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Value Creation in Component Reuse Circular Business Model Innovations

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Abstract: Despite the surging research on circular business models and awareness of the radical transformations that reuse practices cause in industrial value chains, there is minimal knowledge on what are the critical mechanisms of value creation and capture for reuse alongside the technical process. To close this important gap in the intersection of technical- and business-oriented circular economy research, we conduct a multiple-case analysis of two construction industry value chains carrying out reuse of concrete elements. Our extensive analysis reveals nine distinct mechanisms of value creation and capture in component reuse – namely design for reuse, value harvest, component optimization, component validation, value relocation, value chain design, market creation, data management and coping with regulatory and societal impacts. Moreover, we reveal which determinants govern the value creation and capture potential of these mechanisms. Our results offer managers extensive tools to optimize reuse value chains for maximal value creation and capture.

Keywords: circular economy; sustainability; component reuse; business model innovation; value creation; value transfer; value capture; circular value chain

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1 Introduction

As the Circular Economy (CE) has developed and evolved, society and businesses are aiming to harness not only recycling principle, but also reuse principle, as it retains more value and entails greater environmental benefits than recycling (Directive 2008/98/EC, 2008). Circular business model innovations (CBMIs) for the reuse of components and products have transformed multiple industries in recent years, forming an essential part of the CE transition. To realize reuse, multiple distinct operations such as the sourcing of products, their possible processing, validation, and several logistical steps need to be carried out. The value chain to enable the required operations can be organized in multiple ways and overall, the reuse process causes more disruption to the business models and economic value creation compared to recycling, making it more difficult to adapt and manage profitably (Ranta et al., 2018). Component reuse can be considered especially complex due to its design requirements in both product and system levels (Iacovidou & Purnell, 2016; Kim & Kim, 2021). Despite this, the broad body of literature on direct reuse, remanufacturing, repairing, and other subtypes of both component and product reuse in various industrial and geographical contexts heavily focuses on the technical organization and implementation of processes, neglecting the mechanisms of value creation and capture. To provide managers with approaches for profitable implementation of component reuse processes, it is necessary to obtain a more structured understanding of how the value creation and capture mechanisms co-occur with the technical processes in the value chain. Therefore, this paper seeks to clarify how companies can create and capture value from reuse.

Business literature has thus far explored the value creation and capture of reuse CBMIs from a couple of perspectives. Jayaraman & Luo (2007) showed that value can be mined, and competitive advantage created from effective organization of the reverse logistics operations. Russell & Nasr (2022) presented in more detail the economic and environmental benefits resulting from various subtypes of reuse. Vogtlander et al. (2017) revealed critical aspects to consider in business models for reuse. In addition to these fundamental advances, the value of either component or product reuse has been studied in a variety of industry-specific contexts, including energy production (Eligüzel & Özceylan, 2022), electronics (Hischier & Böni, 2021), municipal waste (Zacho et al., 2018), furniture (Krystofik et al., 2018), and engines (Smith & Keoleian, 2004). However, despite the technical complexity of carrying out reuse, literature has not examined what distinct mechanisms comprise value creation and capture in reuse, and how these connect to the technical reuse stages. Moreover, it is crucial to understand which aspects determine the amount of value created and captured for each of these mechanisms.

Hence, the objective of this study is to identify the critical mechanisms of value creation and capture that accompany the technical component reuse process. This includes understanding the most important determinants for both value creation and capture of each of these mechanisms. Therefore, our research question reads:

Which are the critical mechanisms and mechanism-specific determinants of value creation and capture in component reuse CBMIs?

We seek to answer the research question through a qualitative in-depth analysis of two distinct value chains carrying out concrete element reuse. First of these value chains operates Finland and is characterized by several companies constructing a decentralized value chain, while the second value chain operates in Germany and presents a value chain primarily managed by one company in a more centralized manner. Thus, both the value chain cases enable comprehensive understanding by providing two distinct contexts of organizing and executing component reuse. Through the analysis of extensive primary and secondary data, we theorize emergent critical mechanisms and determinants of value creation and capture for component reuse CBMIs. The contributions are attributed to business literature as increased understanding of characteristics of value creation and capture in reuse and to technical component reuse literature as a bridge from well-known technical processes to the previously ambiguous mechanisms of value creation and capture. Managerially, the results provide abundant feedback on how to manage component reuse profitably, either in a specific role in the reuse value chain or in an integrative role.

The paper proceeds as follows. Section 2 reviews existing knowledge on CBMIs and value creation and capture specifically regarding reuse and value chain management in the CE. Methodology is explained in Section 3. Structured results are presented in Section 4, followed by discussion and conclusion in Section 5.

2 Theoretical background

Circular business model innovation from reuse

To implement circular economy, most firms need to implement the 3Rs (Reduce, Reuse, and Recycle) of the CE diagram (Ellen MacArthur Foundation, 2015). In this order, reuse should be prioritized to recycling (Stahel, 2016) as it allows to preserve much of the value embedded in the reused materials.

Reuse is at the heart of CE, which promotes an *economy* that is restorative and regenerative by design (Bocken et al., 2016; Ellen MacArthur Foundation, 2015; Urbinati et al., 2017). To implement reuse, companies need to engage in CBMI (Bocken et al., 2016; Geissdoerfer et al., 2020). CBMI denotes *"innovations to create, deliver, and capture value through circular economy principles, whereby the business rationale is realigned between the network of actors/stakeholders to meet environmental, social, and economic benefits"* (Lahti et al., 2018). Reuse CBMIs encompass several technical subtypes such as direct reuse, remanufacturing, refurbishing, and repairs, with varying degrees of processing involved between use cycles (Russell & Nasr, 2022). Roughly, the reuse process consists of sourcing the products or components at the end of their previous use cycle, collection logistics, processing, quality control, and redistribution. As such, through reuse, companies recapture value by circulating resources at states of highest possible value across the value chain, thereby creating a source of raw materials and preventing the use of virgin resources. However, creating and capturing value through reuse is contingent on the companies' ability to preserve the embedded value (e.g., labor, energy, materials) in their industrial and business operations (Hopkinson et al. 2018).

Embracing reuse is relevant for many industries but holds particular relevance in construction and buildings sectors. Many building materials have high environmental footprints, and the production of cement is alone responsible for up to 8% of global CO2 emissions (Scrivener & Kirkpatrick, 2008). Therefore, the reuse of construction materials and components entails the opportunity to reduce these environmental impacts while also offering some economic benefits (Nußholz et al., 2020). Implementing reuse requires that products are designed for reuse, for instance by using modular systems and standardizing components (Bocken et al., 2016; Ghisellini et al., 2016; Stahel, 2016), and new practices among the actors of the supply chain such as the use of Building Information Modeling (BIM) tools that allow the monitoring of the use of resources during the whole life cycle of the buildings, and information sharing among actors (Akanbi et al., 2018; Charef & Emmitt, 2021).

In Europe, reuse in the building sector is identified as the best practice of managing materials as demonstrated by the Waste Framework Directive and Green Deal policies (Directive 2008/98/EC, 2008; European Commission, 2023). However, reuse is rarely implemented by companies due to several barriers related to either their context of operations or business models. Examples of contextual barriers include regulations which mainly promote recycling, the certification of quality, the cost of removal and reuse of materials, the cost of disassembly, the availability of materials to reuse, and the lack of interest of construction actors to promote waste management through reuse (Giorgi et al., 2022; Nußholz et al., 2019). Other important barriers revolve on the companies' CBMI capability (Giorgi et al., 2022; Nußholz et al., 2019). Indeed, reuse requires companies to embrace CBMI (Bocken et al., 2016; Linder & Williander, 2017). Companies must rethink their value propositions as well as their value creation and capture mechanisms by fostering practices such as take-back, repair, and secondary use of products and materials (Ghisellini et al., 2016; Khitous et al., 2022). Also, how customers perceive and experience reused products (see Ta et al., 2022) may shape value creation. This CBMI requires companies to embrace service-oriented business models through the implementation of Product-Service Systems (PSSs) (Guidat et al., 2014), as they allow to alter products and materials ownership and responsibility, thereby encouraging practices such as design for longevity and maintenance (Bocken et al., 2016; Wang et al., 2019). Therefore, there is a need for new managerial practices and building of new alliances in the value chains of the construction sector (Benachio et al., 2020; Giorgi et al., 2022; Leising et al., 2018).

Value creation and value capture through embedding reuse in circular business model innovation

Extant research on how reuse allows actors in the construction industry to create and capture value contends that material reuse allows to create economic value through cost savings and new business opportunities (Harala et al., 2023; Moreno et al., 2016). Yet, this literature remains scant (Ghisellini et al., 2018; Hart et al., 2019). Generally, this literature explores business practices related to regulatory requirements (e.g., Ferreira et al., 2015), the determinants of reuse's costs (e.g., Jung et al., 2015), and activities required for the processes of recovery and reuse (e.g., Singh & Ordoñez, 2016). Recent literature also points to the need for change in actors' roles, interactions, and mental models (Harala et al., 2023).

Interestingly, material reuse in the construction industry has been linked to superior customer value (e.g., Mokhlesian & Holmén, 2012; Witjes & Lozano, 2016) and the opportunity to innovate (Nußholz et al., 2020). Literature has also investigated financial costs related to reusing materials in the construction industry (e.g., Nußholz et al., 2020;

Vatalis et al., 2013), and the positive impact on brand that companies can gain by imbedding the reuse of building materials into their operations (Harala et al., 2023; Schenkel et al., 2015; Witjes & Lozano, 2016). Recent research also emphasizes employee satisfaction emanating from working in construction companies using the sustainable practice of reuse (Harala et al., 2023). In a recent study, Nußholz et al. (2020) found positive implications of material reuse on company's business model's economic structure and viability, while also expanding business opportunities for other partners in the system.

However, construction companies embracing reuse do not necessarily create economic and environmental benefits (Nußholz et al., 2020) due to the various hurdles they face during their CBMI process and its implementation. These hurdles revolve on legislative requirements, the readiness of the actors of the value chain, certification, and the higher cost of reusing materials compared to the cost of virgin materials. To face these challenges, embracing reuse requires all actors in the construction value chain to engage in CBMI (Werning & Spinler, 2020). Yet, there are still no clear approaches on how to foster value creation for the actors of the construction value chain, which restrains the uptake of reuse in the construction industry (Yu et al., 2021).

Therefore, it is necessary to investigate the impact of reuse on value creation and capture for construction companies. Said alternatively, there is a need to determine the mechanisms of value creation and value capture in reuse by exploring process-bound determinants that promote or hinder the value creation and capture in the construction industry.

Value chain management in the CE, particularly in reuse

As implementation of reuse assumingly has implications also to companies' and industry's value chains needing to be redesigned, we next discuss this aspect.

As also stated by Kirchherr et al. (2017, pp. 224-225), "a circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations." Accordingly, CE impacts companies' business models and operations, as well as supply and value chains, through the development of managerial responsibilities to improve organizational transition processes (Werning & Spinler, 2020).

Given the construction sector is recognized to suffer from high amount of waste and low productivity due to several reasons, such as the fragmentation of its value chains, the large number of diverse stakeholders to be involved, and the complex nature of the projects that have to be run, implementing CE principles and strategies into this sector represents a promising way to innovate its value chains, by means of reducing construction wastes and encouraging value chains' integration (Chen et al., 2022).

Depending on the characteristics of products or components that reuse targets, the value chains to realize reuse can include various actors. Literature has investigated some alternatives for organizing value chain collaboration for reuse (Wu, 2012) and take-back systems at the end of the use cycle (Östlin et al., 2008). However, the how and the effects of vertical integration of reuse process stages in construction value chains, to address value creation and capture mechanisms, are largely unexplored, thus deserving further theoretical and empirical effort.

3 Methodology

We approached the research question through a qualitative multiple-case study (Eisenhardt, 1989), employing the reuse of precast concrete elements through deconstruction and reconditioning as the empirical context. Qualitative research strategy enables analysis of holistic information, such as value chain-wide value creation, while case study method fits the complex industrial contexts particularly well (Dubois & Gadde, 2002; Yin, 2009).

To study how to create and capture value from reuse, we selected one Finnish and one German value chain that expected to create and capture value from the reuse of precast concrete elements and therefore also aimed to reorganize/redesign the focal value chains. The two selected value chains are highly illustrative of typical reuse processes, containing each frequently present process stage and various market actors. While the two value chains both facilitate the same process of concrete element reuse, they do have clear differences in terms of organization and operating environment.

Both cases covered several reuse activities along the process and therefore involved multiple actors from the value chain. The Finnish value chain consists of five companies, which are deconstruction firm, structural engineer, construction firm, element remanufacturer, and logistics partner, and a university partner. The collaborators have dedicated process stage responsibilities, meaning that vertical integration in the value chain is low (Table 1). The German value chain consists of three companies, which are integrator firm, structural engineer, and logistics partner, and a university partner. In this value chain the integrator firm possesses most of the capabilities and resources and is the main responsible for most technical process stages, meaning that the vertical integration in the value chain is high (Table 1). Hence, the two cases have many similarities, but also key differences that promote the reliability and generalizability of the analysis.

Table 1 Main responsibilities of technical component reuse process stages in both cases

Technical process stage	*Main responsibility in Finnish value chain*	*Main responsibility in German value chain*
Disassembly	Deconstruction firm	Integrator firm
Collection logistics	Logistics partner	Logistics partner
Quality control	Companies and university partner	Companies and university partner
Storage	Element remanufacturer	Integrator firm
Processing	Element remanufacturer	Companies and university partner

Redistribution logistics	Logistics partner	Logistics partner
Reassembly	Construction firm	Integrator firm

As the case value chains were a part of a research consortium, the researchers had excellent access to them: in addition to interviews, researchers were able to study value aspects of reuse also through participation in coordination meetings, site visits, and other ethnographic data collection. For the value chain in Finland the data consists of 11 semi-structured interviews with high-ranking managers, 20 coordination meeting minutes, and several secondary data sources. For the value chain in Germany the data includes four semi-structured interviews with top managers, six site visits, multiple reports, and several other secondary data sources.

Data was coded with qualitative data analysis software Atlas.ti by conducting a thematic analysis with data. Researcher triangulation was carried out by reviewing the analysis and results in group discussions, and data triangulation was enabled due to the multiple data sources used.

4 Critical mechanisms and determinants of value creation and capture in component reuse

Our analysis of two cases uncovered the critical mechanisms of value creation and capture from component reuse. The data revealed in total nine distinct critical mechanisms of value creation and capture in component reuse process. Five of these mechanisms are tied to the technical stages of the component reuse process. These are *design for reuse, value harvest, component optimization, component validation,* and *value relocation*. The remaining four are overarching mechanisms, independent of the technical process stage. These are *value chain design, market creation, data management,* and *coping with regulatory and societal impacts*. Figure 1 showcases how the five stage-specific mechanisms (in the inner circle) co-exist with the technical component reuse process (in the outer circle) according to our results. The four overarching mechanisms of value creation and capture are depicted in the center.

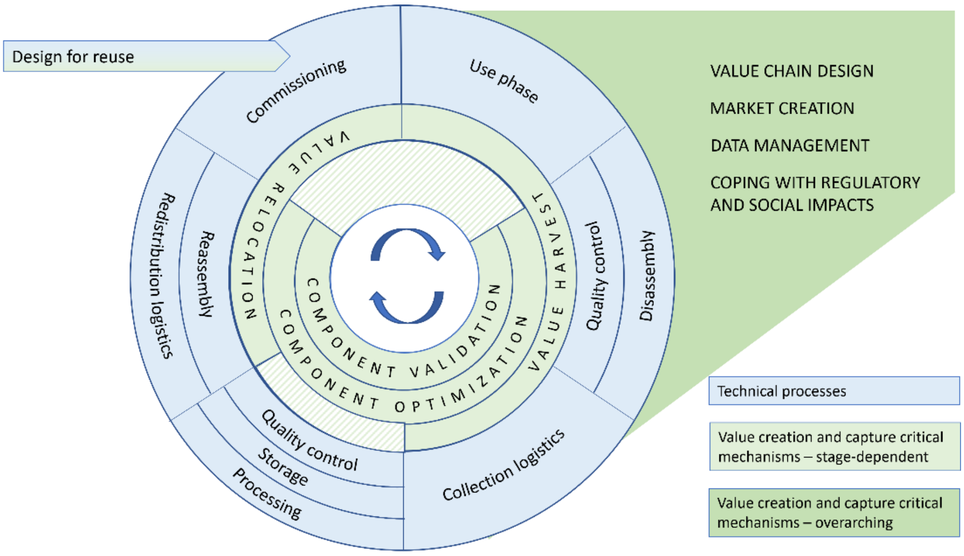

Figure 1 Component reuse value creation and value capture mechanisms along with the technical process.

In addition, for each of the mechanisms, we identified specific determinants of both value created and value captured. Value creation determinants affect the multidimensional goal achievement of the value chain and ultimately of its customers. Value capture determinants, on the other hand, define the economic value accrued to the company or companies in charge of the respective activity. The nine critical mechanisms and related determinants for value creation and capture will be presented next.

Beginning from the end of the use phase and start of a new reuse cycle, we identified *design for reuse* as the first value creation and capture critical mechanism (Figure 2). Design for reuse refers to the definition of the component- or product-level technical specifications. Value creation determinants were found to be standardization and adaptability of the components, as both qualities enable more flexible reuse cycles for the components. For example, if concrete elements have standardized dimensions, architects can better design reused elements into new buildings. Standardization was also identified as a value capture determinant, as high standardization lowers production, handling, and processing costs along the component lifecycle.

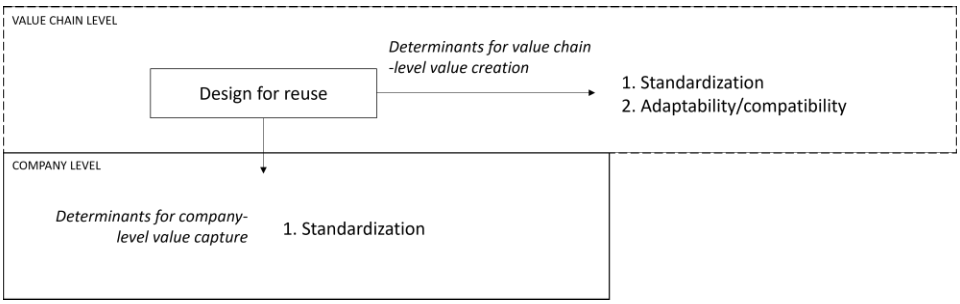

Figure 2 Value creation and value capture determinants of design for reuse.

The second critical mechanism is *value harvest* (Figure 3), which covers the sourcing and take-back logistics of the components for reuse. Value creation determinants are quality of disassembly and handling, as any damage caused to components by operational errors lowers or even destroys the value creation potential of the whole value chain, and awareness of market demand, as early-stage understanding of the future customer demand and relocation place for the components was seen to streamline the overall reuse process, as well as guarantee and increase value creation in our data. For example, it is a waste of resources to slowly deconstruct intact conrete elements only to later realize that there is no demand for their reuse. Determinants for company-level value capture are difficulty and labor-intensity of the harvest and need for special resources that both bring added costs to the company in charge, as well as the transportation costs, which depend on the distance travelled, weight of the freight, and required vehicles and equipment.

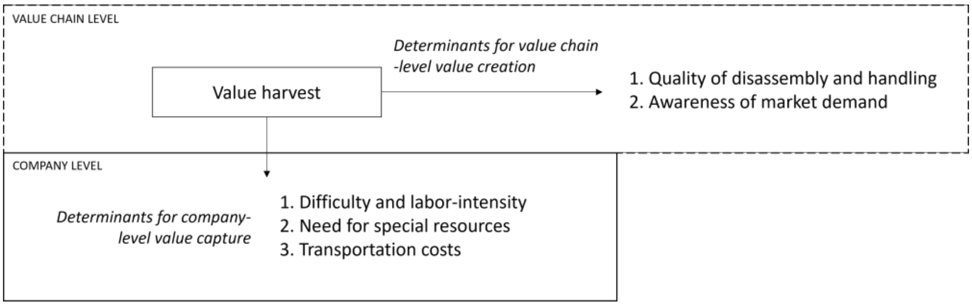

Figure 3 Value creation and value capture determinants of value harvest.

The third critical mechanism is *component optimization* (Figure 4), which refers to ensuring that the quality of the components is brought to a maximal level between use cycles. Technically, this involves de- and re-assembly, processing, storage, and transportation stages. Value creation determinants again include quality of handling, but also capacities (e.g., storage space) that determine the maximal scale in which value can be created, and environmental conditions that can damage the components, thus destroying value. For example, concrete elements cannot be stored outside in the winter in Finland. Determinants for value capture of the component optimization are standardization and volume of reuse, chosen ownership model as it is crucial for revenue structures who owns the components during each phase of the reuse cycle, needed processing space, and transportation costs.

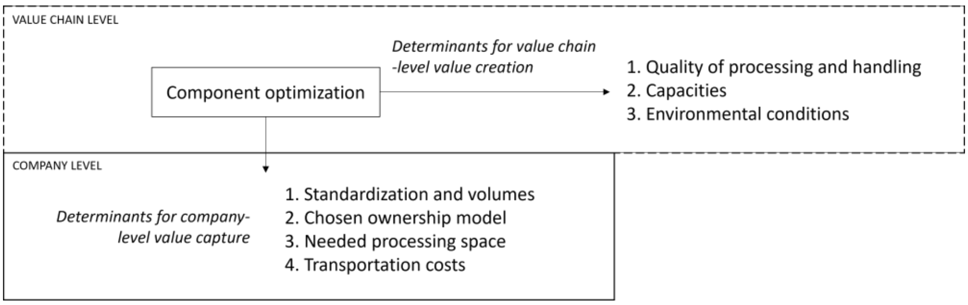

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Figure 4 Value creation and value capture determinants of component optimization.

Alongside the component optimization, we identified *component validation* (Figure 5) as the fourth critical mechanism of value creation and capture. This refers to the strategies employed to confirm the quality of the components. Determinants for value creation were identified as validation timing and quality. For example, if the state of the concrete elements is checked too late for the first time, such as while processing them, possible defective elements reduce the overall value creation due to needless transportation and storage resources used on them. The value capture determinants include validation scale and selected technology. Extensive validation causes unnecessary costs, and some validation technologies might not be cost-effective.

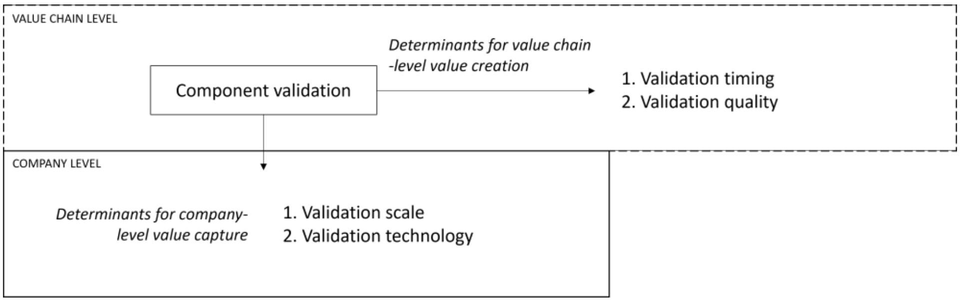

Figure 5 Value creation and value capture determinants of component validation.

Value relocation (Figure 6) was identified as the final technical stage-dependent critical mechanism of value creation and capture. This mechanism means launching of the new use cycle for the component by reassembling, delivering, and commissioning the product for a new customer. Determinants for value creation are, again, quality of handling, and additionally the value of a new parent product. For example, if a reused concrete element ends up in a modern residential building, it may have more value than if it ends up as the wall of a garage. Value capture determinants were identified as sales type and price, difficulty and labor intensity of the process, and transportation costs.

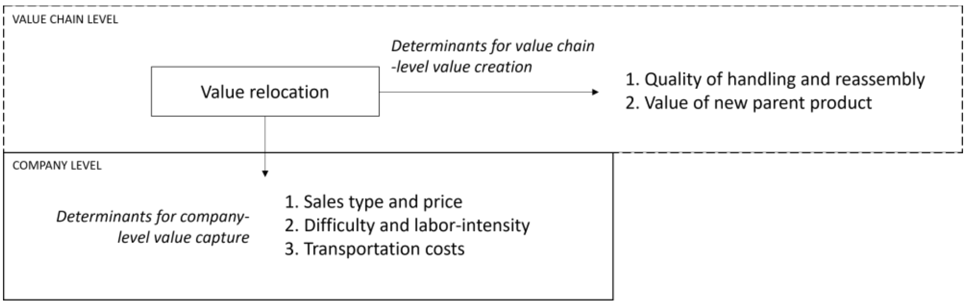

Figure 6 Value creation and value capture determinants of value relocation.

The remaining four critical mechanisms are overarching regardless of the technical reuse stage. *Value chain design* (Figure 7) refers to the organization of the actors and their responsibilities in the value chain to carry out the component reuse. This definition of responsibilities itself, along with project management strategies, were found as the value creation determinants of this mechanism. The earlier discussed ownership model and use of external services are determinants of the value capture potential and structure for the value chain actors, stemming from design decisions.

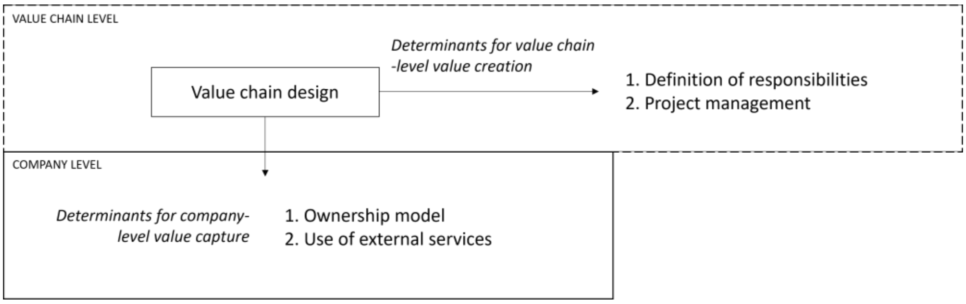

Figure 7 Value creation and value capture determinants of value chain design.

We defined *market creation* (Figure 8) as the next critical mechanism of value creation and capture. This encompasses the work and actions to establish a market for the reused components (often through establishing the market to the new parent products). Determinants of value creation are marketplace structuring and marketing work. For example, many actors in the concrete element reuse value chain agreed that a new market actor organizing a new (online) marketplace for reuse would contribute to the business feasibility and scalability of the value chain. Market creation -related value capture is determined by who is the selling party in each stage of the value chain, as well as the targeted customer segments and their purchase power.

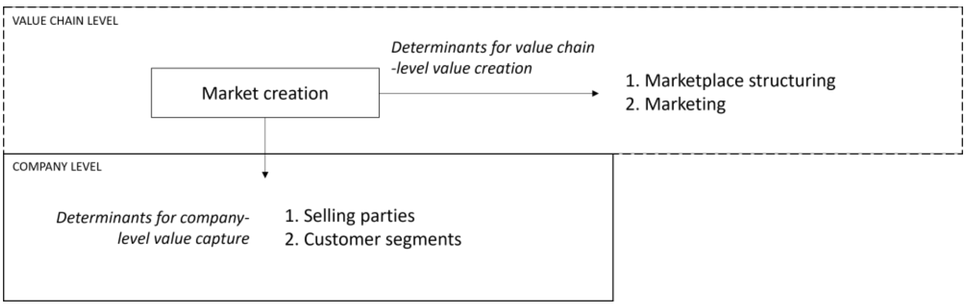

Figure 8 Value creation and value capture determinants of market creation.

As the next mechanism, we have *data management* (Figure 9) in the value chain across all the actors. Technical interfaces and value chain -wide communication were identified as value creation determinants of this mechanism. For example, if there are no working technical interfaces to move the structural data of concrete elements from one company of the value chain to another and/or communication is lacking, value is easily lost. Actor-specific value capture effects from this mechanism are mainly determined by the costs of the data infrastructure.

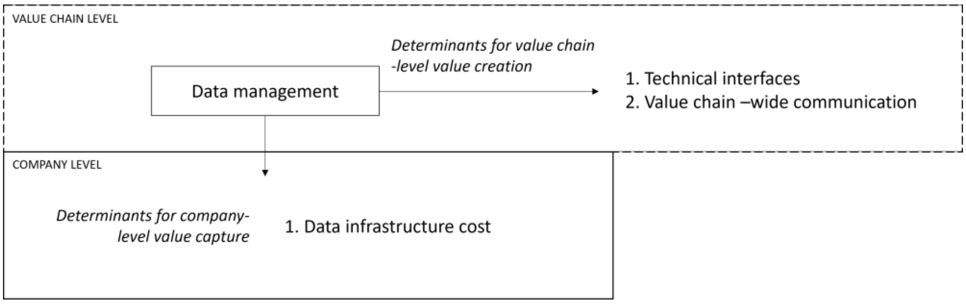

Figure 9 Value creation and value capture determinants of data management.

Finally, *coping with regulatory and societal impacts* (Figure 10) was identified as the last critical mechanism of value creation and capture. The mechanism encompasses anticipating, influencing, dealing with and reacting to the potential drivers and barriers of component reuse emerging from societal and context, especially regarding policy and other organizations. The identified determinants of value creation are customers' regulatory incentives and response from organizations and communities. For example, buildings built with more expensive reused concrete elements might not be able to compete in tendering processes unless the customer applies significant environmental criteria, e.g., because of regulatory reasons. This is also reflected in the value capture potential, as are regulatory effects targeted directly to the value chain actors.

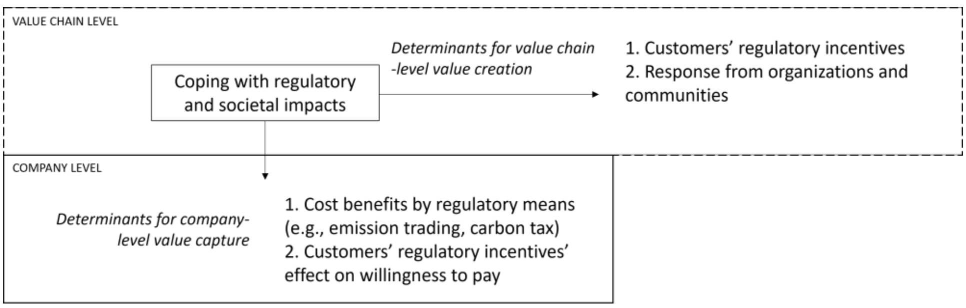

Figure 10 Value creation and value capture determinants of coping with regulatory and societal impacts.

5 Discussion, conclusions, and implications

Our study developed understanding of how companies and value chains can create and capture value from reuse processes, particularly from component reuse in construction sector. We conceptualized nine critical value creation and capture mechanisms with their respective value determinants.

The results yield some interesting, related discussion points. As explained, the Finnish case was characterized by high vertical integration and the German case by low vertical integration in the value chain. Some emerging findings on the benefits of high vertical integration for the value chain can be seen in our results. These include smoother management of different knowledge flows, improved information accessibility, and smaller number of complicated interfaces in terms of both technology and responsibilities. We consider this issue and the relationship of value chain organization and value creation in reuse a fruitful future research avenue.

Our study contributes to the CBMI literature by generating understanding of component reuse value creation and capture as a staged process. It also contributes to technical reuse literature by showcasing how the technical reuse process stages relate to value creation and capture. The case of reuse in the construction industry has thus far remained largely underexplored (Hart et al., 2019). Indeed, despite the recent increase in literature centered on reuse in the construction industry, most of the research remains from engineering and environmental perspective, while the business case of reuse is quasi absent from the literature (Scopus bibliometric data, 2023). Most of the literature explores the environmental impact of reuse in the construction industry (e.g., Bertin et al., 2022), the technicalities of implementing reuse in the building sector (e.g., Dams et al., 2021), and the barriers of implementing reuse in the construction industry (e.g., Ghisellini et al., 2018). Sporadic attempts to explore the value creation and value capture of reuse in construction rely mostly on literature reviews (Dewagoda et al., 2022; Ghisellini et al., 2018; Munaro et al., 2021). Therefore, this study, by relying on extensive data of reusing construction materials contributes to the debate on CBMI for reuse and its uptake in the environmentally burdensome construction industry throughout value creation for actors in the value chain. Moreover, Mhatre and colleagues (2021) contend that most research addressing circular economy is focused on the macro level initiatives. Therefore, this paper also contributes by shedding light on the circular managerial practices taking place at both the micro and meso levels and their business implications.

Regarding managerial implications, our findings on the value creation and capture mechanisms of component reuse can serve managers in three ways. First, they can guide the planning of a new reuse value chain that optimizes the utilization of value-increasing determinants. Second, they can be used to refine features and division of responsibilities in existing reuse value chains for elevated value creation and capture. Finally, our results can also guide managers in strategic positioning decisions, as they give advice on the benefits and downsides of vertical integration in reuse value chains.

Our results open opportunities for further research on how different reuse innovations facilitate the value creation and capture mechanisms. They should be strengthened and tested with studies in other reuse contexts regarding e.g., industry or business model. Moreover, our findings invite innovation management literature to conduct in-detail analyses for different collaboration models and contractual arrangements in reuse value chains. Further research could also focus deeply on how the revealed value creation and capture mechanisms can be organized into circular business models.

We are aware that our study has several limitations. Our reuse cases were purposefully selected two European countries, and component reuse was examined in construction sector context. Other regional or industry contexts can yield different answers. In future research it would be beneficial to also study component reuse in other industry contexts from business model and value creation and capture perspective, such as manufacturing, to expand our understanding of economic aspects of reuse and reused based CBMIs.

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