kinds of territories and jurisdictions ranging for example from municipalities (see e.g., Pekkarinen and Harmaakorpi, 2006) to cross-border regions (Cross-Border Regional Innovation System (CBRIS)) (see e.g., Lundquist and Trippl, 2013; Trippl, 2010), among others.

In empirical RIS studies, a municipality can be considered as a sub-national administrative unit consisting of regional actors, institutions and their connections, while providing essential information regarding the region's (e.g., a municipality) characteristics (e.g., population density, and economic conditions) (Suorsa, 2007). On the other hand, cross-border regions consist of adjacent areas that belong to more than one nation state (Lundquist and Trippl 2013). Thus, implementing an RIS framework in cross-border settings adds increased complexity to studying innovation systems. However, it has the potential to provide valuable insights into how various forms of interaction contribute to cross-border integration by considering the complex interplay of cultural identities, social dynamics, political systems, economic histories, and innovation capacities across regions (Makkonen and Rohde 2016).

When developing a functioning set-up for innovation, there are no best practices but heterogeneity across regions requires differentiated and individual approaches (Tödtling and Trippl 2005). In addition, so far, innovation studies have focused primarily on urban areas (Kern 2019) while regions with lower levels of agglomeration, such as those in the semi-urban areas or peripheries, have received less attention (Eder 2019). This issue is relevant, as especially in the Nordic countries, rural economies are often characterized by a strong reliance on natural resources, long distances, limited local demand, a thin pool of companies, and a restricted supply of business services (Tödtling and Trippl 2005; Virkkala 2007). Yet, material-dependent industries, such as the forest-industry, play a crucial role in sustainable development, since forest industry actors have been found to be key contributors to the development of the emerging bioeconomy (Martin et al. 2023).

In the literature on RIS, a commonly described conceptual typology of regions with varying structures for innovation ranges between a continuum of peripheral and urban regions (Tödtling and Trippl 2005; Isaksen and Trippl 2014; Grillitsch and Hansen 2019). These two categories have been described to show largely different structures for innovation activity with peripheral regions showing weak and limited innovation support systems with no industrial specialization, compared with strong and comprehensive innovation support with a mix of industrial specializations in urban areas (Grillitsch and Hansen 2019). Additionally, peripheral regions are often characterized with organizational thinness, as they have low

levels of company clusters and a weaker capability for knowledge generation and diffusion (Isaksen 2015). In comparison, urban regions often possess a relatively large number of different industries and services, and hubs of several intermediary organizations conducting knowledge generation and diffusion activities (Isaksen and Trippl 2014).

Progress toward a more sustainable society requires enhancing place-specific processes (Coenen et al. 2012) because the costs related to investing in more sustainable market structures (e.g., supply and demand of construction products) are often not equally spread geographically, and the economic hardship may become concentrated in regions that are already economically vulnerable (Marino and Ribot 2012). Furthermore, regions differ in their ability solve particular challenges and some RISs have a stronger capacity to address challenges than others (Tödtling et al. 2022).

Much relies on a regions availability of various tangible and intangible resources such as natural resources (e.g., forests and minerals), infrastructural resources (e.g., buildings, machines, networks, and roads), industrial resources (e.g., technology and firm competencies), human resources (e.g., labor skills, costs, and knowledge), and institutional endowments (rules, routines, norms, values, and culture) (Trippl et al. 2020). Thus, these inherited regional preconditions (MacKinnon et al. 2019) and RIS elements can both drive or hinder the initiation and upscaling of sustainability-oriented innovation (Hansen and Coenen 2015) also shaping the likelihood of sustainable development in the region (Grillitsch and Hansen 2019). Furthermore, the development of regional specialization in sustainable technologies (e.g., wood construction) and industries relies on a sufficiently skilled workforce, expertise in related economic sectors, and the availability of appropriate infrastructure and resources (Moreno and Ocampo-Corrales 2022). Additionally, innovation dynamics often involve actors and influences that span from local to global levels (e.g., national innovation system and international institutions) through the import of innovations (Trippl et al. 2020) and trans-local learning networks (Loorbach et al. 2020) which can influence how innovations evolve in regions (Tödtling et al. 2022).

In connection to regional preconditions, regions face varying challenges (McCann and Soete 2020) and growing disparities between major urban centers and peripheral regions pose significant challenges for our societies (Iammarino et al. 2017) leading to fewer, and less varied and qualified jobs (Grillitsch and Sotarauta, 2018), limited opportunities and economic development in rural areas (Dijkstra et al. 2020). Furthermore, the pace of skilled migration from left-behind and vulnerable regions can accelerate due to the concentration of opportunities and know-how in more prosperous regions posed by the uptake of sustainable solutions and industries (European Commission, 2023). If disregarded, the collapse of social cohesion and the spread of discontent can increase climate-change skepticism, for example (Martin and Islar 2021). Consequently, further research is needed on the specific problems and vulnerabilities in different regions, along with comparative assessments between regions (Trippl et al. 2024).

2.3. Regional innovation systems as platforms for sustainable construction

Key factors which enhance sustainability in construction include reducing carbon emissions and mitigating the impact on land use. Thus, achieving sustainability requires actions in both land-use planning and the construction industry, aiming to address issues such as climate change mitigation, protecting natural ecosystems, and improving human well-being (Chiu 2004; Röck et al. 2020).

Regarding the RIS framework, operationalized from the land-use planning and construction point of view, different actors may hold varying roles in the accumulation and dissemination of knowledge. In comparison, institutional elements such as distinct supply and demand structures (e.g., traditions and path dependencies affecting the forest and construction industries) (Jussila et al. 2022), habits and regulatory frameworks may act as drivers of or barriers to innovation, thus potentially affecting the outcome of a RIS (Autio 1998). Unlike national-level governance, which provides a general setting for innovation, local actions offer more practical opportunities to advance sustainability by fostering knowledge accumulation within municipal actor networks (Holm et al. 2011). For example, local networks may promote small-scale experiments, learning from best practices, and facilitating collective learning. Table 2 shows examples of actors and institutions and of their roles in RIS subsystems regarding sustainability efforts in the Finnish municipalities.

In the RIS framework, *the regional policy subsystem*, *the knowledge generation and diffusion subsystem*, *the knowledge application and exploitation subsystem*, and *the socio-institutional factors* have different, but inter-connected dynamics. The *regional policy subsystem* is composed of civil servants, namely land-use planners, alongside local politicians. In Finnish municipalities, local politicians and civil servants hold significant influence over land-use planning due to their control over local planning monopolies (Busck et al. 2008; Peltonen and Sairinen 2010). As civil servants, urban planners have considerable authority in shaping local development through their involvement in land zoning, acting as key players in managing information, communicating, preparing, and introducing plans (Puustinen 2004). Furthermore, as they work alongside a variety of stakeholders on numerous tasks, they play a pivotal role in driving sustainability change in the built environment, especially through promoting low-carbon or circular construction practices (Persson 2013; Salmi et al. 2022), including their role as initiators of regional innovation (Blayse and Manley 2004; Lähtinen et al. 2019).

The public sector can act as a facilitator for innovation driven projects by granting building permits, and by being customers or partners in public-private partnerships (Gluch and Svensson 2018; Carbonara and Pellegrino 2020; Lindblad and Karrbom Gustavsson 2021), possibly supporting the development of local industries (Franzini et al. 2018). Additionally, the public sector can be an innovator itself by introducing social or organizational elements, including new knowledge, a new organization, or new social practices (Osborne and Brown 2011; Cajaiba-Santana 2014).

The *knowledge generation and diffusion subsystem* refers to the creation and distribution of knowledge, while the *knowledge application and exploitation subsystem* refers to use of existing knowledge. Main actors in the *knowledge generation and diffusion subsystem* are universities and research institutions, whereas *knowledge application and exploitation subsystem* consists mainly, but not exclusively, of industrial companies (Autio 1998). Although actors often mainly represent either of the knowledge subsystems, the roles may be connected. Some main actors related to construction include constructors, main developers, structural and architectural planners, and manufacturers of building components, all of which require their own specialized expertise (Pryke 2012). Regardless of the partly connected roles between the knowledge subsystems, the construction industry has been described to lack coordination between industry and research organizations (Dulaimi et al., 2002). Simultaneously, the lack of coordination between industry and research organizations increases the role of intermediating actors (Gann 2001), which are considered important in advancing wood construction, for example (Vihemäki et al. 2020)

Socio-institutional factors have strong linkages to urban planning in municipalities, including both formal and informal institutions, such as statutory and informal planning approaches (Mäntysalo et al. 2015). These institutions shape the structure of local operations and networks, and can either facilitate or hinder innovation, thereby shaping the overall innovation outcomes within an RIS. Statutory planning refers to a three-level hierarchical planning system, comprised of central government with national land-use policy guidelines (at the highest level), regional level with regional plans (middle level), and the municipal level with local master and detailed plans (at the bottom level) (Hirvonen-Kantola and Mäntysalo 2014). In comparison, informal planning refers to means being used outside the statutory planning system to improve the strategic quality of land-use planning (Albrechts 2006; Albrechts and Balducci 2013). These may be related to public-private partnerships, land-use development schemes, regional visions, and structural plans (Mäntysalo et al. 2015), for instance.

Table 2. List of identified actors and institutions and examples of their roles in RIS subsystems related to sustainability efforts in the Finnish municipalities.

Actor / institution	Examples of roles	Source
	Regional policy subsystem	
Land-use planners	Land-use planners can establish guidelines for specific material requirements, while municipal planning decisions may also directly influence the approval process for local building permits.	(Lähtinen et al. 2019)
Local politicians	Local governments can set more ambitious emission requirements than required at a national level.	(Seppälä et al. 2019)
	Knowledge application and exploitation subsystem	
Companies	Innovators and adopters of new technological knowledge and business models that affect sustainability change.	(Salmi et al. 2022)
Interest organizations	Advocates and lobbyists to uptake new solutions, interpretation of the meanings in municipalities' processes in relation to various (and sometimes conflicting) interest organizations' goals.	(Peltonen and Sairinen 2010; Matschoss and Heiskanen 2017)
Non-governmental organizations	Compilers of existing knowledge and communicators in multi-actor networks.	(Juhola and Westerhoff 2011)
Citizens	Informants for the local decision-making processes and actors, who add or diminish the local acceptance of sustainability through statutory participatory processes or informal civil activities.	(Leino and Peltomaa 2012; Faehnle et al. 2014)
Media	Information deliverers add knowledge to on-time events etc. with effects also on the acceptability of municipality actions.	(Leino and Peltomaa 2012)
	Knowledge generation and diffusion subsystem	
Research organizations	Intermediaries providing data and analysis skills, assessing the feasibility of technological solutions and	(Uotila et al. 2005; Yli-Pelkonen and Kohl 2005;

	producers of new academic knowledge to complement the existing local general knowledge, e.g., on nature.	Matschoss and Heiskanen 2017)
Authorities outside municipality	Steering through fiscal instruments (e.g., taxation and subsidies), programs (EU, national, regional), and information (e.g., evaluation reports), and negotiations (e.g., consideration of viewpoints of different societal actors).	(Häkkinen et al. 2016)
Other municipalities	Peers to produce and circulate together knowledge on climate change mitigation.	(Juhola and Westerhoff 2011; Virtanen et al. 2022)
Educational and teaching organizations	Intermediaries to enhance the credibility of, e.g., new technological solutions and enhance awareness on them among experts.	(Heiskanen et al. 2011)
	Socio-institutional factors	
Informal institutions	Urban development vision focusing on strengthening citys role as a commercial hub, promoting a compact and accessible city structure, and supporting sustainable ecological development.	(Hytönen et al. 2012)
Formal institutions	The Building Act regulates the planning, construction, and use of buildings and construction sites.	(Building Act 2023)

2.4. Local businesses in construction value networks

Industrial development paths are rooted in RISs, which include all companies and industries in the region, along with organizational support structures, networks, and institutional contexts (Miörner and Trippl 2019). Industrial path development and path dependency can take various forms (Martin and Sunley 2006) and are driven by multiple mechanisms and supported by resources at both regional and extra-regional levels (Grillitsch and Asheim 2018).

Path development is often policy initiated as it may require the building of new knowledge organizations and institutional change (Tödtling and Trippl 2013). For instance, construction has been supported by government initiatives (Lazarevic et al. 2020). Local policymakers can promote path development in various regional settings by establishing spaces for knowledge exchange, attracting actors with complementary resources to the region (Isaksen and Trippl 2014), or through demand articulation and market creation (Martin et al. 2023). Additionally, civil servants can drive innovation through public procurement (Martin et al. 2019). Regarding institutional set-up, both formal (e.g., laws and regulations) and informal (e.g., values, visions, attitudes, routines) institutions have their roles in sustainability-oriented RISs (Hansen and Coenen 2015).

Formal institutions are often related to policy processes at higher spatial scales (e.g., national and international laws and regulations), yet policies are often implemented by regional policy actors (Matti et al. 2017). On the other hand, informal institutions, are crucial to influencing the adaption of formal institutions alongside technological advancements and evolving circumstances (Chlebna and Simmie 2018). Especially in the case of sustainable industry renewal, policy implications should differ considerably across regions with varying

industrial structures, necessitating the promotion of sustainable industries while driving the transformation or replacement of less sustainable ones (Grillitsch and Hansen 2019).

The roles of actors in the regional development process closely correspond to the RIS framework, involving *knowledge application and exploitation subsystems*, *knowledge generation and diffusion subsystem* as well as *regional policy subsystem* (Autio 1998). For example, companies, representing the knowledge exploitation subsystem, are important in exploiting knowledge and transforming it into innovations also by collaborating with research organizations (Autio 1998; Harmaakorpi 2006). In the construction and forest industries this may relate to companies participating in piloting building projects which implement new product solutions or building practices (Rahman et al. 2024), for example.

Actors representing the *knowledge generation and diffusion subsystem*, such as universities and research institutions, are important actors in terms of generating and inputting knowledge into the knowledge exploitation subsystem. For example, such organizations may promote sustainability change in the construction industry by developing and testing technological characteristics of new engineered wood products (Heräjärvi et al. 2004). Other actors within the knowledge infrastructure play roles in providing higher education and are crucial for providing competences, skills, and training (Doloreux 2002) for both the private and public sectors (Trippl et al. 2015).

Socio-institutional factors influence the framework of local operations and networks, setting the rules and norms that shape the collaboration and resource flows, therefore possibly hindering or driving innovation. Therefore, to influence sustainability change in the construction industry, for example, institutions can be shaped to reduce lock-ins and to accelerate the diffusion of low-carbon building solutions, such as wood construction (Vihemäki et al. 2020).

Regarding the renewal of the construction industry through the development of wood construction, companies in the mechanical wood industries, such as sawmills and wood element producers, have been identified as key actors within their regional innovation systems. They are also taking on expanding roles and responsibilities across various areas, including peripheral border regions (Martin et al. 2023). This is significant because, beyond the firm driving the innovation, other companies within the value network, become recognized the RIS, for example (Weiss et al. 2020). Sawmills are frequently characterized as raw-material dependent (Ramcilovic-Suominen and Pülzl 2018; Väätäinen et al. 2021; Morales and Dahlström 2023); mature; primarily focused on efficiency, productivity and industrial competitiveness (e.g., Brege et al., 2010; Stendahl et al., 2013); with a low level of innovativeness (Hansen et al. 2017). As a result, these companies have been seen as operating under a production-driven business model (Pelli and Lähtinen 2020), where competitiveness is achieved mainly through production efficiency which relies on large-scale output and advanced technology to minimize raw material and labor costs (Lähtinen and Toppinen 2008).

In the forest industries, the most common approach to measuring competitiveness has been companies' financial performance (Korhonen et al., 2017). To enhance their financial performance, sawmills could seek higher priced products to achieve a healthy financial performance (Lähtinen and Toppinen 2008). This relates to the call for companies to generate more innovations which have been shown to positively impact companies' business success (Han et al. 1998; Saunila and Ukko 2012) and also linked to sawmills market orientation (Crespell et al. 2006). For sawmills, this has led companies to seek for e.g., higher value-added potential, by adding new product properties and services in production (Korhonen and Niemelä 2005). Some sawmills have started to build collaborative relationships with their

customers operating in secondary processing and the construction industry to increase product portfolios and achieve higher profit margins (Makkonen and Sundqvist-Andberg 2017; Makkonen 2018).

Unlike sawmills, engineered wood product and element manufacturers primarily focus on processing sawnwood into prefabricated building materials tailored to the needs of the construction industry (Pelli and Lähtinen 2020; Lähtinen and Häyrinen 2022). In addition, some manufacturers especially of higher value-added wood products for the construction industry such as wood element producers have started to operate as developers and builders in the construction industry markets (Stehn et al. 2021). Over the past decade, the industrial prefabrication of components and modules for construction (i.e., wood element production) has been highlighted as a promising opportunity for the wood product industry to explore new business avenues (Bumgardner et al. 2013). Additionally, building with wood may not only enhance efficiency (Pelli and Lähtinen 2020) but may also contribute to broader sustainability benefits, such as improving users' perceived well-being in the built environment (Harju and Lähtinen 2022).

Mature industries, such as the sawmill industry (Väätäinen et al. 2021) are often supported by established RISs, indicating that on a regional level business renewal requires significant changes in the RIS subsystems to produce new insights, expand markets, establish credibility, and attract investments (Miörner and Trippl, 2019). Especially in mature industries, such changes may happen by creating new system elements along with the old ones or by adapting existing system elements from elsewhere (Miörner and Trippl 2018, 2019). Additionally, other interregional connections (e.g., market linkages, input-output relations and other networks) may be important drivers for regional industry transformation (Trippl et al. 2020). As innovation systems mature, their industry dynamics stabilize, and companies become established (Utterback and Suarez 1993), networks strengthen, institutions are established, the infrastructure is optimized and technological pathways become defined; resulting in path dependencies (Carlsson and Jacobsson 1997).

The construction industry is the main end-user of mechanically processed forest industry products, including sawnwood and engineered wood products (Shmulsky and Jones 2011; Bumgardner et al. 2013). Sawnwood serves both as an intermediate product, used in the production of engineered wood products, and as a final product, applied directly in construction. The construction industry is often considered more risk-averse, fragmented, and path dependent than many other industries (Arora et al. 2014), favoring the use of conventional building materials, such as concrete and steel (Jussila et al. 2022). Established, path dependent production systems, such as in the construction industry, driven by cost competition and tend to promote incremental innovation. This often make actors reluctant to adopt new practices that may initially add extra work and other costs in the short-term (Hurmekoski et al. 2015). To break free from the path dependent structures in the construction industry and to develop innovations regarding wood construction, will require investments in the development of knowledge, skills, logistics, and actor networks as well as institutional changes (Mahapatra and Gustavsson 2008), but this has proven to be a difficult avenue toward renewal (e.g., Lazarevic et al., 2020).

The introduction of new wood-based solutions in building processes has led wood building businesses to establish new collaborative relationships with construction companies while adopting innovative business models through process and product advancements (Brege et al. 2014). Thus, through collaboration within the wood building value-network and with construction industry companies, wood building businesses may gain synergic benefits to meet customer expectations through joint innovation, for example (Makkonen and

Sundqvist-Andberg 2017). This is linked with the wood building businesses potential to act in regional, sectoral or technological innovation systems (Weiss et al. 2020) thus possibly providing value creation and innovations for the construction industry (Lazarevic et al. 2020) and to drive sustainability change in construction through locally grounded initiatives.

3. DATA AND METHODOLOGIES

Each of the three articles consists of individual yet interconnected sub-studies within the dissertation, employing distinct methodological approaches. Table 3 provides a summary of the data and methods utilized in each study. Firstly, a systematic literature review was employed (*Article I*) to assess the available scientific literature on sustainable cross-border innovations. Secondly, an exploratory factor analysis (EFA) and non-parametric testing (*Article II*) were conducted to reveal RIS subsystem and sustainability objectives. Thirdly, linear mixed model regression analysis (*Article III*) was used to analyze the financial performance of Finnish sawmills and wood element producers over a ten-year time period.

Table 3. Data and methodologies employed in sub-studies of Articles I, II and III of the dissertation.

	Article I	Article II	Article III
Type of research	Review	Empirical	Empirical
Method	Systematic literature review	Factor analysis, Mann-Whitney *U* & Pearson correlation	Linear mixed effects regression
Data	Sample of screened peer-reviewed journal articles	Survey data collected from Finnish land-use planners	Adjusted financial reports from companies

A systematic literature review was the chosen methodology for the sub-study in *Article I* as it enabled a comprehensive assessment of available scientific literature on a given question. In our study, specific inclusion criteria were formulated for the systematic search and screening of relevant studies. Compared to conventional reviews, a systematic literature review reduces selection bias when searching for and screening literature. It also improves the transparency and replicability of the study (Pullin and Stewart 2006).

In this research, peer-reviewed studies sourced from the Scopus and Web of Science databases were reviewed. The literature search was conducted in English in May 2018. To be included in our sample, studies must fit with the inclusion criteria formulated for the study: (a) each study must explicitly have dealt with an innovation, (b) been in a cross-border region, and (c) must have used empirical primary data in its analysis. A total of 3 690 unique articles were identified through this process. Before the initial screening, a subset of 50 randomly selected studies were reviewed to ensure inter-reviewer consistency by calculating the Randolphs free-marginal multi-rater kappa (Randolph 2008). The next phase in the review process was the initial screening of abstracts which resulted in 121 articles that seemed suitable for purposes of the study. After full text screening was conducted, the final sample included 37 articles to comprise the data. Due to multiple case studies in some of the research papers, the initial number of cases in the sample was 43. These studies form the dataset, which was gathered using a specially designed data extraction sheet, adhering to the common principles of qualitative meta-synthesis (Walsh and Downe 2005).

The earliest study was published in 1995, but it took significant time for the topic to gain momentum, with annual publications emerging only after 2007. Consequently, research on innovation and innovation systems in cross-border regions is relatively recent and remains a niche field. Geographically, most case studies are concentrated in Europe: of the 43 identified CBRIS cases, 35 were in Europe, while only four were conducted in North America, three in Latin America, one in Africa, and one in Asia.

For the sub-study in *Article II,* the data was collected via an online survey conducted in three rounds, including an initial contact and two follow-up reminders, during March and April 2021. The survey targeted civil servants responsible for various land-use management tasks in Finnish municipalities, encompassing a total of 309 municipalities across mainland Finland and Åland.

The final dataset consists of responses from 163 land-use planners, representing 16% of all recipients. These planners were employed by 92 Finnish municipalities, where they were responsible for local land-use planning tasks. Based on statistical data, these 92 municipalities accounted for approximately 70% of Finland's population in 2020, equating to 3.78 million out of the country's total 5.51 million residents (Association of Finnish Municipalities, www.kuntaliitto.fi).

The online questionnaire included approximately 20 questions addressing the economic, social, and environmental dimensions associated with land-use planning processes and practices in Finnish municipalities. Respondents rated the importance of each variable using a five-point Likert scale, ranging from 1 (not at all important) to 5 (very important), with intermediate options of 2 (not very important), 3 (neither important nor unimportant), and 4 (quite important). Additionally, the respondents had the option to select I don't know, though these responses were excluded from the analysis.

Regarding the RIS framework, altogether 18 variables in three questions addressed the importance of RIS subsystems (eight variables for the socio-institutional subsystem, ten for the knowledge generation and diffusion subsystem/knowledge application and exploitation subsystem). These questions were operationalized using the Land Use and Building Act in

Finland and relevant literature (Hytönen et al. 2013; Salo and Mäntysalo 2017). Regarding the sustainability objectives in local land-use planning, three questions with 27 variables addressed the importance of various potential aspects of sustainable land-use planning which were operationalized based on relevant literature (de Jong et al. 2015; Tiitu et al. 2018; Lähtinen et al. 2019).

Prior to the analysis, municipalities were grouped based on Eurostats Degree of Urbanization classification (Eurostat, 2021). The categorization is based on the combination of geographical contiguity and population density measures so that each municipality belongs exclusively to only one of the three categories: urban, towns and suburbs, or rural. After that, three sequential quantitative approaches were employed to implement the analysis. Firstly, an exploratory factor analysis (EFA) was conducted to reveal RIS structures and the municipalities' sustainability objectives. Secondly, Mann-Whitney U tests were conducted to compare differences between municipality groups in relation to the EFA findings. Thirdly, two-tailed Pearson correlations were calculated to assess the interdependencies between the EFA results separately for the municipality groups.

To reduce the number of original survey variables, an EFA with Kaiser normalization, Varimax rotation, and Maximum Likelihood Estimation was conducted. EFA is a method that assesses an empirical phenomenon by revealing the hidden structures, also known as latent variables or factors (Kim and Mueller 1978; Henson and Roberts 2006) to determine whether a large set of variables can be represented more simply (Fabrigar and Wegener 2011). In the end, the EFA solutions are based on theoretical and empirical considerations, such as how variables are operationalized in analytical frameworks and statistical figures (Kim and Mueller 1978; Henson and Roberts 2006; Beavers et al. 2013).

The EFA results were statistically evaluated using multiple measures. A Kaiser eigenvalue greater than 1 served as the primary criterion for determining the number of factors to retain. Sampling adequacy was assessed using the Kaiser-Meyer-Olkin measure, with a minimum acceptable value of 0.50, and the Bartlett test of sphericity, which assumes correlations exist between the original variables. A threshold of 0.4 was applied to factor loadings (i.e., contribution of a variable to the model), while extracted communality values were required to be at least 0.2 (estimates of the variance of a variable with other variables in the model) (Child 2006). Additionally, to enhance the interpretability of the EFA results, variables with significant double loadings on multiple factors were excluded. Throughout the process, conceptual coherence was considered alongside empirical validity in determining the final factor structure.

The importance of different municipality groups' RIS subsystems and sustainability objectives (EFA factors) were compared using Mann-Whitney *U* tests. The Mann-Whitney *U* test is a non-parametric statistical test used to examine differences in means between groups and is particularly suitable for ranked data (King and Eckersley 2019). The following definition for different levels of statistical significance was used: suggestive evidence of statistical significance = $0.05 \leq p\text{-value} < 0.1$; moderate evidence of statistical significance = $0.01 \leq p\text{-value} < 0.05$; and very strong evidence of statistical significance = $p\text{-value} < 0.01$. During this comparison analysis, the municipality groups: towns and suburbs, and rural were decided to be considered as one group, labelled as other municipalities, due to strong similarities between the two groups, and strong dissimilarities between these groups and the urban group.

Lastly, two-tailed Pearson correlations were computed to evaluate the interdependencies between the RIS subsystems and sustainability objectives in residential building (EFA

solutions for the three distinct models and municipality groups). The Pearson correlation quantifies the strength of the linear relationship between two variables

In sub-study of *Article III,* the competitiveness of Finnish sawmills and wood element producers was evaluated by analyzing the financial performance of companies at either stage of the processing chain. At the heart of companies business models are their decisions regarding product portfolios and roles within value chains, which are shaped by their internal strategic strengths (i.e., resources and capabilities). These firm-specific characteristics influence each company's potential to achieve success in its business environment (Spanos and Lioukas 2001; Hawawini et al. 2003; Lähtinen 2007).

Based on the objectives of the study, the data was collected from the firms official financial statements (i.e., income statement and balance sheet) and their attachments from ten accounting periods (2012-2021) collected by the Finnish Patent and Registration Office and obtained as adjusted financial statement data from the Alma Talent database, which is a private Finnish business information provider. Thus, a panel data-set of firm-specific financial statement information is the dataset of the study. In financial statements, the balance sheet reflects a company's financial position, while the income statement outlines its earnings structure (Committee of Corporate Analysis 2011). Additionally, the cash flow statement can provide insights into annual net investments, derived from the official balance sheet figures on investments and divestments in intangible and tangible assets. Along with adjusted firm-level financial statement data, the Alma Talent database offered qualitative information through news articles, which were used to verify companies' product portfolios (i.e., focus on primary or secondary processing of wood industry products). This helped ensure data validity and supported the interpretation of results.

Before conducting the analysis, a preliminary review of the companies' product portfolios was carried out to ensure that only those with a strategic focus on manufacturing sawnwood or wood element products were included in the final dataset. Additionally, to maintain comparability between the two wood product industry categories, only companies with an annual turnover between 1 and 75 million euros were selected for analysis. As a result of this process, the study's dataset consists of 36 sawmills (primarily engaged in the primary processing of sawnwood) and 34 wood construction element manufacturers (primarily focused on the secondary processing of wood construction elements).

Official statistics do not separately record these specific industry classifications, making it challenging to precisely determine the coverage of companies within their respective industries in this study. However, based on Statistics Finland's industry classification (StatFin 2023), there were 869 companies categorized under Sawmilling and Planing of Wood in 2023, though this figure does not account for company size. As for element producers, a 2020 report by Ministry of Economic Affairs and Employment in Finland (2020) identified a total of 32 companies engaged in wood construction element production, suggesting that the dataset used in this study provides a fairly comprehensive representation of the sector.

The selection of financial measures employed as proxies to evaluate competitiveness was guided by insights into the characteristics of various financial statement figures, recommendations from the Committee of Corporate Analysis (Committee of Corporate Analysis 2011, 2017), data availability in the Alma Talent database, and findings from empirical studies on wood product industry competitiveness (e.g., Lähtinen and Toppinen, 2008). In practice, the aim was to identify and select financial metrics that reflect liquidity, solvency, and profitability—key dimensions of financial performance traditionally analyzed in financial statement assessments (Laitinen 2000).

Liquidity was measured using the *current atio*, where values above 2 indicate good liquidity, 1–2 signify satisfactory liquidity, and below 1 reflect poor liquidity. Solvency was assessed through the *equity ratio %*, with benchmark values above 40% representing strong solvency, 20–40% indicating satisfactory solvency, and below 20% denoting weak solvency. Profitability was evaluated using the *return on capital employed* (*ROCE %*) and the *net profit ratio %.*

Prior to a regression analysis, in accordance with the study's objectives, the development of the financial performance measures (*Current Ratio, Equity Ratio*, *Net Profit Ratio %* and *ROCE %*) and the companies size through the turnover and the average annual number of employees were assessed. The results on competitiveness and company size development were visualized using box plots, covering ten accounting years (2012–2021), to illustrate variations in financial performance within the industry.

In the second phase of the statistical analysis, linear mixed model (LMM) regressions were applied, which is a method that is particularly useful for analyzing repeated measures or longitudinal data (Cnaan et al. 1997). In mixed-effects models, coefficients at the group level are referred to as random effects, while all other coefficients are considered fixed effects (Gelman and Hill 2006). Our models include fixed effects for *value-added, materials, salaries, investments,* and *year* to account for variations within companies over time, enabling the isolation of individual contributions to the outcome. To capture differences between companies, unique *Company ID*s were incorporated as random effects with a random intercept. This approach assumes that company-specific factors, such as business model, leadership, or market position, vary randomly and independently across firms (Gelman and Hill 2006).

In equation (1), the dependent variable Y_{ij} denotes the outcome of interest (e.g., a financial performance measure) for the *i*-th observation within the *j*-th company. The fixed effects are influenced by a global intercept β_0, which represents the population-average parameter across all companies, Year ($\beta_1(\text{Year}_{ij})$), which captures temporal trends, and other firm-specific variables (Materials_{ij}, Salaries_{ij}, Value-Added_{ij}, and Investments_{ij}). The random effect is represented by b_{0j}, which accounts for the company-specific random intercepts. The error term $\in_{ij}$ reflects the difference between the predicted and observed values in the following equation:

(1)

$$Y_{ij} = (\beta_0 + b_{0j}) + \beta_1(\text{Year}_{ij}) + \beta_2(\text{Materials}_{ij}) + \beta_3(\text{Salaries}_{ij}) + \beta_4(ValueAdded_{ij}) + \beta_5(\text{Investments}_{ij}) + \in_{ij}$$

In the longitudinal regression modelling, autocorrelation was addressed using the autoregressive AR(1) process. Furthermore, variance component parameters were estimated using the restricted maximum likelihood (REML) method, which is commonly preferred (Lin et al. 2013) and considered the most efficient estimator for slopes in linear mixed modeling (Alpargu and Dutilleul 2006). The estimation was performed using the R programming language and the nlme package.

4. MAIN RESEARCH FINDINGS

The following chapter summarizes the three original articles which form the dissertation research according to their main findings. Table 4 presents the research gaps addressed in each article.

Table 4. Overview of the identified research gaps addressed in the sub-studies in Articles I, II and III.

Article	Research gaps
Article I: Resilient cross-border regional innovation systems for sustainability? A systematic review of drivers and constraints	Efforts to **integrate the concepts of regional innovation, cross-border integration, and sustainability** into a unified framework remain limited. Advancing toward an innovation system that fosters resilience and sustainability across borders requires a deeper understanding of the **factors that drive or hinder the integration of CBRIS**, as well as those influencing their adaptability and long-term viability.
Article II: Land-Use Planning in Municipalities as a Driver for Sustainable Residential Building in Finland: A Regional Innovation System Approach.	The interconnections between **local land-use governance and actor collaboration have potential to increase sustainability in the built environment through innovation** but remain underexplored. While previous studies acknowledge the individual roles of these factors and their potential to facilitate mutual learning and knowledge co-creation, their systemic relationships require further examination, particularly across different types of localities. Moreover, research has largely focused on **cities as the primary locations of sustainability challenges, often overlooking the role of rural communities**, despite their crucial contribution to the resource base.
Article III: Longitudinal analysis of financial performance of sawmills and wood construction element producers in Finland	The research gap lies in the absence of quantitative analyses **comparing the financial performance of firms engaged in primary (sawmills) and secondary (wood element producers) wood processing.** While existing studies recognize the role of these firms in enhancing competitiveness through sustainability-oriented market offerings and emphasize value-added processing as a strategy to strengthen firms' market positions, they do not quantitatively assess performance differences and determinants in these two industry segments. This gap limits the understanding of how **cost structures, value creation, and investment activities influence financial performance** in firms with different processing focuses, which is critical for guiding strategic decision-making in the wood product industry.

Article I is a literature review to explore the research conducted on the implications of global and regional changes in social, political, economic, and ecological systems in cross-border regions. In the article, a resilient cross-border regional innovation system (CBRIS) for sustainability is defined through a systematic literature review regarding previous literature on resilience, sustainability, and CBRIS integration to answer its research questions.

In the analysis on the level of integration of CBRIS, a framework by Lundquist and Trippl (2013) was adopted and extended to additionally include a sustainability dimension (Table 5). Each of the dimensions has a three-level description on the integration stage: I an asymmetric cost-driven system, II an emerging knowledge driven system, and III a symmetric innovation driven system, with stage I being the least integrated and III the most integrated CBRIS.

To answer the first research question, "What is the general status of the evidence base regarding CBRIS integration?", our results suggest that cross-border regional development is typically driven by the triple helix model of innovation where governmental, business, and research organizations are at the core. From a sustainability perspective, public participation requires more thorough evaluation in cross-border regions, where the commitment of citizens and stakeholders can be crucial for defining and achieving sustainability goals (Reed et al. 2018).

Regarding the second research question, "What drives and constrains CBRIS integration?" about drivers and constraints of CBRIS integration (Lundquist and Trippl 2013), our results reveal a systematic pattern between CBRIS integration and strong economic synergies, and weak CBRIS integration and economic constraints. Similar mutual patterns can also be observed for the other drivers and constraints. The reviewed articles had a strong focus on economic synergies and institutional and policy set-ups, whereas other CBRIS integration dimensions (Lundquist and Trippl 2013) have received less attention. The proposed sustainable integration of CBRIS and its connection to desirable resilience require greater focus and more thorough evaluation to enable cross-border regions to adopt more sustainable development trajectories.

Regarding the third and fourth research question, "How are sustainability goals reflected in literature on CBRIS integration?" and "What do we know about the resilience and sustainability of CBRIS?" according to the reviewed literature, sustainability plays little to no role in the studied CBRIS, and resilience has largely remained a neglected topic. Given that the future success of border regions may largely hinge on their capacity to establish shared innovation spaces and adapt to ever-changing environments and disruption in CBRIS integration, this apparent gap should raise concerns among policymakers striving to mitigate the negative effects of reduced border permeability.

Table 5. Stages and dimensions of CBRIS integration adopted from *Article I* (based on Lundquist and Trippl, 2013)

	I Asymmetric cost-driven system	II Emerging knowledge-driven system	III Symmetric innovation-driven system
Economic synergies	Strong differences in specialization.	Emerging complementarities (cognitive proximity) and functional proximity in some economic sectors.	Complementarities (cognitive proximity) and functional proximity in several economic sectors.
Research synergies	Strong differences in specialization.	Emerging complementarities (cognitive proximity) and functional proximity in some scientific fields.	Complementarities (cognitive proximity) and functional proximity in several scientific fields.
Knowledge flows	Cost-driven asymmetrical linkages.	Symmetric linkages in some areas.	Intensive cross-border knowledge exchange.
Institutional structures	Long institutional (hard or soft) distance.	Decreasing institutional (hard or soft) distance.	Long institutional (hard or soft) distance.
Policy structures	Lack of leadership and legitimacy.	Emerging cross-border coordination of innovation policies, involving some actors from different sides of the border.	Effective vision and leadership.
Physical proximity	Long physical distance	Decreasing physical distance.	Short physical distance.
Sustainability	Sustainability not considered on the cross-border scale.	Project-driven developments towards sustainability across the border.	Common cross-border policies for sustainability.

In *Article II* land-use planning systems in Finnish municipalities and their sustainability objectives were studied by using a regional innovation system approach. Before the analysis, municipalities were classified according to Eurostats Degree of Urbanization (Degurba) into three categories: densely populated (urban), intermediate density (towns and suburbs), and thinly populated areas (rural) (Eurostat, 2021). However, the initial analysis proved that towns and suburbs and rural municipalities shared very similar characteristics and were thus combined into one group, named "other municipalities".

Firstly, to answer the first research question, "Based on RIS framework, what are the structures of municipalities land-use planning?", the study assessed institutional structures, actor roles in municipalities land-use planning systems by identifying their subsystems based on RIS framework. Additionally, at this stage, municipalities sustainability objectives in land-use planning were identified using an exploratory factor analysis (EFA) method.

One factor model was utilized to define institutional elements, one for actor roles, and one for sustainability objectives. Regarding the first EFA model connected to the Socio-institutional subsystem in RIS, two factors emerged, highlighting the use of both informal and statutory approaches to achieve land-use planning objectives in Finnish municipalities. The factors were named: 1) *informal planning* factors, and 2) *local statutory planning* factors. The second EFA model related to the importance of different stakeholders in fulfilling the land-use planning objectives connected with knowledge generation and diffusion subsystem and knowledge application and exploitation subsystem in RIS. The model resulted in two-factor solutions, and these were named: 1) *information compilers, deliverers, and users*, and 2) *research and governance organizations*. The third EFA model was conducted to assess general themes related to municipalities' sustainability objectives. It also resulted in a two-factor solution and the factors were named as 1) s*ustainable building focus* and 2) *ecosystem service focus* factors.

Secondly, the comparisons between RIS subsystems and sustainability objectives (Table 6) (second research question: "Are there regional differences between RISs?") show statistically significant differences between the two municipality groups in the use of *informal planning* and *research and governance organizations* factors, with urban planners valuing these factors more. Additionally, for sustainability objectives in residential building, urban municipalities prioritize the *sustainable building focus* factor, while other municipalities emphasize the *ecosystem service focus* factor.

Table 6. Comparisons with urban and other municipalities in relation to exploratory factor analysis (EFA) results on the regional innovation system (RIS) (i.e., socio-institutional subsystem, knowledge subsystems) and sustainability objectives in municipalities' land-use planning.

	Factor models	Factors	n	Mean rank difference (urban – others)	p-value
Regional Innovation System	**Socio-institutional factor model**	**F1: Informal planning**	**138**	**24.73**	**< 0.001*** **
		F2: Local statutory planning	138	8.95	0.198
	Stakeholder factor model	F1: Information compilers, deliverers, and users	135	10.21	0.143
		F2: Research & governance organizations	**135**	**17.55**	**0.012****
	Sustainability objectives factor model	**F1: Sustainable building focus**	**118**	**26.68**	**< 0.001*** **
		F2: Ecosystem service focus	**118**	**-13.95**	**0.030****

*Suggestive evidence of statistical significance = 0.05 ≤ p-value < 0.1; **moderate evidence of statistical significance = 0.01 ≤ p-value < 0.05; ***very strong evidence of statistical significance = < 0.01 p-value.

Thirdly, in connection to the third research question, "What is the interaction between RIS subsystems and sustainability objectives?" the study assessed relationships between the RIS subsystems and sustainability objectives in residential building. Figure 2 presents a summary of those results highlighting the interconnections between RIS subsystems and their roles in achieving sustainability goals in Finnish municipalities.

The *socio-institutional subsystem* shows that informal land-use planning is more connected to new knowledge creation, existing knowledge use, and sustainable residential building objectives. These connections are consistent across urban and other municipalities, suggesting informal approaches are more effective in enhancing local sustainability goals. In terms of sustainability in residential building, new knowledge creation has stronger links with local sustainability than existing knowledge use. Despite some differences between urban and other municipalities, the findings indicate that knowledge accumulation is crucial for sustainability actions, benefiting business and citizens.

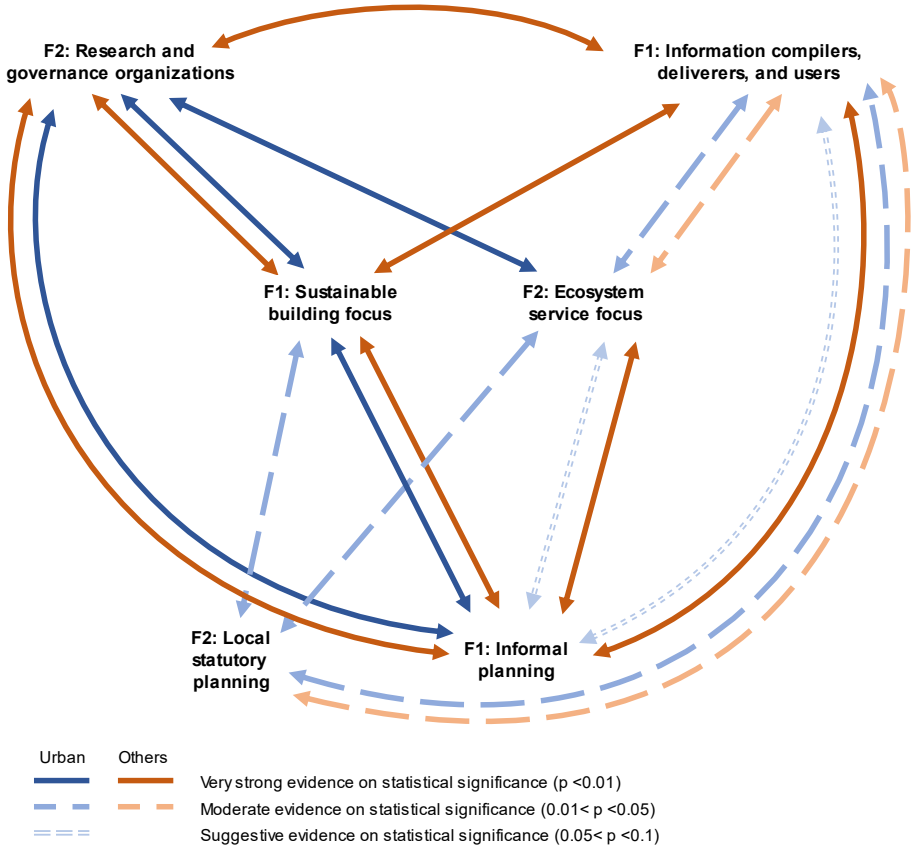

Figure 2. Illustration of two-tailed Pearson correlations between independent variables for both municipality groups

Article III addressed the development of the financial performance of Finnish sawmills and wood element producers which represent distinct, yet partially overlapping, stages of processing within the mechanical wood industry, each forming different types of connections with the construction industry's building processes (Brege et al. 2014). In the research, it is recognized that competitiveness arises from a blend of industry-level factors and firm-specific characteristics, both of which influence a company's potential for success in its business environment (Spanos and Lioukas 2001; Hawawini et al. 2003; Lähtinen 2007). Therefore, the analysis of competitiveness enables a better understanding of renewal in the construction industry by assessing a niche technology of prefabricated wood construction.

Firm-level financial performance provides information on the outcome of the success of business model formulation and implementation, which are based on interpretations made on the future events and external environmental factors made at the phase of business model design to enhance competitiveness (Hunt and Morgan 1996; Barr 1998; Siggel 2006). At the core of a company's business model are decisions regarding product portfolios and roles within value chains, built on internal strategic strengths, such as resources and capabilities. These firm-specific characteristics influence the potential for success within the business environment (Spanos and Lioukas 2001; Hawawini et al. 2003; Lähtinen 2007). However, for manufacturing firms like sawmills and wood element producers, the ability to make strategic changes through business model formulation is constrained by path dependencies in their use of raw materials and machinery (Lähtinen and Häyrinen 2022).

Regarding the first research question, "Does focus on primary or secondary processing in wood product industry influence the financial performance of firms?", the article's results suggest that wood element producers operating in an emerging industry tend to exhibit greater variation in their *ex ante* business model formulation and implementation compared to sawmilling firms. In the established sawmilling industry, sawlogs are the primary raw material (Väätäinen et al. 2021), whereas wood element producers have a broader range of initial options, as they can utilize sawnwood or various engineered wood products, such as LVL, CLT, or glulam (Heräjärvi et al. 2004). Additionally, wood element producers experience greater variability in their roles within the construction industry, which can range from material supplier to subcontractor or main contractor (Brege et al. 2014; Pelli and Lähtinen 2020). Moreover, wood element manufacturers can differentiate themselves by selecting specific product offerings, such as non-volumetric or volumetric elements, to set themselves apart from competitors (e.g., Wood From Finland, 2024). In terms of industry-level development, and also linked to the first research question, the liquidity and solvency rates show signs of opposite trends between the two industries. Both measures indicate that the trends have been consistent throughout the period of interest: an upward trend for sawmills and a downward trend for element producers.

The second research question, "How do costs, value creation, and investment activities influence the financial performance of different types of companies, as measured by various financial measures?" was tackled using linear mixed model regression analysis. Based on the results (Table 7), the models show significant similarities between the two types of businesses (i.e., sawmilling and wood element producers). The results highlight that the production activities are a central feature of both sawmilling and wood element manufacturing rather than a focus on developing services or software, for instance. Regarding the similarities, costs (*material, salaries*) were found to have a negative impact on financial performance for both sawmills and wood element producers. For value-added, the results suggest a positive effect on firm-level competitiveness for both industries. The impact of investments on the two industries yielded inconclusive results. While most performance indicators showed a

negative effect, there was a slight positive impact on the solvency of element producers. This lack of clear evidence regarding the relationship between investments and competitiveness may be attributed to the oversight of dynamic effects, as larger investments typically require more time to fully realize their production capacity.

Table 7. Summary of the impacts of costs, value-added, and innovation on industries' competitiveness (red negative, green positive, white insignificant). The figures represent regression model coefficients.

	Ln Current Ratio Liquidity	**Equity Ratio** Solvency	**Net profit ratio (%)** Profitability (abs.)	**ROCE (%)** Profitability (rel.)
Sawmills				
Salaries	-3.22		-0.68	-1.46
Materials		-0.82	-0.39	
Investments	-0.33	-0.24		-2.05
Value-added			0.15	0.54
Wood element production				
Salaries			-0.89	-0.75
Materials	-0.7		-0.49	-1.01
Investments		0.02	-0.11	
Value-added		0.24	0.19	

5. DISCUSSION AND CONCLUSION

5.1. Limitations of the dissertation

In addition to the systematic literature review methodology employed in *Article I*, the research design of this dissertation relied empirically on quantitative methodologies, which have some drawbacks. For example, the aggregation process of categorizing individual municipalities into groups, such as urban and rural municipalities, enabled statistical analysis, however it restricted the possibility for more detailed analyses on region-specific aspects of innovation systems. Similarly, treating sawmills and wood element manufacturers as two distinct processing stages enabled quantitative analyses of these aggregated categories. However, to study firm-level high-value, low natural resource-intensive business strategies, for example, more qualitative methods and case focused approaches would be needed, for example, to identify and assess effective business strategies and successful approaches.

The results presented in *Article I* relied on systematic literature review which used published peer-reviewed articles as data (during years 1995-2018), possibly leaving out important unpublished work and grey literature, leading to a selection bias. The results revealed that resilience and sustainability remain underdeveloped within CBRIS, with empirical research largely overlooking the ecological impacts in cross-border regional development. Regarding the study's framework about the level of cross-border integration, we were unable to determine which of the stages the analyzed cases represent. Especially,

due to often limited project intervals of the analyzed articles, it was not possible to evaluate CBRIS integration over a long period of time. Additionally, although each article included in the systematic literature review was carefully examined to determine if they contained relevant data, there is always a chance of human error related to interpreting the articles, including regarding what types of cases can be considered as innovations.

Regarding cross-border regions, the reviewed literature was highly focused on northern Europe with several active local research institutes. However, CBRISs also exist elsewhere but have received less research attention, leaving several potential cases and regions unexplored. Similarly, in *Article II* the focus was on one single country, Finland, limiting the generalization potential of our findings, for example regarding the importance of informal and formal land-use planning means. Also, actors were treated as single stakeholder groups, even though there are distinct subgroups of business actors with possibly varying levels of importance. These could include building developers, building product manufacturers, technical universities, and social sectors, among others.

As is commonly criticized in RIS research, the sub-study in *Article II* is also limited to a static depiction of the situation at a given point in time and does not enable analysis for example of ongoing developments. With *Article III*, this issue is different as it includes a ten-year period in the study. However, it does also include period-specific events and external influences, such as in 2021 when especially sawmills' profitability improved rapidly due to economic turbulence and increased prices globally. Additionally, regarding system's change, this dissertation's empirical results have a focus on the development of a specific RIS subsystem (especially the k*nowledge application and exploitation subsystem*), limiting its overall contribution to knowledge creation regarding the broader development of RIS, including all subsystems and institutional factors.

5.2. Contribution of the dissertation

Altogether the dissertation adopts a broad understanding of sustainability-oriented innovation, by studying regions with distinct characteristics (urban, rural and cross-border regions), and assessing local businesses' potential to innovate and maintain long-term competitiveness by analyzing their realized financial performance. It contributes both theoretically, methodologically, as well as empirically to the regional innovation system (RIS) literature.

More specifically, it offers insights into the current state of innovation research at national (i.e., cross-border), and local (i.e., municipality) levels especially through business perspective from a specific industry (i.e., wood for construction purposes). Theoretically, the novelty of the results and findings made in this dissertation relate to adding knowledge on the integration of sustainability aspects in RIS through national and local-level actions, and the role of different actors and institutions to enhance sustainability-oriented innovations. Methodologically, the dissertation introduces a novel combination of data and methodological approaches by integrating local survey data collected through a questionnaire from Finnish land-use planners with a quantitative analysis to understand how different actors connect in terms of RIS, and what their interlinkages are in enhancing sustainability-oriented innovations. Empirically, it explores the roles of construction industry actors and institutions, their interconnectedness, and their alignment with sustainability objectives in regions with different characteristics. Further, it examines the realized development trajectory of wood

building businesses' financial performance and operational conditions as a proxy of developments in the construction industry.

Inspired by the findings from the sub-studies and literature on RISs in industrial path development (see e.g., Miörner and Trippl 2018; Martin et al. 2023), Figure 3 serves as an illustrative representation of the expanded roles and responsibilities of actors and institutions in sustainability-oriented regional innovation systems rather than an empirical result. It visually highlights how the subsystems are no longer confined to distinct boundaries (like in original Figure 1), and the responsibilities of actors and institutions within these subsystems have expanded to include roles in other subsystems, which is visually represented in Figure 3 by overlapping shapes that primarily correspond to individual subsystems and their selected example actors. Additionally, Figure 3 highlights the importance of aligning RIS objectives with all actors through how all actor shapes intersect with the sustainability-oriented innovation circle at the center of the figure. Similarly to Figure 1, other RISs, international institutions and national innovation system(s) influence regional innovation dynamics which shape the overall innovation environment.

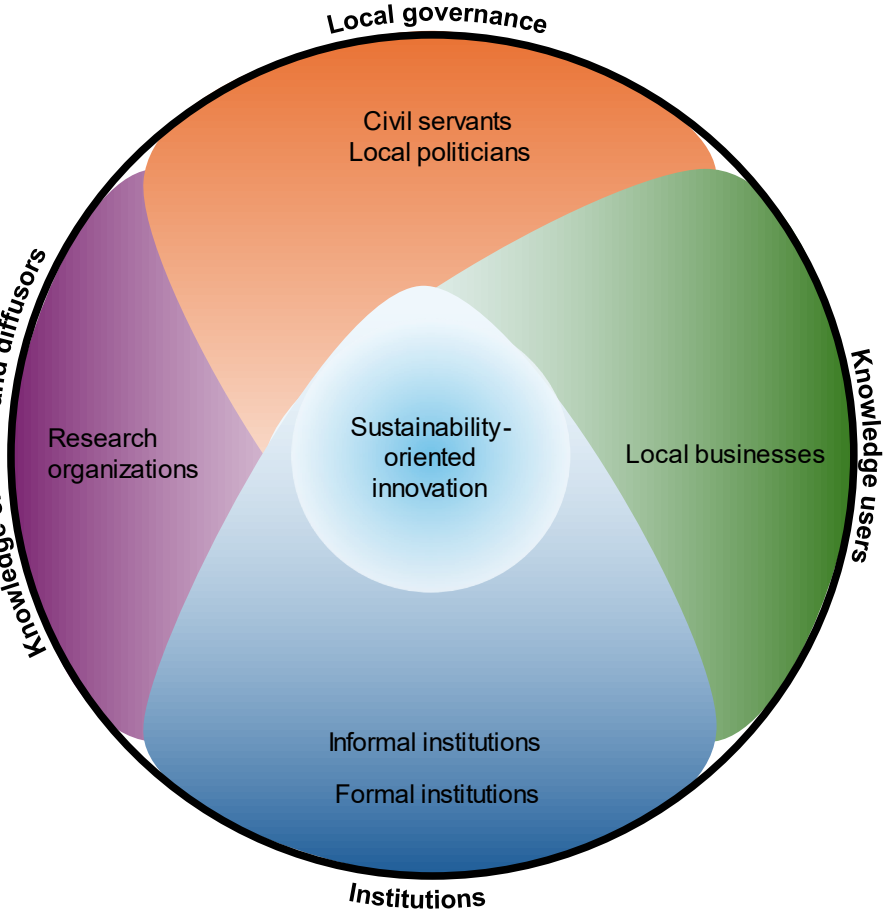

Figure 3. Illustrative representation of example actors and their expanded roles and responsibilities within sustainability-oriented innovation systems with aligned objectives between actors.

As a conceptual outcome of the dissertation, a resilient cross-border regional innovation system is introduced to determine factors contributing to the resilience and sustainability in the context of cross-border regions. The novelty of the concept relies in bridging the literature on innovation systems with resilience and sustainability in a cross-border context providing a way of rethinking the processes that could potentially lead to greater sustainability, especially in border regions. In line with recent calls to expand the objectives of innovation systems to cover sustainability-orientation, results in the dissertation suggest sustainability to be largely absent also from the current scientific literature on CBRIS.

Empirically, the dissertation applies the RIS concept to land-use planning and construction in the context of Finland. It contributes to the RIS literature on sustainability by identifying sustainability objectives within urban and rural RISs and examining the relationships between RIS subsystems and the sustainability objectives of their respective systems. Empirically, the result supports earlier research by showing that, regardless of

national land-use planning systems, informal planning tools play a significant role in enhancing local sustainability.

Building on this, the dissertation shows that in urban regions, informal planning tools are more prominent compared to rural areas. The findings suggest that urban municipalities place greater emphasis on informal mechanisms, reflecting their potential to drive sustainability objectives in these settings, whereas for rural municipalities such evidence is less evident. This may relate to the nature of the statutory planning system, which follows normative mechanisms to guide land-use planning and construction based on rules and legislation instead of trying to develop new solutions in collaboration with other actors such as businesses, for example. However, this may change to some degree in Finland with the introduction of the new Building Act in January 2025, which promotes the adoption of carbon footprint calculation and favors green technologies throughout the entire new construction lifecycle, from planning and design to demolition (Building Act 2023). Results in this dissertation support the claim that informal institutions are more connected to generating new ideas compared to formal institutions and they are better at influencing the behavior and willingness of individuals (e.g., entrepreneurs) to consider new ideas and seek change. Furthermore, informal institutions may impact formal institutional arrangement to co-evolve through e.g., technological development and changing circumstances. For instance, such a development can be interpreted with the evolvement of Finnish formal construction regulations.

Regarding RIS actors, the dissertation's results suggest that rural municipalities might be lacking key actors and resources needed for innovation activities as knowledge creators (i.e., research and governance organizations) are less important in these municipalities compared to urban municipalities. At the same time, although local businesses have been found to be important actors in the development of the forest-based bioeconomy, their connectedness to other RIS actors in terms of land-use planning and construction was found to be more limited, especially in the case of urban municipalities, which are generally considered as hubs of innovation activity. The declining financial performance, particularly in solvency and liquidity, of businesses in the mechanical wood industries, which are part of the wood construction value-network, suggests that their successful implementation in RISs remains limited. Overall, this aligns with recommendations identified in previous research to build strategic alliances among civil society, business, and local government, and to strengthen connections between urban and rural areas (Rönkkö and Aarrevaara 2017).

In this dissertation, industrial development was assessed by the realized financial performance of companies operating in wood construction, namely Finnish sawmills and wood element producers. The financial statement data enabled a retrospective analysis of the businesses' economic conditions that determine their ability to compete and innovate. If firms are not financially viable over time, they risk going out of business, highlighting the fundamental role of economics in driving sustainability-oriented innovations, especially in industries prone to economic fluctuations such as the wood and construction industries. The results on the two stages of processing (i.e., sawmilling and wood element production) show signs of typical manufacturing industries, including the high negative impact of materials and salaries on financial performance, but there are also clear differences. For example, sawmills' show smaller within industry variation in their profitability, indicating, that the industry is more mature compared to wood element producers. This may also relate to the broader scope of wood element producers' business models, as they may operate beyond material and product manufacturing, engaging in the construction industry as contractors, for example.

5.3. Conclusions and way forward

As an outcome of the dissertation, it is contended that innovation should be fostered in a way that enables the renewal of regions and industries toward more sustainable development pathways. At the same time, it is important to recognize that different regions and geographical levels (e.g., national and regional) encounter unique opportunities and challenges in terms of developing innovations. Achieving sustainability objectives set on global or national levels depends on the ability of local actors to adapt and implement higher level commitments, highlighting the need for regional focus in innovation research and policy design. Furthermore, the integration of insights from different methodological approaches, capturing both system dynamics and the financial conditions of key industries, is crucial. Understanding these factors provides a more comprehensive view of the structural enablers and constraints of sustainability-oriented innovation, supporting the development of more effective policies and strategies. By incorporating financial performance analysis into innovation studies, research can better reflect ex post conditions that have driven or hindered technological changes.

The RIS framework has been extensively applied across various regions, countries, and at the EU level to guide place-based innovation policies and it is also used as a tool for researchers. The use of the RIS framework, like any other framework, is typically directed toward its intended purpose. A recent shift in the innovation literature and policy has been the shift from economy orientation towards an emphasis on sustainability-oriented innovations. This focus encourages experimentation and the application of the framework in ways that integrate sustainability considerations. The emphasis on sustainability varies between different regions in the innovation system literature, and, for example, in cross-border regions the integration of sustainable development has been particularly limited. In such regions, areas consist of adjacent regions that belong to more than one nation, the notion no size fits all is emphasized, placing regional consideration even more at the center.

The disparities in economic conditions between often peripheral border regions (or rural regions in general), and urban areas underscore the varying goals and opportunities for RISs across regions. This is particularly evident in the built environment, where regional differences, such as those between urban and rural municipalities, influence the approaches and priorities for land-use planning and construction. Areas differ in what type of actors exist in the region as well as in how significant they are in their corresponding innovation systems. For example, research organizations are often found in urban areas, whereas many industrial manufacturing companies' production facilities, e.g., in the forestry sector, are located in rural regions. Additionally, RISs may differ in their institutional set-ups as some of them emphasize informal over statutory approaches in driving sustainable innovation. This highlights the crucial role of inter-municipal collaboration between actors, especially the interaction between actors operating in urban and rural municipalities.

Based on the results of this dissertation, it is crucial to understand how different RISs, especially in regions with homogeneous characteristics, are connected. It is important to examine which actors and institutions from various subsystems interact with those in other RISs. Additionally, identifying those actors that are excluded from inter-regional interactions, and the reasons for their exclusion, is essential. This is relevant in land-use planning and construction, as the whole network of actors from manufacturers of primary and secondary products to architectural and structural designers and contractors of building projects are often located in very different kinds of municipalities, highlighting the linkages between urban and peripheral regions.

The dissertation identified connections between certain RIS subsystems and institutional factors in land-use planning and construction from a sustainability-oriented innovation perspective. However, links between some subsystems, as well as between subsystems and institutional factors, remained less evident. This may indicate that there is a lack of interaction between actors or resources within the innovation system that are needed to enhance sustainability-oriented innovations. Alternatively, the findings may be explained by the limitations of the methods and approaches used in the study, which may have been insufficient to reveal the relevant information. Thus, it would be important to also explore the lacking interaction between some actors and/or institutions, using different methodologies than those was used in sub-studies of this dissertation. For example, a qualitative approach could be used to investigate the perspectives of politicians or civil servants as independent individuals and/or in independent case studies, rather than aggregating and generalizing their views.

In the case of achieving more sustainable development in the future, our economies are still likely to rely on competitive and profitable businesses that have the means to develop sustainable innovations. The traditional forest-related industries, as providers of bio-based products, play a crucial role, in building an economy that is less dependent on fossil-based materials. Their consideration in innovation systems is essential to ensure that interactions are aligned throughout the entire value network, driving system change with competitive businesses and innovation. By recognizing and integrating actors in the mechanical wood processing value network, regions can better leverage their strengths to create innovations that support long-term economic and environmental goals within and across regions. Thus, a valuable avenue for further research would be to explore managerial decision-making, given the increasing need to assess the viability of high-value, low natural resource-intensive niche strategies in alignment with initiating national and international bioeconomy agendas.

6. REFERENCES

Albrechts L (2006) Shifts in strategic spatial planning? Some evidence from Europe and Australia. Environment and Planning A: Economy and Space 38:1149–1170. https://doi.org/10.1068/a37304

Albrechts L, Balducci A (2013) Practicing strategic planning: In search of critical features to explain the strategic character of plans. DISP - The Planning Review 49:16–27. https://doi.org/10.1080/02513625.2013.859001

Alpargu G, Dutilleul P (2006) Stepwise Regression in Mixed Quantitative Linear Models with Autocorrelated Errors. Communications in Statistics - Simulation and Computation 35:79–104. https://doi.org/10.1080/03610910500416082

Anderson JC, Håkansson H, Johanson J (1994) Dyadic Business Relationships within a Business Network Context. Journal of Marketing 58:1–15. https://doi.org/10.2307/1251912

Arora SK, Foley RW, Youtie J, et al (2014) Drivers of technology adoption—the case of nanomaterials in building construction. Technological Forecasting and Social Change 87:232–244. https://doi.org/10.1016/j.techfore.2013.12.017

Asheim BT (1995) Regionale innovasjonssystem–en sosialt og territorielt forankret teknologipolitikk. Nordisk Samhällsgeografisk Tidskrift 20:17–34

Asheim BT, Grillitsch M, Trippl M (2016) Regional innovation systems: Past–present–future. Handbook on the Geographies of Innovation 45–62. https://doi.org/10.4337/9781784710774.00010

Autio E (1998) Evaluation of RTD in regional systems of innovation. European Planning Studies 6:131–140. https://doi.org/10.1080/09654319808720451

Bandura A (2006) Toward a psychology of human agency. Perspectives on psychological science 1:164–180. https://doi.org/10.1111/j.1745-6916.2006.00011.x

Barr PS (1998) Adapting to Unfamiliar Environmental Events: A Look at the Evolution of Interpretation and Its Role in Strategic Change. Organization Science 9:644–669. https://doi.org/10.1287/orsc.9.6.644

Barton H (2009) Land use planning and health and well-being. Land Use Policy 26:S115–S123. https://doi.org/10.1016/j.landusepol.2009.09.008

Beavers A S, Lounsbury J W, Richards J K, et al (2013) Practical Considerations for Using Exploratory Factor Analysis in Educational Research. Practical Assessment, Research, and Evaluation 18:. https://doi.org/10.7275/qv2q-rk76

Binz C, Truffer B, Coenen L (2016) Path Creation as a Process of Resource Alignment and Anchoring: Industry Formation for On-Site Water Recycling in Beijing. Economic Geography 92:172–200. https://doi.org/10.1080/00130095.2015.1103177

Blayse AM, Manley K (2004) Key influences on construction innovation. Construction Innovation 4:143–154. https://doi.org/10.1191/1471417504ci073oa

Boehnke RF, Hoppe T, Brezet H, Blok K (2019) Good practices in local climate mitigation action by small and medium-sized cities; exploring meaning, implementation and linkage to actual lowering of carbon emissions in thirteen municipalities in The Netherlands. Journal of Cleaner Production 207:630–644. https://doi.org/10.1016/j.jclepro.2018.09.264

Braczyk H-J, Cooke P, Heidenreich M (2003) Regional innovation systems: the role of governances in a globalized world. Routledge. https://doi.org/10.4324/9780203330234

Brege S, Nord T, Sjöström R, Stehn L (2010) Value-added strategies and forward integration in the Swedish sawmill industry: positioning and profitability in the high-volume segment. Scandinavian Journal of Forest Research 25:482–493. https://doi.org/10.1080/02827581.2010.496738

Brege S, Stehn L, Nord T (2014) Business models in industrialized building of multi-storey houses. Construction Management and Economics 32:208–226. https://doi.org/10.1080/01446193.2013.840734

Buhl A, Schmidt-Keilich M, Muster V, et al (2019) Design thinking for sustainability: Why and how design thinking can foster sustainability-oriented innovation development. Journal of Cleaner Production 231:1248–1257. https://doi.org/10.1016/j.jclepro.2019.05.259

Building Act (2023) FINLEX. In: 132/1999. https://finlex.fi/en/legislation/collection/2023/751. Accessed 25 Mar 2025

Bumgardner M, Johnson S, Luppold W, et al (2013) Markets and Market Forces for Lumber. In: Hansen E, Panwar R, Vlovsky R (eds) The Global Forest Sector: Changes, Practices, and Prospects. pp 41–76

Busck AG, Hidding MC, Kristensen SBP, et al (2008) Managing rurban landscapes in the Netherlands, Denmark and Sweden: Comparing planning systems and instruments in three different contexts. Geografisk Tidsskrift 108:1–16. https://doi.org/10.1080/00167223.2008.10649584

Cajaiba-Santana G (2014) Social innovation: Moving the field forward. A conceptual framework. Technological Forecasting and Social Change 82:42–51. https://doi.org/10.1016/j.techfore.2013.05.008

Carbonara N, Pellegrino R (2020) The role of public private partnerships in fostering innovation. Construction Management and Economics 38:140–156. https://doi.org/10.1080/01446193.2019.1610184

Carina E, Keskitalo H, Liljenfeldt J (2012) Working with sustainability: Experiences of sustainability processes in Swedish municipalities

Carlsson B, Jacobsson S (1997) In search of useful public policies—key lessons and issues for policy makers. In: Technological systems and industrial dynamics. Springer. pp 299–315. https://doi.org/10.1007/978-1-4615-6133-0_11

Child D (2006) The essentials of factor analysis, 3rd edn. Continuum

Chiu RLH (2004) Socio-cultural sustainability of housing: A conceptual exploration. Housing, Theory and Society 21:65–76. https://doi.org/10.1080/14036090410014999

Chlebna C, Simmie J (2018) New technological path creation and the role of institutions in different geo-political spaces. European Planning Studies 26:969–987. https://doi.org/10.1080/09654313.2018.1441380

Churkina G, Organschi A, Reyer CPO, et al (2020) Buildings as a global carbon sink. Nature Sustainability 3:269–276. https://doi.org/10.1038/s41893-019-0462-4

Cnaan A, Laird NM, Slasor P (1997) Using the general linear mixed model to analyse unbalanced repeated measures and longitudinal data. Statistics in Medicine 16:2349–2380. https://doi.org/10.1002/(SICI)1097-0258(19971030)16:20<2349::AID-SIM667>3.0.CO;2-E

Coenen L, Benneworth P, Truffer B (2012) Toward a spatial perspective on sustainability transitions. Research Policy 41:968–979. https://doi.org/10.1016/j.respol.2012.02.014

Coenen L, Morgan K (2020) Evolving geographies of innovation: existing paradigms, critiques and possible alternatives. Norsk Geografisk Tidsskrift - Norwegian Journal of Geography 74:13–24. https://doi.org/10.1080/00291951.2019.1692065

Committee of Corporate Analysis (2011) The Guide to the Analysis of Financial Statements of Finnish Companies. Gaudeamus. Helsinki

Committee of Corporate Analysis (2017) Yritystutkimuksen Tilinpäätösanalyysi. Gaudeamus, Helsinki University Press. Helsinki

Cooke P (1992) Regional innovation systems: Competitive regulation in the new Europe. Geoforum 23:365–382. https://doi.org/10.1016/0016-7185(92)90048-9

Crespell P, Knowles C, Hansen E (2006) Innovativeness in the North American softwood sawmilling industry. Forest Science 52:568–578. https://doi.org/10.1093/forestscience/52.5.568

D'Amato D, Droste N, Allen B, et al (2017) Green, circular, bio economy: A comparative analysis of sustainability avenues. Journal of Cleaner Production 168:716–734. https://doi.org/10.1016/j.jclepro.2017.09.053

de Jong M, Joss S, Schraven D, et al (2015) Sustainable–smart–resilient–low carbon–eco–knowledge cities; making sense of a multitude of concepts promoting sustainable urbanization. Journal of Cleaner Production 109:25–38. https://doi.org/10.1016/j.jclepro.2015.02.004

Dewald U, Truffer B (2011) Market Formation in Technological Innovation Systems—Diffusion of Photovoltaic Applications in Germany. Industry and Innovation 18:285–300. https://doi.org/10.1080/13662716.2011.561028

Dijkstra L, Poelman H, Rodríguez-Pose A (2020) The geography of EU discontent. Regional Studies 54:737–753. https://doi.org/10.1080/00343404.2019.1654603

Doloreux D (2002) What we should know about regional systems of innovation. Technology in society 24:243–263. https://doi.org/10.1016/S0160-791X(02)00007-6

Doloreux D, Gomez IP (2018) A review of (almost) 20 years of regional innovation systems research. Path Dependence and Regional Economic Renewal 17–33

Drejer I, Vinding AL (2006) Organisation, 'anchoring' of knowledge, and innovative activity in construction. Construction Management and Economics 24:921–931. https://doi.org/10.1080/01446190600799166

Dubois A, Gadde L-E (2002) The construction industry as a loosely coupled system: implications for productivity and innovation. Construction Management and Economics 20:621–631. https://doi.org/10.1080/01446190210163543

Dulaimi MF, Y.Ling FY, Ofori G, Silva ND (2002) Enhancing integration and innovation in construction. Building Research & Information 30:237–247. https://doi.org/10.1080/09613210110115207

Eder J (2019) Innovation in the Periphery: A Critical Survey and Research Agenda. International Regional Science Review 42:119–146. https://doi.org/10.1177/0160017618764279

Edquist C (1997) Systems of Innovation: Technologies, Institutions and Organizations. Pinter Publisher Ltd. London

European Commission (2019) A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment

European Commission: Directorate-General for Internal Market I Entrepreneurship and SMEs, Rodríguez-Pose A, Bartalucci F (2023) Regional vulnerability to the green transition. Publications Office of the European Union. https://doi.org/10.2873/739058

European Commission. Statistical Office of the European Union., Organisation for Economic Co-operation and Development., Food and Agriculture Organization of the United Nations., et al (2021) Applying the degree of urbanisation : a methodological manual to define cities, towns and rural areas for international comparisons : 2021 edition.

Fabrigar LR, Wegener DT (2011) Exploratory factor analysis. Oxford University Press. https://doi.org/10.1093/acprof:osobl/9780199734177.001.0001

Faehnle M, Bäcklund P, Tyrväinen L, et al (2014) How can residents' experiences inform planning of urban green infrastructure? Case Finland. Landscape and Urban Planning 130:171–183. https://doi.org/10.1016/j.landurbplan.2014.07.012

Fernandes AJC, Rodrigues RG, Ferreira JJ (2022) National innovation systems and sustainability: What is the role of the environmental dimension? Journal of Cleaner Production 347:131164. https://doi.org/10.1016/j.jclepro.2022.131164

Franzini F, Toivonen R, Toppinen A (2018) Why Not Wood? Benefits and Barriers of Wood as a Multistory Construction Material: Perceptions of Municipal Civil Servants from Finland. Buildings 8:. https://doi.org/10.3390/buildings8110159

Gann D (2001) Putting academic ideas into practice: technological progress and the absorptive capacity of construction organizations. Construction Management & Economics 19:321–330. https://doi.org/10.1080/01446190010020480

Gann DM, Salter AJ (2000) Innovation in project-based, service-enhanced firms: the construction of complex products and systems. Research Policy 29:955–972. https://doi.org/10.1016/S0048-7333(00)00114-1

Gault F (2018) Defining and measuring innovation in all sectors of the economy. Research policy 47:617–622. https://doi.org/10.1016/j.respol.2018.01.007

Gelman A, Hill J (2006) Data Analysis Using Regression and Multilevel/Hierarchical Models. Cambridge University Press. Cambridge. https://doi.org/10.1017/CBO9780511790942

Gluch P, Svensson I (2018) On the nexus of changing public facilities management practices: purposive and co-creative actions across multiple levels. Construction Management and Economics 36:259–275. https://doi.org/10.1080/01446193.2017.1381751

Grillitsch M, Asheim B (2018) Place-based innovation policy for industrial diversification in regions. European Planning Studies 26:1638–1662. https://doi.org/10.1080/09654313.2018.1484892

Grillitsch M, Hansen T (2019) Green industry development in different types of regions. European Planning Studies 27:2163–2183. https://doi.org/10.1080/09654313.2019.1648385

Häkkinen T, Rekola M, Ala-Juusela M, Ruuska A (2016) Role of Municipal Steering in Sustainable Building and Refurbishment. Energy Procedia 96:650–661. https://doi.org/10.1016/j.egypro.2016.09.123

Hall J, Matos S, Silvestre B, Martin M (2011) Managing technological and social uncertainties of innovation: The evolution of Brazilian energy and agriculture. Technological Forecasting and Social Change 78:1147–1157. https://doi.org/10.1016/j.techfore.2011.02.005

Han JK, Kim N, Srivastava RK (1998) Market orientation and organizational performance: is innovation a missing link? Journal of marketing 62:30–45. https://doi.org/10.1177/002224299806200403

Hansen E, Rasmussen CC, Nybakk E (2017) Recessionary period activities in forest sector firms: Impacts on innovativeness. Journal of Forest Economics 28:80–86. https://doi.org/10.1016/j.jfe.2017.06.004

Hansen EG, Grosse-Dunker F (2012) Sustainability-oriented innovation. Encyclopedia of Corporate Social Responsibility: Heidelberg, Germany. https://doi.org/10.1007/978-3-642-28036-8_552

Hansen T, Coenen L (2015) The geography of sustainability transitions: Review, synthesis and reflections on an emergent research field. Environmental Innovation and Societal Transitions 17:92–109. https://doi.org/10.1016/j.eist.2014.11.001

Harju C, Lähtinen K (2022) Consumers' Consciousness for Sustainable Consumption and Their Perceptions of Wooden Building Product Quality. Forest Products Journal 72:155–169. https://doi.org/10.13073/FPJ-D-22-00014

Harmaakorpi V (2006) Regional Development Platform Method (RDPM) as a tool for regional innovation policy. European Planning Studies 14:1085–1104. https://doi.org/10.1080/09654310600852399

Hassink R, Isaksen A, Trippl M (2019) Towards a comprehensive understanding of new regional industrial path development. Regional Studies 53:1636–1645. https://doi.org/10.1080/00343404.2019.1566704

Hawawini G, Subramanian V, Verdin P (2003) Is performance driven by industry-or firm-specific factors? A new look at the evidence. Strategic management journal 24:1–16. https://doi.org/10.1002/smj.278

Heiskanen E, Lovio R, Jalas M (2011) Path creation for sustainable consumption: promoting alternative heating systems in Finland. Journal of Cleaner Production 19:1892–1900. https://doi.org/10.1016/j.jclepro.2011.02.005

Hekkert MP, Janssen MJ, Wesseling JH, Negro SO (2020) Mission-oriented innovation systems. Environmental Innovation and Societal Transitions 34:76–79. https://doi.org/10.1016/j.eist.2019.11.011

Henson RK, Roberts JK (2006) Use of Exploratory Factor Analysis in Published Research: Common Errors and Some Comment on Improved Practice. Educational and Psychological Measurement 66:393–416. https://doi.org/10.1177/0013164405282485

Heräjärvi H, Jouhiaho A, Tammiruusu V, Verkasalo E (2004) Small-Diameter Scots Pine and Birch Timber as Raw Materials for Engineered Wood Products. International Journal of Forest Engineering 15:23–34. https://doi.org/10.1080/14942119.2004.10702494

Hertwich E, Ali S, Ciacci L, et al (2019) Material efficiency strategies to reducing greenhouse gas emissions associated with buildings, vehicles, and electronics – A review. Environmental Research Letters 14:. https://doi.org/10.1088/1748-9326/ab0fe3

Hirvonen-Kantola S, Mäntysalo R (2014) The recent development of Finnish planning system. Routledge London and New York

Holm J, Stauning I, Søndergård B (2011) Local climate mitigation and eco-efforts in housing and construction as transition places. Environmental Policy and Governance 21:183–198. https://doi.org/10.1002/eet.569

Holt GD (2013) Construction business failure: conceptual synthesis of causal agents. Construction Innovation 13:50–76. https://doi.org/10.1108/14714171311296057

Huang-Lachmann J-T, Lovett JC (2016) How cities prepare for climate change: Comparing Hamburg and Rotterdam. Cities 54:36–44. https://doi.org/10.1016/j.cities.2015.11.001

Hunt SD, Morgan RM (1996) The Resource-Advantage Theory of Competition: Dynamics, Path Dependencies, and Evolutionary Dimensions. Journal of Marketing 60:107–114. https://doi.org/10.1177/002224299606000410

Hurmekoski E, Jonsson R, Nord T (2015) Context, drivers, and future potential for wood-frame multi-story construction in Europe. Technological Forecasting and Social Change 99:181–196. https://doi.org/10.1016/j.techfore.2015.07.002

Hytönen J, Mäntysalo R, Akkila I, et al (2012) Kaupunkiseutujen kasvukivut II. Päätelmiä maankäytön suunnitteluyhteistyön kehityksestä viidellä kaupunkiseudulla Paras-ARTTU-ohjelman tutkimuksia nro 22:

Hytönen J, Mäntysalo R, Peltonen L, et al (2013) Defensive routines in land use policy steering in Finnish urban regions. European Urban and Regional Studies 23:40–55. https://doi.org/10.1177/0969776413490424

Iammarino S, Rodríguez-Pose A, Storper M (2017) Why Regional Development matters for Europe's Economic Future. European Commission

Isaksen A (2015) Industrial development in thin regions: trapped in path extension? Journal of Economic Geography 15:585–600. https://doi.org/10.1093/jeg/lbu026

Isaksen A, Trippl M (2014) Regional industrial path development in different regional innovation systems: A conceptual analysis. Lund University, CIRCLE-Centre for Innovation Research

Isaksen A, Trippl M, Mayer H (2022) Regional innovation systems in an era of grand societal challenges: reorientation versus transformation. European Planning Studies 30:2125–2138. https://doi.org/10.1080/09654313.2022.2084226

Jacobsson S, Bergek A (2011) Innovation system analyses and sustainability transitions: Contributions and suggestions for research. Environmental Innovation and Societal Transitions 1:41–57. https://doi.org/10.1016/j.eist.2011.04.006

Juhola S, Westerhoff L (2011) Challenges of adaptation to climate change across multiple scales: a case study of network governance in two European countries. Environmental Science & Policy 14:239–247. https://doi.org/10.1016/j.envsci.2010.12.006

Jussila J, Nagy E, Lähtinen K, et al (2022) Wooden multi-storey construction market development – systematic literature review within a global scope with insights on the Nordic region. Silva Fennica 56:. https://doi.org/10.14214/sf.10609

Kadefors A (1995) Institutions in building projects: Implications for flexibility and change. Scandinavian Journal of Management 11:395–408. https://doi.org/10.1016/0956-5221(95)00017-P

Kajander J-K, Sivunen M, Vimpari J, et al (2012) Market value of sustainability business innovations in the construction sector. Building Research & Information 40:665–678. https://doi.org/10.1080/09613218.2012.703893

Karhinen S, Peltomaa J, Riekkinen V, Saikku L (2021) Impact of a climate network: The role of intermediaries in local level climate action. Global Environmental Change 67:102225–102225. https://doi.org/10.1016/j.gloenvcha.2021.102225

Kern K (2019) Cities as leaders in EU multilevel climate governance: embedded upscaling of local experiments in Europe. Environmental Politics 28:125–145. https://doi.org/10.1080/09644016.2019.1521979

Kim J-O, Mueller CW (1978) Introduction to Factor Analysis. SAGE Publications, Inc. https://doi.org/10.4135/9781412984652

King AP, Eckersley RJ (2019) Chapter 6 - Inferential Statistics III: Nonparametric Hypothesis Testing. In: King AP, Eckersley RJ (eds) Statistics for Biomedical Engineers and Scientists. Academic Press. pp 119–145. https://doi.org/10.1016/B978-0-08-102939-8.00015-3

Kinnunen J, Saunila M, Ukko J, Rantanen H (2022) Strategic sustainability in the construction industry: Impacts on sustainability performance and brand. Journal of Cleaner Production 368:133063. https://doi.org/10.1016/j.jclepro.2022.133063

Klitkou A, Capasso M, Hansen T, Szulecka J (2019) New path development for forest-based value creation in Norway. From waste to value 73–90. https://doi.org/10.4324/9780429460289-4

Köhler J, Geels FW, Kern F, et al (2019) An agenda for sustainability transitions research: State of the art and future directions. Environmental Innovation and Societal Transitions 31:1–32. https://doi.org/10.1016/j.eist.2019.01.004

Korhonen S, Niemelä JS (2005) A conceptual analysis of capabilities: Identifying and classifying sources of competitive advantage in the wood industry. The Finnish Journal of Business Economics 54:11–47

Kuittinen M, Le Roux S (2017) Vähähiilisen rakentamisen hankintakriteerit

Labaran YH, Mathur VS, Muhammad SU, Musa AA (2022) Carbon footprint management: A review of construction industry. Cleaner Engineering and Technology 9:100531. https://doi.org/10.1016/j.clet.2022.100531

Lähtinen K (2007) Linking resource-based view with business economics of woodworking industry: earlier findings and future insights. Silva Fennica 41:149–165. https://doi.org/10.14214/sf.312

Lähtinen K, Häyrinen L (2022) Servitisation and the Future of Business Development – Insights from the Forest Industry. In: The Role of Business in Global Sustainability Transformations. Routledge. pp 96–115. https://doi.org/10.4324/9781003003588-9

Lähtinen K, Toppinen A (2008) Financial performance in Finnish large- and medium-sized sawmills: The effects of value-added creation and cost-efficiency seeking. Journal of Forest Economics 14:289–305. https://doi.org/10.1016/j.jfe.2008.02.001

Lähtinen K, Toppinen A, Malm N (2019) Effects of Lobbying Among Urban Planners in Finland-Views on Multi-Storey Wooden Building. BioProducts Business 4:. https://doi.org/10.22382/bpb-2019-007

Laitinen EK (2000) Long-term Success of Adaptation Strategies: Evidence from Finnish Companies. Long Range Planning 33:805–830. https://doi.org/10.1016/S0024-6301(00)00088-1

Land use and building act (1999) FINLEX. In: Suomen säädöskokoelma. https://finlex.fi/fi/lainsaadanto/saadoskokoelma/1999/132

Lazarevic D, Kautto P, Antikainen R (2020) Finland's wood-frame multi-storey construction innovation system: Analysing motors of creative destruction. Forest Policy and Economics 110:. https://doi.org/10.1016/j.forpol.2019.01.006

Le Bivic C, Melot R (2020) Scheduling urbanization in rural municipalities: Local practices in land-use planning on the fringes of the Paris region. Land Use Policy 99:105040–105040. https://doi.org/10.1016/j.landusepol.2020.105040

Leino H, Peltomaa J (2012) Situated knowledge–situated legitimacy: Consequences of citizen participation in local environmental governance. Policy and Society 31:159–168. https://doi.org/10.1016/j.polsoc.2012.04.005

Lin B, Pang Z, Jiang J (2013) Fixed and Random Effects Selection by REML and Pathwise Coordinate Optimization. Journal of Computational and Graphical Statistics 22:341–355. https://doi.org/10.1080/10618600.2012.681219

Lindblad H, Karrbom Gustavsson T (2021) Public clients ability to drive industry change: the case of implementing BIM. Construction Management and Economics 39:21–35. https://doi.org/10.1080/01446193.2020.1807032

Loorbach D, Wittmayer J, Avelino F, et al (2020) Transformative innovation and translocal diffusion. Environmental Innovation and Societal Transitions 35:251–260. https://doi.org/10.1016/j.eist.2020.01.009

Lundquist K-J, Trippl M (2013) Distance, Proximity and Types of Cross-border Innovation Systems: A Conceptual Analysis. Regional Studies 47:450–460. https://doi.org/10.1080/00343404.2011.560933

Lundvall B-A, Dosi G, Freeman C (1988) Innovation as an interactive process: from user-producer interaction to the national system of innovation. 1988 349:369–369

MacKinnon D, Dawley S, Pike A, Cumbers A (2019) Rethinking Path Creation: A Geographical Political Economy Approach. Economic Geography 95:113–135. https://doi.org/10.1080/00130095.2018.1498294

Mahapatra K, Gustavsson L (2008) Multi-storey timber buildings: breaking industry path dependency. Building Research & Information 36:638–648. https://doi.org/10.1080/09613210802386123

Makkonen M (2018) Stakeholder perspectives on the business potential of digitalization in the wood products industry. BioProducts Business 63–80

Makkonen M, Sundqvist-Andberg H (2017) Customer value creation in B2B relationships: Sawn timber value chain perspective. Journal of Forest Economics 29:94–106. https://doi.org/10.1016/j.jfe.2017.08.007

Makkonen T, Rohde S (2016) Cross-border regional innovation systems: conceptual backgrounds, empirical evidence and policy implications. European Planning Studies 24:1623–1642. https://doi.org/10.1080/09654313.2016.1184626

Mäntysalo R, Jarenko K, Nilsson KL, Saglie IL (2015) Legitimacy of Informal Strategic Urban Planning—Observations from Finland, Sweden and Norway. European Planning Studies 23:349–366. https://doi.org/10.1080/09654313.2013.861808

Marino E, Ribot J (2012) Special Issue Introduction: Adding insult to injury: Climate change and the inequities of climate intervention. Global Environmental Change 22:323–328. https://doi.org/10.1016/j.gloenvcha.2012.03.001

Martin H, Grundel I, Dahlström M (2023) Reconsidering actor roles in regional innovation systems: transformative industrial change in the forest-based bioeconomy. Regional Studies 57:1636–1648. https://doi.org/10.1080/00343404.2022.2151581

Martin H, Martin R, Zukauskaite E (2019) The multiple roles of demand in new regional industrial path development: A conceptual analysis. Environ Plan A 51:1741–1757. https://doi.org/10.1177/0308518X19863438

Martin M, Islar M (2021) The ‘end of the world’ vs. the ‘end of the month’: understanding social resistance to sustainability transition agendas, a lesson from the Yellow Vests in France. Sustainability Science 16:601–614. https://doi.org/10.1007/s11625-020-00877-9

Martin R (2010) Roepke Lecture in Economic Geography—Rethinking Regional Path Dependence: Beyond Lock-in to Evolution. Economic Geography 86:1–27. https://doi.org/10.1111/j.1944-8287.2009.01056.x

Martin R, Sunley P (2006) Path dependence and regional economic evolution. Journal of Economic Geography 6:395–437. https://doi.org/10.1093/jeg/lbl012

Matinaro V, Liu Y (2017) Towards increased innovativeness and sustainability through organizational culture: A case study of a Finnish construction business. Journal of Cleaner Production 142:3184–3193. https://doi.org/10.1016/j.jclepro.2016.10.151

Matschoss K, Heiskanen E (2017) Making it experimental in several ways: The work of intermediaries in raising the ambition level in local climate initiatives. Journal of Cleaner Production 169:85–93. https://doi.org/10.1016/j.jclepro.2017.03.037

Matti C, Consoli D, Uyarra E (2017) Multi level policy mixes and industry emergence: The case of wind energy in Spain. Environment and Planning C: Politics and Space 35:661–683. https://doi.org/10.1177/0263774X16663933

Mazzucato M (2018) Mission-oriented innovation policies: challenges and opportunities. Industrial and Corporate Change 27:803–815. https://doi.org/10.1093/icc/dty034

McCann P, Soete L (2020) Place-based innovation for sustainability. Publications Office of the European Union: Luxemburg

Ministry of Economic Affairs and Employment (2020) Työ-ja elinkeinoministeriön julkaisuja: Katsaus teolliseen puurakentamiseen − puuelementit

Miörner J, Trippl M (2019) Embracing the future: path transformation and system reconfiguration for self-driving cars in West Sweden. European Planning Studies 27:2144–2162. https://doi.org/10.1080/09654313.2019.1652570

Miörner J, Trippl M (2018) Paving the way for new regional industrial paths: Actors and modes of change in Scania's games industry. In: Path Dependence and Regional Economic Renewal. Routledge. pp 127–143. https://doi.org/10.4324/9781351267809-8

Mokhlesian S, Holmén M (2012) Business model changes and green construction processes. Construction Management and Economics 30:761–775. https://doi.org/10.1080/01446193.2012.694457

Morales D, Dahlström M (2023) Smart specialization and participatory processes in green path renewal. Analysis of the forest-based bioeconomy in sparsely populated regions in the Nordics. European Planning Studies 31:1734–1753. https://doi.org/10.1080/09654313.2022.2106120

Moreno R, Ocampo-Corrales D (2022) The ability of European regions to diversify in renewable energies: The role of technological relatedness. Research Policy 51:104508. https://doi.org/10.1016/j.respol.2022.104508

Mulgan G (2006) The Process of Social Innovation. Technology, Governance, Globalization 1:145–162. https://doi.org/10.1162/itgg.2006.1.2.145

Nelson RR (1993) National Innovation Systems: A Comparative Analysis. Oxford University Press

Olsson P, Galaz V, Boonstra WJ (2014) Sustainability transformations: a resilience perspective. Ecology and society 19:. https://doi.org/10.5751/ES-06799-190401

Osborne SP, Brown L (2011) Innovation, public policy and public services delivery in the UK. The word that would be king? Public Administration 89:1335–1350. https://doi.org/10.1111/j.1467-9299.2011.01932.x

Palermo V, Bertoldi P, Apostolou M, et al (2020) Assessment of climate change mitigation policies in 315 cities in the Covenant of Mayors initiative. Sustainable Cities and Society 60:102258–102258. https://doi.org/10.1016/j.scs.2020.102258

Pekkarinen S, Harmaakorpi V (2006) Building regional innovation networks: The definition of an age business core process in a regional innovation system. Regional Studies 40:401–413. https://doi.org/10.1080/00343400600725228

Pelli P, Lähtinen K (2020) Servitization and bioeconomy transitions: Insights on prefabricated wooden elements supply networks. Journal of Cleaner Production 244:118711–118711. https://doi.org/10.1016/j.jclepro.2019.118711

Peltonen L, Sairinen R (2010) Integrating impact assessment and conflict management in urban planning: Experiences from Finland. Environmental Impact Assessment Review 30:328–337. https://doi.org/10.1016/j.eiar.2010.04.006

Persson C (2013) Deliberation or doctrine? Land use and spatial planning for sustainable development in sweden. Land Use Policy 34:301–313. https://doi.org/10.1016/j.landusepol.2013.04.007

Pino RM, Ortega AM (2018) Regional innovation systems: Systematic literature review and recommendations for future research. Cogent Business and Management 5:. https://doi.org/10.1080/23311975.2018.1463606

Pryke Stephen (2012) Social network analysis in construction / Stephen Pryke. Wiley-Blackwell. Chichester. https://doi.org/10.1002/9781118443132

Pulkka L, Ristimäki M, Rajakallio K, Junnila S (2016) Applicability and benefits of the ecosystem concept in the construction industry. Construction Management and Economics 34:129–144. https://doi.org/10.1080/01446193.2016.1179773

Pullin AS, Stewart GB (2006) Guidelines for systematic review in conservation and environmental management. Conservation biology 20:1647–1656. https://doi.org/10.1111/j.1523-1739.2006.00485.x

Puustinen Sari (2004) Yhdyskuntasuunnittelu ammattina : suomalaiset kaavoittajat ja 2000-luvun haasteet. Ympäristöministeriö, alueidenkäytön osasto

Rahman MdR, Wallin I, Toivonen R, Toppinen A (2024) Local policy networks in support of wood-based construction: A case study from Joensuu, Finland. Forest Policy and Economics 163:103225. https://doi.org/10.1016/j.forpol.2024.103225

Ramcilovic-Suominen S, Pülzl H (2018) Sustainable development – A 'selling point' of the emerging EU bioeconomy policy framework? Journal of Cleaner Production 172:4170–4180. https://doi.org/10.1016/j.jclepro.2016.12.157

Randolph JJ (2008) Online kappa calculator. In: Online kappa calculator. http://justusrandolph.net/kappa/

Raven R, Walrave B (2020) Overcoming transformational failures through policy mixes in the dynamics of technological innovation systems. Technological forecasting and social change 153:119297. https://doi.org/10.1016/j.techfore.2018.05.008

Reed MS, Vella S, Challies E, et al (2018) A theory of participation: what makes stakeholder and public engagement in environmental management work? Restoration Ecology 26:S7–S17. https://doi.org/10.1111/rec.12541

Rinkinen S, Oikarinen T, Melkas H (2016) Social enterprises in regional innovation systems: a review of Finnish regional strategies. European Planning Studies 24:723–741. https://doi.org/10.1080/09654313.2015.1108394

Rinne J, Primmer E (2016) A Case Study of Ecosystem Services in Urban Planning in Finland: Benefits, Rights and Responsibilities. Journal of Environmental Policy & Planning 18:286–305. https://doi.org/10.1080/1523908X.2015.1076721

Röck M, Saade MRM, Balouktsi M, et al (2020) Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy 258:114107–114107. https://doi.org/10.1016/j.apenergy.2019.114107

Rohracher H (2001) Managing the Technological Transition to Sustainable Construction of Buildings: A Socio-Technical Perspective. Technology Analysis & Strategic Management 13:137–150. https://doi.org/10.1080/09537320120040491

Rönkkö E, Aarrevaara E (2017) Towards Strengths-Based Planning Strategies for Rural Localities in Finland. European Countryside 9:397–415. https://doi.org/10.1515/euco-2017-0024

Salmi A, Jussila J, Hämäläinen M (2022) The role of municipalities in transformation towards more sustainable construction: the case of wood construction in Finland. Construction Management and Economics. https://doi.org/10.1080/01446193.2022.2037145

Salo R, Mäntysalo R (2017) Path dependencies and defensive routines in Finnish city-regional land-use policy cooperation: case Ristikytö. International Planning Studies 22:128–144. https://doi.org/10.1080/13563475.2016.1219653

Sathre R, Gustavsson L (2007) Effects of energy and carbon taxes on building material competitiveness. Energy and Buildings 39:488–494. https://doi.org/10.1016/j.enbuild.2006.09.005

Saunila M, Ukko J (2012) A conceptual framework for the measurement of innovation capability and its effects. Baltic Journal of Management 7:355–375. https://doi.org/10.1108/17465261211272139

Schot J, Steinmueller WE (2018) Three frames for innovation policy: R&D, systems of innovation and transformative change. Research Policy 47:1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Schumpeter J (1911) Theorie der wirtschaftlichen Entwicklung. Duncker und Humblot

Segerstedt A, Olofsson T (2010) Supply chains in the construction industry. Supply chain management: an international journal 15:347–353. https://doi.org/10.1108/13598541011068260

Seppälä J, Saikku L, Soimakallio S, et al (2019) Hiilineutraalius ilmastopolitiikassa -Valtiot, alueet ja kunnat. Suomen ilmastopaneeli

Sharif N (2006) Emergence and development of the National Innovation Systems concept. Research Policy 35:745–766. https://doi.org/10.1016/j.respol.2006.04.001

Shearmur R (2012) Are cities the font of innovation? A critical review of the literature on cities and innovation. Cities 29:S9–S18. https://doi.org/10.1016/j.cities.2012.06.008

Shmulsky R, Jones D (2011) Forest Products and Wood Science - An Introduction https://doi.org/10.1002/9780470960035.fmatter

Siggel E (2006) International competitiveness and comparative advantage: A survey and a proposal for measurement. Journal of Industry, Competition and Trade 6:137–159. https://doi.org/10.1007/s10842-006-8430-x

Solly A (2021) Land use challenges, sustainability and the spatial planning balancing act: Insights from Sweden and Switzerland. European Planning Studies 29:637–653. https://doi.org/10.1080/09654313.2020.1765992

Spanos YE, Lioukas S (2001) An Examination into the Causal Logic of Rent Generation: Contrasting Porter's Competitive Strategy Framework and the Resource-Based Perspective. Strategic Management Journal 22:907–934. https://doi.org/10.1002/smj.174

StatFin (2023) Internet database of statistics Finland. https://pxdata.stat.fi/PxWeb/pxweb/en/StatFin/StatFin__yrti/statfin_yrti_pxt_13w3.px/. Accessed 10 Feb 2025

Stehn L, Engström S, Uusitalo P, Lavikka R (2021) Understanding industrialised house building as a company's dynamic capabilities. Construction Innovation 21:5–21. https://doi.org/10.1108/CI-09-2019-0086

Stendahl M, McCluskey D, Eliasson L (2013) Integrated production of semi-finished components in sawmills, part I: External interactions. Wood Material Science & Engineering 8:253–270. https://doi.org/10.1080/17480272.2013.834965

Stokes EC, Seto KC (2019) Characterizing and measuring urban landscapes for sustainability. Environmental Research Letters 14:. https://doi.org/10.1088/1748-9326/aafab8

Taylor MZ (2016) The Politics of Innovation: Why Some Countries Are Better Than Others at Science and Technology. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780190464127.001.0001

Tiitu M, Viinikka A, Kopperoinen L, Geneletti D (2018) A Spatial Multi-Criteria Approach Based on Practitioner Engagement. Journal of Environmental Assessment Policy and Management 20:1–26. https://doi.org/10.1142/S1464333218400045

Tödtling F, Trippl M (2013) Transformation of regional innovation systems: From old legacies to new development paths. In: Re-framing regional development. Routledge. pp 297–317

Tödtling F, Trippl M (2005) One size fits all?: Towards a differentiated regional innovation policy approach. Research Policy 34:1203–1219. https://doi.org/10.1016/j.respol.2005.01.018

Tödtling F, Trippl M, Desch V (2022) New directions for RIS studies and policies in the face of grand societal challenges. European Planning Studies 30:2139–2156. https://doi.org/10.1080/09654313.2021.1951177

Toppinen A, Miilumäki N, Vihemäki H, et al (2019) Collaboration and shared logic for creating value-added in three Finnish wooden multi-storey building projects. Wood Material Science & Engineering 14:269–279. https://doi.org/10.1080/17480272.2019.1653365

Trippl M (2010) DEVeloping cross-border regional innovation systems: Key factors and challenges. Tijdschrift voor Economische en Sociale Geografie 101:150–160. https://doi.org/10.1111/j.1467-9663.2009.00522.x

Trippl M, Baumgartinger-Seiringer S, Frangenheim A, et al (2020) Unravelling green regional industrial path development: Regional preconditions, asset modification and agency. Geoforum 111:189–197. https://doi.org/10.1016/j.geoforum.2020.02.016

Trippl M, Seiringer SB, Kastrup J (2024) Challenge-oriented regional innovation systems: towards a research agenda. Investigaciones Regionales= Journal of Regional Research 105–116. https://doi.org/10.38191/iirr-jorr.24.026

Trippl M, Sinozic T, Lawton Smith H (2015) The Role of Universities in Regional Development: Conceptual Models and Policy Institutions in the UK, Sweden and Austria. European Planning Studies 23:1722–1740. https://doi.org/10.1080/09654313.2015.1052782

Uotila T, Melkas H, Harmaakorpi V (2005) Incorporating futures research into regional knowledge creation and management. Futures 37:849–866. https://doi.org/10.1016/j.futures.2005.01.001

Utterback J, Suarez F (1993) Structure, competition, and industry. Research Policy 22:1–21. https://doi.org/10.1016/0048-7333(93)90030-L

Uyarra E, Ribeiro B, Dale-Clough L (2019) Exploring the normative turn in regional innovation policy: responsibility and the quest for public value. European Planning Studies 27:2359–2375. https://doi.org/10.1080/09654313.2019.1609425

Väätäinen K, Anttila P, Eliasson L, et al (2021) Roundwood and biomass logistics in Finland and Sweden. Croatian Journal of Forest Engineering: Journal for Theory and Application of Forestry Engineering 42:39–61. https://doi.org/10.5552/crojfe.2021.803

Vihemäki H, Toppinen A, Toivonen R (2020) Intermediaries to accelerate the diffusion of wooden multi-storey construction in Finland. Environmental Innovation and Societal Transitions 36:433–448. https://doi.org/10.1016/j.eist.2020.04.002

Viholainen N, Kylkilahti E, Autio M, et al (2021) Bringing ecosystem thinking to sustainability-driven wooden construction business. Journal of Cleaner Production 292:. https://doi.org/10.1016/j.jclepro.2021.126029

Virkkala S (2007) Innovation and Networking in Peripheral Areas—a Case Study of Emergence and Change in Rural Manufacturing. European Planning Studies 15:511–529. https://doi.org/10.1080/09654310601133948

Virtanen MJ, Reinekoski T, Lahikainen L, Lehtonen T-K (2022) Travels and Trials of Climate Knowledge in Finnish Municipalities. Science & Technology Studies 35:2–20. https://doi.org/10.23987/sts.97519

Walsh D, Downe S (2005) Meta-synthesis method for qualitative research: a literature review. Journal of Advanced Nursing 50:204–211. https://doi.org/10.1111/j.1365-2648.2005.03380.x

Weber KM, Rohracher H (2012) Legitimizing research, technology and innovation policies for transformative change: Combining insights from innovation systems and multi-level perspective in a comprehensive 'failures' framework. Research Policy 41:1037–1047. https://doi.org/10.1016/j.respol.2011.10.015

Weiss G, Ludvig A, Živojinović I (2020) Four decades of innovation research in forestry and the forest-based industries – A systematic literature review. Forest Policy and Economics 120:102288. https://doi.org/10.1016/j.forpol.2020.102288

Wood From Finland (2024) Finnish Timber Guide 2024. https://woodfromfinland.fi/timber-guide/. Accessed 10 Feb 2025

Yli-Pelkonen V, Kohl J (2005) The role of local ecological knowledge in sustainable urban planning: perspectives from Finland. Sustainability: Science, Practice and Policy 1:3–14. https://doi.org/10.1080/15487733.2005.11907960