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Building Digital Foundations:
A Course of Action Towards a Circular Construction Industry

An Exploratory Case Study

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Executive Summary

This thesis aims to explore the potential for digital platform ecosystems to support the development of the circular economy in the Norwegian construction industry. While there is a general understanding among scholars and industry professionals that digitalization can enable circularity, the existing literature on the intersection of these two concepts is limited. Existing literature does not adequately address the potential for using digital platforms to promote circularity across industry value chains and achieve the goals of a circular economy.

To gain a holistic perspective on this potential, the thesis is based on an exploratory case study involving clients, consultants, architects, and contractors in the construction industry. The study aims to contribute to existing literature by developing a conceptual framework linking the concept of a circular economy to digital platform ecosystems, as well as by exploring why and how such a platform ecosystem can support the transition to circularity in the construction industry.

The study's findings are twofold. Firstly, the study suggests the need for an improved organization of the value chain actors on digital platforms to facilitate iterative collaboration on project-level. Particularly, we identified that the implementation of circularity in the industry depend on frequent involvement of contractors and consultants. Moreover, in order to succeed in the transition towards circularity, we argue that the industry needs an industry-wide platform to create a market for reused materials. Therefore, our study suggests that the industry requires a multidimensional platform with both project-specific and industry-wide components.

Secondly, we identified three fundamental attributes that need to be present on a digital platform ecosystem for circularity: *flexibility*, *data accumulation*, and *interaction*. Based on these findings, we reassess our preliminary framework linking the circular economy to digital platform ecosystems and describe how the fundamental attributes can support this relationship.

Overall, our thesis contributes to a better understanding of how industry actors can be organized on digital platform ecosystems to support circularity. In addition, the thesis provides the fundamental attributes necessary to configure a digital platform ecosystem for circularity in the construction industry.

Preface

This thesis is written as a part of the Master of Science in Economics and Business Administration at the Norwegian School of Economics (NHH) where we are pursuing a specialization in Business Analysis and Performance Management. The study is part of the Digital Innovation for Growth (DIG) research center, a national center for research on digital innovation for sustainable growth. Through our participation in DIG, our focus has been to contribute with insights into how and why digital ecosystems can contribute to sustainable development.

First and foremost, we would like to express our sincere gratitude to our supervisor Tina Saebi, for her guidance, support and encouragement throughout the research and writing process. We are grateful for her expertise, patience, and willingness to always go the extra mile to help us succeed.

Additionally, we are thankful to the interview participants, who generously shared their time and insights with us. Their honesty and willingness to participate in our research were instrumental in its success. We would like to express our gratitude to each and every one of them for their valuable contributions.

Finally, we would like to thank our fellow students at NHH for five fantastic years here in Bergen.

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Kristin Vagle Runa Fløtre Øfsti

Contents

1. Introduction

The construction industry lays the foundation for much of what we associate with modern society: Our homes, infrastructure, hospitals, and schools. Still, the industry's impact on our lives encompasses much more than providing a roof overhead. The industry also plays a significant role in the Norwegian economy and is the largest employer, and the second largest contributor to GDP in the country. Conversely, the industry is also responsible for massive consumption of resources and energy, constituting a threat to the sustainable development necessary to reach the targets set in the Paris Agreement (UNEP, 2022). With its prominent role in society and significant climate impact, a transition of the construction industry might be one of the key solutions in securing a sustainable future.

A course of action for securing a sustainable future, that has flourished among authorities and industry actors, is the transition towards a more circular construction industry. The circular economy offers an opportunity to increase material efficiency in the sector by reducing material use and increasing the longevity of our buildings (Byggfloken, 2019). Furthermore, the 2020 EU Action Plan highlights the implementation of the circular economy as one of the leading solutions for reducing the climate impact of the construction industry (EU, 2020). According to the Action Plan, greater material efficiency in the sector can reduce industry emissions by up to 80%. The interest in circularity has also spiked within the Norwegian industry, where collaborative initiatives like Byggfloken have been initiated to discuss the potential and solutions to enable a circular transition (Byggfloken, 2019). However, the initiative expresses that construction industry actors are still struggling to raise industry-wide competence on circularity and organize the traditional industry to cooperate in the transition towards circularity.

Both researchers and authorities imply that digitalization will be important in the transition to a resource-efficient and circular economy (Jensen, 2022). Accordingly, the EU 2020 Action Plan underlines the importance of innovation and digitalization for tracking, tracing, and mapping resources to dematerialize the economy and reduce dependency on natural resources (EU, 2020). Although the link between digitalization and the circular economy seems apparent, the actors and stakeholders in the construction industry are calling for direction on how digital tools should be applied in construction processes and projects to stimulate the development of circularity (Nordic, 2022). Hence, this thesis aims to provide a better understanding of how digital platforms should be configured based on perspectives from various industry actors and principles of the circular economy.

The research field on the intersection between digital technologies and the circular economy is still in its infancy, despite considerable interest among scholars in the past few years (Liu, Liu, & Osmani, 2021). Although several researchers point out digitalization as an essential enabler in the transition to a resource-efficient and circular economy (Antikainen, Uusitalo, & Kivikytö-Reponen, 2018; Çetin, De Wolf, & Bocken, 2021), there is still limited research on how this can be achieved.

Most research within the field has assessed digitalization from a technological perspective, assessing how specific digital technologies, such as AI and IoT (Çetin, De Wolf, & Bocken, 2021), or a combination of technologies (Kovacic, Honic, & Sreckovic, 2020) can be used to enable circularity in the construction industry. For instance, Kovacic et al. (2020) propose a framework that integrates building technical models with digital technologies on platforms to support implementation of circularity in construction projects. Although their research shows the relevance of digital platform ecosystems for circularity, they fail to address the distinct needs of different value chain actors in relation to circularity. Hence, to extend the current field of research, we wish to explore how digital platforms can be used to support the development of circularity in the construction industry based on perspectives from various industry actors.

To date, few studies have investigated how digital platform ecosystems can enhance collaboration in the construction industry to enable the transition toward circularity. As a result, we lack a thorough understanding of how industry actors should be organized on digital platforms for circularity. Previous studies have primarily focused on digital platforms for circularity from a single firm perspective (Iansiti & Levien, 2004; Tiwana, Konsynski, & Bush, 2010). However, a recent paper investigates how collaboration on digital platforms can enable circular flows of waste in the food industry (Ciulli, Kolk, & Boe-Lillegraven, 2020), highlighting the need for collaboration across value chains. Regardless, there is limited, perhaps even nonexistent, theoretical emphasis on how combining capabilities and knowledge of multiple industry actors can enable circularity in construction. Thus, we wish to address the research gap by investigating the ideal organization of industry actors on digital platforms to support the circular development.

Furthermore, existing literature on digital platforms is mainly linked to certain aspects of the circular economy and lacks a holistic integration of the two concepts. For instance, the existing literature assesses how digital platforms can help reduce resource use (Berg & Wilts, 2019) or waste (Ciulli, Kolk, & Boe-Lillegraven, 2020). However, resource exploitation and waste minimization will not restore and regenerate the environment itself (Velenturf & Purnell, 2021). According to Velenturf and Purnell (2021), the circular economy needs to be applied through a whole system perspective, including social, environmental, technical, and economic values to secure a sustainable development. Hence, we aim to address the current research gap by exploring what fundamental attributes need to be present on a digital platform to induce circularity in line with a whole system perspective.

1.1 Research Question

Research on circularity in the construction industry highlights the importance of cross-sectional communication and coordination to realize the objectives of the circular economy. Considering the high fragmentation and resource use of construction industry value chains (Bygballe, Grimsbu, Engebretsen, & Reve, 2019), we believe using digital platform ecosystems can support the industry's transformation towards circularity. Accordingly, this thesis will answer the following research question:

"How can digital platform ecosystems offer an opportunity for the development of the circular economy in the Norwegian construction industry?"

To investigate how the industry can successfully manage the transition towards circularity, we will explore the following sub-questions: 1) *How should industry actors be organized on digital platforms for circularity?* and 2) *What fundamental attributes needs to be present on a digital platform ecosystem to contribute to circularity in the construction industry?* Hence, our study aims to address two research gaps in contemporary literature. First, we address the lack of research on how circularity can be achieved through industry organization and value chain cooperation on digital platforms. Second, we aim to expand the current literature on the relation between digital platforms and circularity by analyzing what fundamental attributes of digital platforms will contribute to circularity defined from a whole system perspective. Moreover, our study will provide important guidance for industry actors and stakeholders on how digital platforms can be applied to develop circularity.

1.2 Outline of the Thesis

To answer the research question, we will conduct an exploratory case study of the Norwegian construction industry value chain. Following the introduction, we will clarify the concepts of circular economy (CE) and digital platform ecosystems (DPEs) in chapter 2, as the literature on the concepts is vast without any widely agreed-upon definitions. Then, contingent on our conceptualization, we will develop a preliminary framework connecting the two core concepts and show the impact of digital platform ecosystems on the circular economy in the construction industry. In chapter 3 we will provide an overview of the Norwegian construction industry to give the reader a sufficient basis for further reading. Chapter 4 will elaborate on our methodological choices. Furthermore, in chapter 5, we will present our findings and results. Finally, in chapter 6, our findings will be discussed rooted in reviewed literature before we present our conclusion and concluding remarks in chapter 7.

1.3 Boundaries of the Thesis

We set some boundaries for the thesis based on the study's scope and time limit. As our focus lies on connecting the two concepts, the circular economy and digital platform ecosystems, we will not delve into the technical aspects of digital platforms and the construction industry. We limit the scope of our thesis to the Norwegian construction industry and define it as all business directly related to a construction process, excluding the development of coherent infrastructure and manufacturing and transportation of building materials. Although we have decided to limit the scope of this thesis to the Norwegian industry, many of the characteristics also apply globally. Our research will, therefore, to some extent, apply to construction industries in other industrial countries.

Lastly, we would like to point out that we are studying the ongoing process of making the construction industry more circular within a limited timeframe, which means our findings mainly reflect the current state of circular development. Furthermore, due to the time constraint, we have limited our study to involve informants with central roles in the construction process. Therefore, our findings will focus on perspectives from clients, consultants, architects, and contractors in the construction value chain, restricting insights from less influential actors such as subcontractors.

2. Theoretical Background

The literature on the circular economy and digital platform ecosystems have evolved in silos, with only a few intersecting points of research. As a result, little is known about what requirements a digital platform ecosystem needs to fulfil, in order to foster circularity among its participating actors. In this chapter we will present existing literature on the thesis' core concepts, the circular economy and digital platform ecosystems. The purpose of the chapter is to derive a preliminary framework to describe the relation between the two core concepts. The theoretical conceptualization will be reassessed based on the empirical findings in the discussion in chapter 6.

2.1 The Circular Economy

The circular economy represents the first building block in the thesis' theoretical background. In this section, we will assess literature on circular economy encompassing existing notions of CE and principles that has been discussed in the literature as core to achieve all dimensions of a circular economy in practice. Concluding, we conceptualize circularity in the construction industry context.

The circular economy is deeply intertwined with the concept of sustainability. Manmade climate changes have caused severe and irreversible environmental consequences globally, leading to increased traction on sustainable development. Concerns about the exhaustion of scarce resources initiated the shaping of 17 sustainable goals based on the vision set out by the Brundtland Report. This report defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". These SDGs seek to harmonize the indivisible three dimensions of sustainable development: social equity, environmental quality, and economic prosperity, which need to be present simultaneously for an economy to be sustainable. Numerous concepts and principles are derived intended to address the SDGs, one of which we refer to as the circular economy.

Consider sustainability an umbrella covering any principle and initiative that strives to meet the vision of the Brundtland report; circularity adds the importance of the intentional design of a system, which separates circularity from sustainability (U.S Chamber of Commerce Foundation, 2022). In the literature, the relationship between CE and sustainability is described as a beneficial relation, more specifically, a relationship where circularity is among several solutions for fostering a sustainable system (Geissdoerfer, Savaget, Bocken, & Hultink, 2016). Such a subset relation is described as preferable to maintain diversity while, concomitantly, elucidating the wide variety of complementary strategies that relevant industry stakeholders, such as consumers, companies, and the government, can implement (Geissdoerfer, Savaget, Bocken, & Hultink, 2016). The depicted connection of how sustainable development is commenced through a circular economy is also supported by Velenturf and Purnell (2021), who have studied principles for a sustainable circular economy. The following section will describe the concept of circularity in detail.

2.1.1 The Concept of the Circular Economy

The concept of the circular economy can be traced back to the American economist Boulding (1966) who described an economy where continuous reproduction of the material form is possible through a cyclical ecological sphere. Grounded in Boulding's understanding of circularity, many understandings and definitions have emerged within the literature of CE. A comprehensive review of 114 CE definitions indicates that the concept is most frequently used in combination with reduce, reuse, and recycle (3R) activities (Kirchherr, Reike, & Hekkert, 2017). The review further find that the most employed definition of CE is the one defined by the Ellen MacArthur Foundation (EMF). EMF defines CE as a "*restorative and regenerative system designed to keep materials, components, and products at their highest possible value at all times*" (Ellen MacArthur Foundation, 2022). This definition highlights critical traits of the circular economy from a value perspective, indicating that the primary purpose is preserving value within the system. However, the definition does not concretize the outcome of circularity, nor how to achieve its restorative nature.

In contrast to a linear "take-make-dispose" economy, EMF argues that circularity closes the gap between production and natural ecosystem cycles and thereby represents a way to overcome the contradiction between economic growth and environmental sustainability. This conceptualization builds on the concept of cradle-to-cradle (C2C), described as "*a human-designed closed-looped system where resources circulate in an infinite cycle of production, recovery, and reuse, and where there is no waste*" (McDonough & Braungart, 2002, p.8). Through research on closed-loop material flows, McDonough and Braungart (2002) identifies design as the apparent source of conflict between industrial prosperity, environmental harmony, and economic viability. Similarly, Geissdoerfer et al. (2016) define CE as a "*regenerative system where resource input and waste are minimized by slowing, closing and* *narrowing the material loop, which can be achieved through long-lasting design, reuse, remanufacturing, repair, refurbishing, remanufacturing, and recycling*" (p. 759). This definition highlights diversity in the CE concept as it describes various complementary strategies that can be adapted to become more sustainable.

Moreover, roots of CE are also found in industrial ecology, a concept first introduced by environmental academics in the 1970s (Preston, 2012). This concept, contrasted to the ones mentioned in the previous section, describes the change of industrial systems to ecosystems by recognizing how resource cycling increases efficiency and facilitates new ways of value creation. Hence, the approach focuses on the cascading of resources along supply chains rather than the individual organization. Ghisellini et al. (2016) expand the CE supply chain aspect by addressing how partnerships and networks of companies operating in different stages of the supply chain are crucial for a CE. This argument is also supported by Dolby (1971), who adds the manner of interdependence between actors in the economy, and Boulding (1966), who claims that "knowledge sharing is far more important than matter because matter only acquires meaningfulness to humans when becomes the object of our knowledge" (p.4). Unlike the definitions by EMF (2022) and Geissdoerfer et al. (2016), the views of these latter definitions go beyond individuality and include the whole system in their conceptualization of CE.

2.1.2 The Principles of a Circular Economy

The principles of CE have been discussed broadly in the literature and describe the core of achieving a circular economy in practice. Despite a common agreement within the CE literature about the 3Rs, reduce, reuse, and recycle, being the core principles of CE (Feng & Yan, 2007; Preston, 2012), there is a lack of coherence in what the Rs represent. The reduce aspect emphasizes the reduction of raw material and energy input through improved production efficiency and consumption processes. For instance, reduce can be facilitated by introducing new technologies and new product designs that use fewer harmful materials. Further, reuse accentuates the utilization of the same materials or components for the purpose they were conceived multiple times, diminishing the need for virgin materials, energy usage and emission of harmful substances. Finally, recycling refers to the reprocessing of waste materials into new substances or materials.

Furthermore, other approaches to similar core principles have been established globally. One of the more prominent frameworks is the European Union Waste Framework Directive (European Commission, 2022). This framework includes “recovery” in addition to reduce, reuse, and recycle. Other authors have gone beyond the 4R framework and included 6Rs Sihvonen et al. (2015) or even 9Rs van Buren et al. (2016). The fact that the Rs are not aligned across the different principles and definitions has been a source of critique against circularity as it could cause implementation difficulties if, for example, author X conceptualizes “how to” of CE as recycling, whereas author Y considers the 3Rs as an answer to “how to”. This confusion could create misleading results when accumulating knowledge for an industry transition. To support this critique, Dacin et al. (2010) found that the current state of conceptual confusion serves as a barrier to advances in the field. Hence, to successfully increase circularity in an economy, the principles should be consistent and adaptable for all parts of the supply chain.

Other critiques of the R frameworks are described by Velenturf and Purnell (2021), who highlights the lacking coherence between CE conceptualization and sustainable development. Previous research first and foremost focus on how CE is considered an approach to maximize economic and environmental benefits, neglecting the third dimension involving social equity (Velenturf & Purnell, 2021; Kirchherr, Reike, & Hekkert, 2017). This argument is also supported by Geissdoerfer et al. (2016), who recognize that scholarly analyses until now have had a strong focus on “technological” goals, like resource efficiency and recycling, creating an empirical bias arising from the long tradition of recycling and waste treatment technologies in many western countries. Therefore, Velenturf and Purnell (2021) have developed a new set of ten consistent principles for the design, implementation, and evaluation of the adaption of sustainable CE closely tied to the concept of CE, which can be found in Table 1.

Table 1: Ten Principles for the Circular Economy

Principles for Redefining the Relation Between Nature and Society	
Beneficial reciprocal flows of resources between nature and society	Advocate for a system where nature and society coexist in a biophysical environment instead of a system that contradicts the concept of environmental regeneration
Reduce and decouple resource use	Promote dematerialization, efficiency, and absolute decoupling of resource exploitation from economic growth through political governance and technological progress

Principles for Transforming Production	
Design for circularity	Design efforts at the levels of material selection and product design, supply chains and overarching industrial systems through a "whole system" perspective, thereby deriving the best option for a supply chain from a whole system assessment combining economic, social, technical, and environmental values. Transforming industrial systems towards circularity by continuously monitoring, evaluating, and adapting sustainable practices and phasing out non-sustainable ones
Circular business models to integrate multi-dimensional value	Develop innovative business models incorporating social, environmental value and economic value
Principles for Co-Creating Social Value with Consumers, Citizens, and Communities	
Transform consumption	Dissociate from producer-driven consumption by promoting demand-driven consumption of products and services with high durability and upgradability. The transition towards a sharing economy and product-service systems
Citizen participation in sustainable transitions	Involvement of all actors in an economy to take part in the transition towards circularity by raising citizen engagement and participation to promote change in common social values
Coordinating the Transition	
Coordinated participatory and multi-level change	Coordination of development and implementation of circular economy strategies and practices across industries and actors
Mobilize diversity to develop a plurality of circular economy solutions	Development of shared knowledge systems acknowledging the local differences between economies and addressing these through a context-dependent implementation of CE practices, rather than assuming "one size fits all", resistance to the unknown and uncertainty of the transition towards circularity can be mitigated
Principles for Governance of Progress Towards Sustainable Circularity	
Political economy for multi-dimensional prosperity	Prosperity needs to be seen in the light of the environment and the social aspect rather than the economic aspect isolated
Whole system assessment	A whole system assessment to evaluate and optimize strategies to progress towards and maintain a sustainable CE regularly will be needed to continue sustaining the core values of environmental quality, social equity, and environmental prosperity

The reviewed literature describes eminent factors and principles for successfully implementing and evaluating a circular economy. Nonetheless, the bearing point of our research is the construction industry; thus, the next section will emphasize reviewed literature on circular economy concepts in the construction industry.

2.1.3 Circular Economy in the Construction Industry

Numerous scholars have studied circularity in the construction industry resulting in a vast number of definitions of circularity in context of the industry. Leising et al. (2017) elaborate on the CE, describing a "*life cycle approach that optimizes the buildings useful lifetime, integrating the end-of-life phase in the design, and uses new ownership models where materials are only temporarily stored in buildings that act as material banks*" (p.3) This definition draws on the life cycle approach by adding the aspect of buildings as a storage facility for materials. By facilitating for creation of new ownership models, materials can be reused or redistributed at the end of the building's lifetime. Pomponi and Moncaster (2017), on the other hand, focus on CE in different parts of the value chain and states the importance of "*a building that is designed, planned, built, operated, maintained, and deconstructed in a manner consistent with CE principles*" (p.117). The principles they refer to are the same as those described in the previous section, highlighting the importance of a system-oriented approach in the design, execution, and evaluation of a construction to successfully implement circularity. Hence, Pomponi and Moncaster (2017) describes that integration of CE across the whole construction value chain requires action at many different stages. Furthermore, they elaborate six overarching dimensions that need to be considered in implementing circularity in the construction industry. These six dimensions are behavioral, governmental, societal, economic, technological, and environmental.

2.1.4 Towards a more Holistic Definition of the Circular Economy

Based on the conducted literature review, we have established a comprehensive knowledge base to define the concept of CE for the purpose of this paper. Lacking a comprehensive definition of CE in the construction setting, we have chosen to use the presented literature to develop a separate definition on which our paper will be based. We build on the importance of a regenerative system designed to keep materials at their highest possible value. In this way, the materials will be renewed and restored throughout the industry value chain without diminishing resource quality. As Velenturf and Purnell (2021) argue in their review of sustainable CE, our definition also seeks to highlight the importance of an ecosystem to include a holistic view of the construction industry rather than an isolated view of one building.

This also draws on the most prominent part of the definition of Pomponi and Moncaster (2017) by incorporating the whole supply chain in our conceptualization.

Further, by incorporating both the material and immaterial aspects of resources, we address the need for interaction between stakeholders promoting synergies in the industry, as highlighted by Boulding (1966). Additionally, as there is a broad agreement that circularity requires action on different fundamental dimensions, we choose to emphasize these in our definition through the consistent principles by Velenturf and Purnell (2021) for a successful implementation of a sustainable CE. Similarly, we consider it appropriate to add a feature of the well-established 3R frameworks: reduce, reuse, and recycle, as these are considered concrete measures to increase circularity in the industry. Rooted in the definitions of EMF (2022) and Pomponi and Moncaster (2017) and our interpretations of circularity and circularity in the construction industry, we define CE as follows:

"The circular economy is a regenerative ecosystem where material- and immaterial resources are cascaded between industry actors induced by fundamental principles to keep inputs in a construction life cycle at their highest possible value"

An overview of the definitions constituting the basis for our holistic conceptualization of the circular economy can be found in Appendix A.

2.1.5 Limitations of the Conceptualization

Although our conceptualization is based on a thorough review of existing literature on circularity, we find it appropriate to mention some limitations that might prevail. Firstly, as discussed in the previous sections, there is no commonly agreed upon definition of circularity. Considering that we have not gone through all existing literature, there could be some similarities and differences are not included our conceptualization. Furthermore, Kirchherr et al. (2017) describe that scholars often define circularity in the specific context they study, due to space restrictions in research papers. As a result, few papers work to develop a common understanding of circularity in the literature. It could also be that authors find some aspects of the concept self-evident and thus chooses not to address these aspects in their definitions, again emphasizing that the understanding of the concept might be broader than the written definitions presented.

2.2 Digital Platform Ecosystems

The second theoretical building block necessary to answer the thesis' research question is the concept of digital platform ecosystems. In the following section, we will present literature describing attributes of digital platforms and how different types of digital platforms relates to digital platform ecosystems. The section will be divided in two main sections. First, key attributes of digital platforms will be assessed before the ecosystem literature will be discussed to emphasize the effects of including a network of actors on digital platforms. Finally, we will conceptualize digital platform ecosystems for circularity based on the attributes of digital platforms and ecosystems.

The use of digital platforms in businesses and industries has spiked in the past decade and have been adopted expeditiously in diverse industries like banking, healthcare (de Reuver, Verschuur, Nikayin, Cerpa, & Bouwman, 2015), energy (Kiesling, 2016) and transportation (Svahn & Mathiassen, 2015). Moreover, various European research projects reveal the significance of digital platforms in fostering a more circular approach, due to its ability to connect distinct actors. For instance, FiberEUse is a digital platform funded by the EU that integrates innovation initiatives in the textile industry to increase the reuse and recycling of materials based on a holistic circular approach (FiberEUse, 2022). Nevertheless, limited research has been done on applying digital platforms to induce circularity in the construction industry context.

2.2.1 Digital Platforms

Digital platforms have been an important topic of research within the information systems and management literature as an increasing number of businesses and industries adopt large-scale platforms (Asadullah, Faik, & Kankanhalli, 2018). Over time the research on platforms has diverged into two dominating perspectives: *the technological perspective* and the *market-based perspective*. In combination, the two perspectives give a holistic approach to digital platforms and incorporate their most important characteristics. In the following section, we will introduce these two perspectives and derive a preliminary conceptualization to summarize key features of digital platforms.

The Technological Perspective

The technological perspective accentuates the technical components and processes that make up a digital platform (Asadullah, Faik, & Kankanhalli, 2018) and conceptualize digital platforms as technological architectures (Baldwin & Woodard, 2009) that help firms generate modular product innovation (Jiao, Simpson, & Siddique, 2007).

One of the most cited scholars within this perspective, Ceccagnoli et al. (2012), define a digital platform as a *"set of components used in common across a product family whose functionality can be extended through applications"* (p.263), emphasizing how the platform's components and applications facilitate product development. Other researchers explain the technological components more in-depth. For example, Tiwana et al. (2010) define a digital platform as "*the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate"* (p.675). Accordingly, a digital platform consists of a technological core of software that can be extended to connected modules and interfaces. In this way, the platform's modules allow the production of independent components through a system of different actors with little need for coordination (Baldwin & Clark, 2000).

The modular architecture is a source of three essential qualities with digital platforms: 1) economies of scale since the use of standardized interfaces reduces interdependencies and the translation costs between different modules (Farrell & Saloner, 1985; Katz & Shapiro, 1994), 2) economies of substitution as the modular components are easy to upgrade, reducing the need for building systems from scratch (Garud & Kumaraswamy, 1993), and 3) innovative abilities as the modular digital architecture is "malleable", meaning it reconfigures to adapt user needs and initiate new technological advances (Yoo, Henfridsson, & Lyytinen, 2010). Hence, modularity facilitates an efficient and flexible platform structure, adaptable to changing needs.

The Market-Based Perspective

The market-based perspective views platforms as two-sided markets (Rochet & Tirole, 2003) that mediate transactions between user groups creating network effects (Alstyne, Parker, & Choudary, 2016). Hence, the perspective highlights how interactions between the platform's users create value.

Evans (2003), one of the earliest scholars within the economic literature to study the concept, defines a platform as *"a multi-sided entity that coordinate demand between distinct groups that need each other in a specific context"* (p.191). By being multi-sided, the platform enables direct interaction between two or more distinct types of customers (Rochet & Tirole, 2003) that cooperate to create value (Øverby & Audestad, 2018). Additionally, its function as an intermediary reduces the cost of searching and the need for coordination between the platform's actors (Asadullah, Faik, & Kankanhalli, 2018). Value is created through network effects, where one group's benefit is enhanced as more groups join the platform (Evans, 2003; Schilling, 2002). In this way, one group's benefit from joining the platform depends on the size of the other group joining (Armstrong, 2006).

According to the market perspective, key characteristics of digital platforms include 1) connecting mutually dependent and distinct groups, 2) reduction in transaction costs from coordination, and 3) network effects based on the number of actors. However, one limitation of interpreting digital platforms as two-sided markets is that it gives a limited perspective on the dynamics of how and why platforms evolve and does not distinguish between the roles of the users (Gawer, 2014).

Scholars argue that the combination of technological and intermediary features is the reason why digital platforms are so successful in many different areas (Gawer, 2014; Schreieck, Wiesche, & Krcmar, 2016). Therefore, we synthesize the two perspectives and derive a conceptualization of digital platforms comprising four features from the literature review we consider particularly important: 1) The use of standardized digital interfaces to achieve economies of scale, 2) the modular architecture facilitating economies of substitution and innovation, 3) the combination of technological components and a marketplace enable efficient and convenient transactions between consumers and producer, and 4) the network effects that arise as more users participate.

2.2.2 Digital Platform Ecosystems

Literature on digital platform ecosystems (DPEs) complements the theory of digital platforms as it elaborates on the effects and features of having a more extensive network of platform users. Furthermore, since we are studying the use of digital platforms in an industry setting, the DPE literature will help portray how and why industry actors will engage on digital platforms, as well as challenges related to industry-wide platforms.

The DPE literature is rooted in the biological understanding of ecosystems and the literature on digital platforms. In biology, the term describes the cooperation, survival, and value creation of interdependent organisms in nature (Adner, 2017). Iansiti and Levien (2004) draws on the same understanding and argue that ecosystems are *"characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival"* (p.5) Their definition represents a holistic perspective on ecosystems in that they consist of interdependent actors across industry boundaries that create value from a symbiotic relationship. The ecosystem perspective on digital platforms is closely related to what Gawer and Cusumano (2013) refer to as external digital platforms in the digital platform literature. Their contribution on the differences between internal and external platforms highlights the benefits and challenges from including a large network of actors on a platform compared to a smaller one.

The Differences Between Internal and External Digital Platforms

According to Gawer (2014), internal platforms consist of actors from a single company with few incentives to compete with the other platform actors and little autonomy to innovate in their activities. Therefore, the platform's interfaces are relatively closed, restricting participation from actors outside the company's boundaries. These platforms are also known as "product platforms" in the literature (Wheelwright & Clark, 1992) and create value by organizing a set of assets in structure in which a company can efficiently develop and produce a stream of derivative products (Meyer & Lehnerd, 1997; Muffato & Roveda, 2002). By connecting distinct users within the firm, the platforms facilitate coordination to reuse components or technologies in product development, control high production and inventory costs, or reduce time to market (Gawer & Cusumano, 2013). However, the systematic planning of "reusing" product components (Baldwin & Woodard, 2009) creates a trade-off between functionality and performance. Hence, internal platforms are only capable of incremental innovations and mainly contributes to efficient coordination and production within firms (Gawer & Cusumano, 2013).

External platforms, on the other hand, have an open interface enabling complementary firms and competitors to connect to the platform (Gawer, 2014). A complementary firm can be defined as a company whose activities complement the activities of others. External platforms, therefore, consist of an extensive network of actors with high levels of autonomy and strong innovative abilities (Gawer, 2014). As more actors connect to the platform, the network effects will increase the platform's innovative abilities and value creation in a reinforcing mechanism (Gawer & Cusumano, 2013). A well-known example of an external platform is Apple’s AppStore. The AppStore platform connects actors from the industry to contribute with complementary innovations, creating value in an open innovation environment. Hence, by giving third-party firms access to the platform's data, they can cooperate in inventing complementary solutions such as industrial applications and services (Pauli, Fielt, & Matzner, 2021). However, since the platform’s actors belong to the same competitive landscape, external platforms risk that actors start competing and innovating for competing platforms, ultimately reducing revenues and profits (Eisenmann, Parker, & Alstyne, 2006). Accordingly, to preserve value creation from complementary innovations, the external platforms depend on a governing mechanism that aligns the platform actors’ interests and activities.

Characteristics of Digital Platform Ecosystems

The theoretical understanding of digital platform ecosystems appears to have many similarities with the definition of external digital platforms. Since the network of ecosystem actors is often centered on digital platform technologies (de Reuver, Sørensen, & Basole, 2017), the DPE literature has established a close connection between the two concepts (Skog, Wimelius, & Sandberg, 2018). Adomavicius et al. (2008) refer to digital platform ecosystems as *“sociotechnical networks of interdependent digital technologies and associated actors that are related based on a specific context of use”* (p.782), reflecting the web of elements that constitute an ecosystem such as digital technologies, firms, institutions, and customers (Skog, Wimelius, & Sandberg, 2018).

The effect of a more extensive network of actors is source of two distinct characteristics of platform ecosystems: Complementarities and generativity. Firstly, Jacobides et al. (2018) argue that complementarities can explain why we might see ecosystems replace traditional market-based organizations and vertically integrated supply chains. Complementarities are products that need each other to function or whose value increases when produced or consumed together (Jacobides, Cennamo, & Gawer, 2018). They refer to these as unique and supermodular complementarities, accordingly. The complementarities between the actors in an ecosystem constitute a structure that allows for the development of complex interdependent products or services without the need for vertical integration (e.g., a company controls their suppliers) or hierarchical control. The actors’ incentives to cooperate due to complementarities result in a structure that enables organic group-level coordination. Thus, in line with Adner

(2017), an ecosystem can be interpreted as an alignment structure where multilateral partners must interact and form mutual agreements regarding the position and flows to realize their full value proposition. Therefore, the ecosystem perspective extends the interpretation of external digital platforms by introducing network complementarities as an alignment mechanism, reducing the need for governance.

Secondly, the DPEs are a source of generativity that reflects the ecosystem's *"overall capacity to produce unprompted changes driven by large, varied and uncoordinated audiences"* (Zittrain, 2005, p.8). Hence, digital platform ecosystems are driven by innovation, adoption, and scaling, reflecting the evolution of digital infrastructures (Henfridsson & Bygstad, 2013). Innovation emerges from actors integrating resources when producing new products and services. As more products are created, more actors are willing to join and adopt the infrastructure, ultimately resulting in scaling. Hence, generativity will rise and be fueled because ecosystem actors can build on digital solutions provided by the platform when innovating their products and services (Nambisan, 2019). For example, when complementary actors share knowledge on the platform that can facilitate innovation for other actors, generativity scales the ecosystem's innovative abilities (Dokko, Kane, & Tortoriello, 2014).

Mechanisms of Digital Platform Ecosystems

Hein et al. (2020) extend the perspective of digital platform ecosystem by explaining how the ecosystem's characteristics interrelate on digital platforms. They argue that DPEs consist of three main building blocks, *platform owner*, *value-creating mechanisms* and *complementors*, that are all crucial for the ecosystem's function and success.

The platform owner represents the ecosystem's governance mechanism, ranging from high to low centralized power (Hein, et al., 2020). With higher centralization, the platform owner defines and maintains the governance, facilitating quick responses; however, it can become an overwhelming strategy as ecosystems grow larger. The opposite strategy is a decentralized distribution governed by peer-to-peer communities with direct influence on the direction of the ecosystem (Hein, et al., 2020).

Furthermore, the value-creating mechanisms include the ability to facilitate transactions and innovation (Hein, et al., 2020), consistent with the features of digital platforms reviewed in the previous section. Finally, the complementors refer to the ecosystem's actors with various levels of autonomy, reflecting how much freedom they have (Ye & Kankanhalli, 2018) or how tightly they are coupled to the platform (Boudreau, 2012). Tightly coupled complementors are typically strategic partners with mutual trust, commonly defined goals, and contracts (Steensma & Corley, 2000). In contrast, highly autonomous complementors are actors that, to varying levels, engage on the platform with high flexibility and few boundaries (Lusch & Nambisan, 2015). Thus, consistent with the need for aligning autonomous actors on external platforms (Eisenmann, Parker, & Alstyne, 2006), the ecosystem extends the perspective by arguing that complementors must be aligned based on their degree of autonomy.

To summarize, digital platform ecosystems comprise a more significant number of actors than internal digital platforms, which introduces a new set of advantages and challenges. The ecosystem's generative nature fuels innovation and efficiency on the platform which strengthens the platform's value creation mechanisms. However, ecosystems with a high level of centrality risk inflexibility as the number of actors on the platform increases (Hein, et al., 2020). In addition, if the level of autonomy is higher than the level of trust and goal alignment allows, there is a risk of self-destructive competition (Gawer & Cusumano, 2013). However, if successfully implemented, digital platform ecosystems have the potential for stronger value-creation compared to internal digital platforms.

2.2.3 Conceptualization of Digital Platform Ecosystems

We conceptualize DPEs as a system with three main features, *efficiency, innovation*, and *network.* On an overarching level, the efficiency and innovation features reflect what Hein et al. (2020) refer to as the value-creating mechanisms and complementors, whereas the network feature considers the extended network of complementary platform actors that stimulate generativity in the ecosystem.

In more detail, the efficiency feature comprises the elements that reduce resource use for the ecosystem participants in construction. This involves three elements: 1) economies of scale from sharing and using standardized interfaces, 2) cost reductions in transactions from enabling digital technologies across processes within the firm, the supply chain, and the industry, and 3) economies of substitution from the modular architecture that allows integration of new components. The second feature, innovation, includes the elements of digital platform ecosystems that can facilitate innovation. Three elements facilitate innovation: 1) the complementarities among the ecosystem's interdependent actors that create incentives for value-creating innovations, 2) the high level of autonomy allows for independent innovation in which each actor makes choices to maximize their utility, and 3) the modular architecture is adaptable and easily reconfigured which stimulates innovative responses to changing needs. The ecosystem's actors make up the ecosystem's third feature, network. By being interdependent complementors, the participants in the ecosystems are stimulated to coordinate and cooperate to create mutual benefits for each other. However, their need for governing alignment to coordinate depends on their level of autonomy. As the number of actors in the ecosystem grows, the mutual benefits in efficiency and innovation are fueled by the generativity from scaling and adoption. An overview of the definitions on which our conceptualization is based can be found in Appendix B.

2.3 Preliminary Conceptual Framework

Based on the ten principles for a circular economy (Velenturf & Purnell, 2021), and our conceptualization of digital platform ecosystems, we have derived a preliminary framework that connects the two theoretical building blocks by mapping out where the features of DPE can contribute to the principles of CE. In line with our conceptualization, the preliminary framework portrays the relation between CE principles and DPE's features, as illustrated in Figure 1 below.

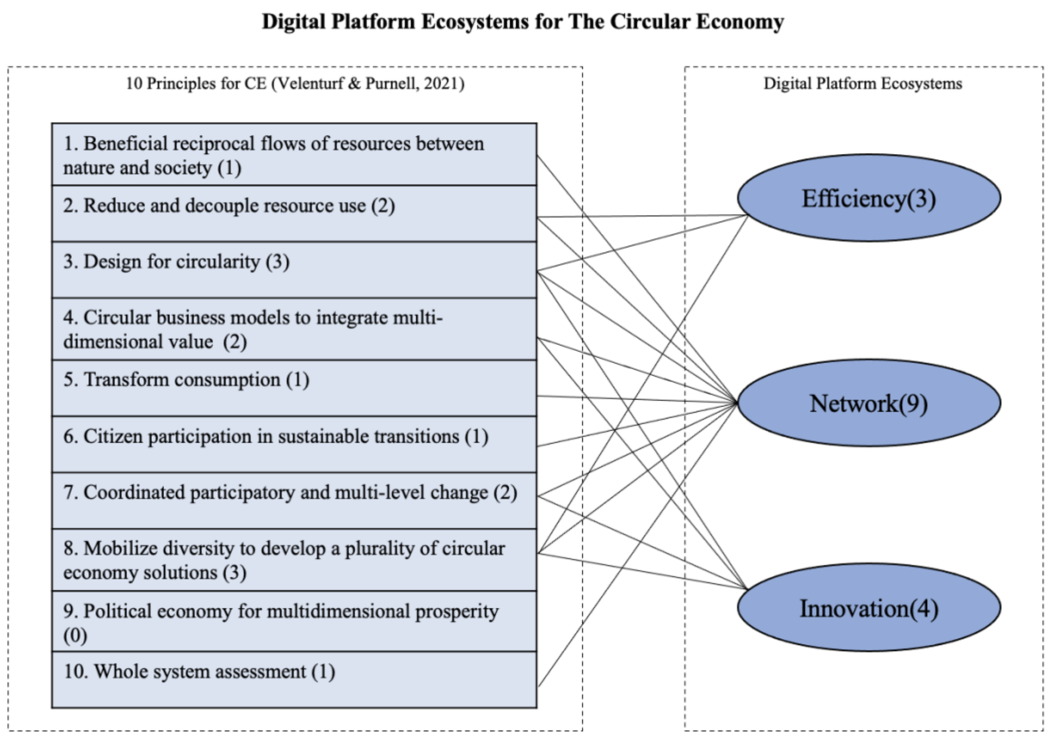

Figure 1: Preliminary Framework for the Circular Economy

Our framework indicates that some features of DPEs are more important for CE than others. The most important feature is the network of interdependent actors, as many of the principles for CE depend on cooperation or coordination through networks. Moreover, the principles that will benefit the most from a digital platform ecosystem are "*Design for circularity"* and "*Mobilize diversity to develop a plurality of circular economy solutions".* For instance, a digital platform ecosystem will incorporate several dimensions of the circular economy in designs for circularity (Pomponi & Moncaster, 2017). Firstly, the platform's network will facilitate knowledge sharing and innovation in material selection, product design and supply chain. Moreover, the technological interface and solutions of the platform will enable the monitoring and evaluation of current sustainable practices and new initiatives, to support decision-making related to the integration of circular actions. On the other hand, we find that digital platform ecosystems will to little, or no extent, facilitate *"Citizen participation in sustainable transitions",* as the primary purpose of digital platforms is not social engagement from communities or society.

3. The Norwegian Construction Industry

This chapter will briefly introduce the Norwegian construction industry and provide an overview of the construction industry value chain. The following information was collected from secondary data sources to provide the necessary background for the case study in order to form the research setting.

3.1 Industry Characteristics

The construction industry is a major contributor to Norway's economy and society, while also responsible for a significant environmental footprint due to its resource-intensive nature and large generation of waste. In fact, Norway's circularity metric is only 2,4%, indicating that more than 97% of the consumed materials are not cycled back into the economy (Circular Norway, 2020).

In addition, the industry is characterized by low productivity and low margins. This is in part due to the complexity of the industry value chain and the project-based structure (McKinsey, 2016). According to Statistics Norway, the productivity in the construction industry has fallen by 10% since the year 2000, while in the same period, the productivity in the private sector in mainland Norway increased by 30% (SSB, 2018).

Moreover, Norway is among the leading countries in Europe in digitalization (Regjeringen, 2021), creating a great potential for applying digital tools to address these issues. Thus, the adoption of digital tools in the construction industry could help to streamline processes, reduce errors and rework, and increase productivity.

3.2 The Value Chain

The construction industry value chain is lengthy, complex, and fragmented, including numerous activities where each actor has its own goals, functions, and competencies. To understand how the industry is organized and how value is created, we will in this section elaborate on the value chain and its actors. The value chain organization is illustrated in Figure 2.

Construction projects come in a wide range of sizes and types, resulting in the emergence of a multitude of models and frameworks for organizing them. On an overarching level, value creation in the construction industry happens through six phases: 1) Project organization, 2) Planning and projection, 3) Procurement, 4) Construction, 5) Operation and maintenance and 6) Demolition and development (Bygballe, Grimsbu, Engebretsen, & Reve, 2019). These phases are considered generic in the sense that they appear in all construction projects (Eikeland, 2001).

Each of the six phases involve actors essential for the construction project (Eikeland, 2001). The actors can be individuals, a group, or a company, and are typically linked by temporary, non-repeating relationships (Lidsheim & Dalsegg, 2021). However, the inconsistency in the structure of building processes can make it difficult for actors to coordinate tasks in different projects. To address this issue and increase consistency within the Norwegian construction industry, Bygg21 has created a framework for describing the implementation of building projects (Bygg21, 2015). As the complexity of the Bygg21 framework exceeds the needs in this thesis, we will apply parts of the insights in our representation of the generic phases of the construction industry value chain. In the following, each phase of the value chain will be elaborated.

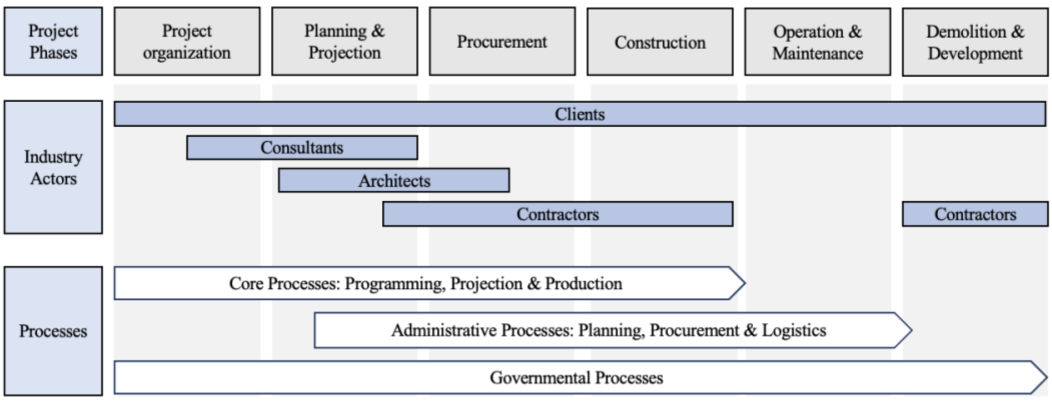

Figure 2: Construction Industry Value Chain, Source: Authors' own drawing

3.2.1 Phase 1: Project Organization

The first phase of the construction project starts with the client, who can be an individual, a company, an organization, or the government initiating a construction project. The client is typically the buyer, and in most cases also the owner of a constructed building (Arbeidstilsynet, 2022). If the client is not the owner of the building, they are responsible for communicating the process of the construction between owners and users (Bygg21, 2015).

Furthermore, the client delegates authority and is responsible for the management of the construction process that is carried out for them (Hansen, 2019). It is important for the client to consider trade-offs such as the quality of the finished product, costs, risks, and progress, and they hire consultants with special competencies to assist with the initial financial, risk and quality analysis of the project's scope and viability (Bygg21, 2015).

3.2.2 Phase 2: Planning and Projection

The purpose of the planning and projection phase is two-sided. On one side, the projection is intended for the client and project organizers to document and illustrate the expected outcome based on the clients' visions and goals related to design and functionality. On the other side, the projections are meant to cover the contractors' need for information and data throughout the construction process (Eikeland, 2001). The planning and projection phase typically happens in three stages (Bygg21, 2015). In the first stage, the overall concepts and business cases are analyzed by consultants and architects based on the owner's projected demands. Next, in the processing stage, technical solutions and strategic plans are developed for the chosen project by the actors in line with regulatory plans. Finally, in the detailed planning stage, consultants and contractors prepare complete drawings and digital representations of the product using Building Information Models (BIM). Decisions made during this stage, such as those related to materials, design, and energy efficiency, significantly impacts the circularity of the finished construction (Iyer-Raniga & Huovila, 2020). Therefore, sustainability considerations should be assessed by architects, consultants, and contractors during the planning and projection phase.

3.2.3 Phase 3: Procurement

The production phase of the value chain includes the actors producing various products and components required in the industry (Eikeland, 2001). Because this phase depends on several external factors that we do not have insight in, this part of the value chain will not be a point of focus in our scope.

3.2.4 Phase 4: Construction

During the construction phase of the value chain, the contractors are responsible for physically building or delivering services according to the client's demand. The construction phase can be controlled either by the client or by the contractors in cases of turnkey contracts. Turnkey contracts apply when a single actor cover several stages of the value chain, such as both the design and the construction, which is often the case for larger building companies. Smaller contractors, on the other hand, are often managed by the client and may need to hire sub-contractors, such as electricians, plumbers, and bricklayers, to complete the construction (Eikeland, 2001). The wide range of contractors and sub-contractors creates a competitive environment in which costs, and regulations are the main priorities.

3.2.5 Phase 5: Operation and Maintenance

The operation and maintenance phase of the construction process can be divided into the building delivery process and the continuous operation of the building (Bygg21, 2015). Prior to handing over the building to the owners and users, contractors need to conduct quality checks and functional tests, as well as provide the necessary documentation for the operation of the building. The practical operation and maintenance of the building involves technical, administrative, and managerial actors who can perform maintenance and identify problems that needs to be repaired (Standard Norge, 2020). While the operations and maintenance phase have a significant impact on resource use and waste generation, the actors in this stage often lack the ability and awareness to make a change towards circularity, as these decisions are typically made during the planning and projection stage.

3.2.6 Phase 6: Demolition and Development

The final phase of the construction value chain is defined by the owner's decision to either demolish or develop the building based on its viability (Bygg21, 2015). For instance, in some cases the cost of maintenance and operation will exceed the perceived benefit of restoring the building, leading to demolition. A case study conducted in Belgium reveals that the environmental impact of demolishing and building a new building is 20% higher than renovating the existing building stock (Wastiels, Janssen, Decuypere, & Vrijders, 2016). In addition, building from scratch increases life-cycle costs by 30%. However, new buildings tend to be more efficient in terms of energy and space utilization. Thus, the owner needs to consider the condition and purpose of the building, as well as the environmental and economic impact, when determining whether to demolish or restore the building.

3.3 The Construction Processes

In order to successfully plan and execute a construction process, Eikeland (2001) highlights three key processes that must occur: Core, administrative and governmental. These processes are intertwined across the construction value chain and involve key actors who enable the execution of the construction project. Hence, the overall construction process is a value creating interplay between numerous sub-processes.

The core processes are responsible for describing and producing the planned construction and include programming, projection, and production enabled by clients, consultants, architects, and contractors (Eikeland, 2001). Concurrently, the administrative processes ensure that the core processes are carried out in accordance with the contracted requirements for quality, costs, and time of the projected construction. Finally, all construction projects must follow the Norwegian Plan and Building Act and Regulations on technical requirements for construction works (TEK17), which outline the minimum characteristics a construction must have in order to be legally built in Norway (Dibk, 2022). These requirements are enforced by the governmental processes that plan and evaluate that all parts of the construction are in compliance with current legislation. In other words, the core processes develop the construction, the administrative processes manage it, and the governmental processes control it. For instance, an architect needs to design the construction within the maximum cost set by the client, while also following the proposals of the hired consultant who specializes in technical requirements. Therefore, not only do the processes run concurrently during the project, but they also involve actors from different parts of the value chain who need to coordinate their activities to successfully align the key processes.

4. Methodology

In this section we intend to describe and explain the methodological choices made in our research. The first part will explain the research approach, research design and choice of methodology. Thereafter, we will clarify our data collection and approach to data analysis. In the last part of the chapter, we discuss the quality of the research conducted before finally reflecting on the study's ethical aspects. An overview of our methodological choices can be found in Table 2.

Table 2: Methodological Choices

Concept	Methodological choice
Research approach	Abductive
Research design	Exploratory
Research method	Qualitative
Research strategy	Case study Cross-sectional
Data collection	Semi-structured interviews Secondary data
Data analysis	Transcription Gioia method coding

4.1 Research Approach

As we seek to develop the theory around how the involvement of digital platform ecosystems can facilitate for circularity in the construction industry, we chose an abductive research approach. This approach is a combination of a deductive and an inductive approach, combining already existing theories and data collection to generate new, or modify existing theory (Saunders, Lewis, & Thornhill, 2019). Combining the two distinct approaches in an abductive approach, can help overcome inherent weaknesses of the two approaches. A lot of research has been done on both the concept of circularity and digital platform ecosystems. However, limited research has studied the link between the two concepts in context of the construction industry. An abductive approach is considered suitable when a lot of theory exists on a topic in a context, but significantly less in the context you are investigating (Saunders, Lewis, & Thornhill, 2019). An abductive approach, thus, allowed us to have a more iterative research process where we modified and expanded existing theory based on our findings. In particular, we identified a research gap in how circularity can be facilitated through the presence of all relevant actors on the same digital platform. Consequently, this is considered a unique opportunity to study, which makes an abductive approach appropriate.

4.2 Research Design

Considering the limited amount of existing research conducted on the chosen topic, this thesis has an exploratory design to clarify and gain new insight on a phenomenon. Exploratory design is, according to Saunders et al. (2019), investigative, and thus appropriate for our study, where we want to use open-ended questions to explore how involvement of construction industry actors on a digital platform can increase circularity. Due to limited existing literature on digital platforms facilitating circularity, and even less in construction industry context, it was essential for us to choose a flexible research design, as data could provide insights that changed the direction of the study. Thus, as an exploratory design is dynamic and adaptable (Saunders, Lewis, & Thornhill, 2019), it was considered suitable for the purpose of our thesis. Since the abductive research approach seeks to explore a phenomenon, this fits well with an exploratory design.

4.3 Research Method

Based on our research question, we chose a qualitative research method for data collection to gain deeper insights into the research topic. Qualitative method is applicable where non-numerical data is used, thus often combined with exploratory design to develop new and better understandings of the topic (Saunders, Lewis, & Thornhill, 2019). As our research question is comprehensive, and the industry of research is complex, a qualitative method contributed to a holistic perspective of digital platform ecosystems and circularity by including numerous actors in the construction industry. By using this method, we were able to collect personal reflections from different informants across the construction industry value chain. Through the informants' subjective concerns, we gathered the insights necessary to answer our research question.

4.4 Research Strategy

Research strategy is the specific plan on how to collect necessary data to answer our research question. We decided to do a case study, which according to Saunders et al. (2019) is the most common strategy for qualitative data collection. A case study explores an event or phenomenon in its natural context (Saunders, Lewis, & Thornhill, 2019). Because we wanted to investigate the phenomenon of circular economy and digital platforms in a construction industry value chain context, we chose a study where we study the specific case of the construction industry. Considering the limited timeframe of one semester and the scope of the thesis, the case study can be characterized as a cross-sectional study with interviews (Saunders, Lewis, & Thornhill, 2019). However, as the advent of digitalization leads to rapid changes in the surroundings and the conditions under which the companies operate, it could also be interesting to carry out a longitudinal study to investigate the development over time.

Nonetheless, case studies have its weaknesses that should be taken into consideration. Yin (2014) points out that when using this research strategy, the researchers must be aware of the affect the researchers' prejudices and understandings can have on the results. In addition, Yin (2014) mentions that researchers can be inaccurate, not following systematic method procedures and allow ambiguous evidence to influence the direction of the findings. Therefore, it was important to us as researchers to establish good routines when conducting interviews and in the data analysis. Despite the addressed weaknesses, we believe a case study will provide the detailed understanding necessary to develop new insights of the chosen topic.

4.5 Data Collection

Based on our choice of qualitative research methodology, we chose to conduct in-depth interviews, more specifically semi-structured interviews, to collect data. Interviews are generally suitable for an exploratory research design as it will be an opportunity for the interviewer to explore points of interests, clarify complexity, and confirm meanings (Saunders, Lewis, & Thornhill, 2019). We chose this way to collect data, as it facilitates for an open conversation following the responses from our informants. To establish certain frames for the interview, without limiting the conversations, we prepared an interview guide with a list of predetermined themes we wanted cover, and some key questions accordingly. Thus, semi-structured interviews were considered suitable for our research as we wanted to explore new theories, as well as clarifying existing literature on circularity and digital platforms in the construction industry.

4.5.1 Informant Selection

Due to a limited timeframe for the research, and a lengthy and complex industry value chain, we found it appropriate to interview 2-3 informants from each part of the value chain, including clients, architects, consultants, and contractors. According to Saunders et al. (2019), five in-depth interviews are considered to be the minimum sample size, which our sample of eight informants in total supports. Qualitative research is not necessarily intended to generalize from a representative sample, but rather achieve an in-depth understanding (Saunders, Lewis, & Thornhill, 2019). Thus, our informants were selected with an emphasis on propriety rather than representativeness. Further, we used a strategic selection meaning that we first defined a target group before we selected individuals to interview. Our target group covered employees in companies operating in the construction industry value chain, and informants with experience from projects with a circular or digital focus. Through strategic selection we ensured maximum exploration of the different actors in the construction value chain with diverse perspectives on our research topic (Saunders, Lewis, & Thornhill, 2019).

Additionally, we found it relevant to apply the "snowball-method" to find an appropriate sample of informants (Saunders, Lewis, & Thornhill, 2019). This method builds on the analogy that the informant sample is initially small, before it gradually expands as a rolling snowball. Hence, we identified informants by contacting people with relevant experience and knowledge within the field of our research question. Applying the snowball method, our first three interview informants were able to refer to other interesting informants, both within and outside their own company. However, this method can reduce the variation in the sample, as the informants will mainly consist of people from the same network (Saunders, Lewis, & Thornhill, 2019). To ensure our sample portrayed diverse perspectives, we deliberately contacted actors within different companies and phases of the construction industry value chain, both large and medium sized companies.

Moreover, we formulated anonymous labels for each individual informant, in compliance with guidelines from Norwegian Center for Research Data (NSD, 2022). These labels were based on the informants' job position in the value chain as well as the size of the informants' company.

4.5.2 Interview Guide

In preparation for the semi-structured interviews, we drafted interview guides according to the principles of Saunders et al. (2019), taking a broad-to-specific approach. This approach suggests starting with broad questions before narrowing the questions down to uncover specific insights. Hence, specific questions were used as follow up questions to extract desired information on the informants' opinions on aspect of the phenomenon we were researching. Moreover, by starting with open ended questions the probability of research bias from leading questions, was reduced as the questions were assessed freely by the informants before interference from the researchers. Thus, we weighted open-ended questions that started with "what", "why" and, "how". Furthermore, we used the conceptualizations of the circular economy and digital platform ecosystems, and insights gathered from industry research, as a basis for the interview questions to link the questions to our research topic. Hence, the purpose of the interview guide was to partly shape the focus and create a degree of structure to the interviews to avoid confusion and lack of sense of meaning to the interview (Saunders, Lewis, & Thornhill, 2019).

An essential prerequisite for a successful in-depth interview is to create a relaxed atmosphere where the informants feel comfortable with sharing their subjective experiences and opinions (Tjora, 2021). To facilitate such an atmosphere, Tjora (2021) describes three essential sections of question for an interview, 1) warm-up questions, 2) reflection questions, and 3) round-up questions. These three sections are considered important to create a safe and comfortable atmosphere where the informant can express him-/herself truly. In addition to starting every interview with warm-up questions, we sent a simplified interview guide to each informant prior to the interview, to prepare and make sure the informant was comfortable with the topics we wanted to discuss. By giving the informants the opportunity to prepare for the questions, we facilitated both a comfortable setting and predictability during the interview for both parties. Predictability and preparedness are considered to promote validity and reliability (Saunders, Lewis, & Thornhill, 2019), which will be discussed in a later chapter in this section. The interview guides can be found in Appendix E.

4.5.3 Conducting Interviews

We conducted a total of eight interviews, with informants from eight different medium- and large size companies working in the construction industry value chain. Each interview had a duration varying from 45 – 70 minutes. Prior to the interviews, we agreed that one of us would lead the interviews to ensure that the questions from the interview guide was followed, while the other took notes and supplemented with follow-up questions. In the beginning of each interview, in accordance with the recommendation of Tjora (2021), we had a short informal conversation with the interview objects to build up our credibility and ensure that the technical aspects were in place. We then made sure that the objects had read and agreed to the content of the consent form and asked the permission to record the interview for transcription. The recordings were stored in Microsoft Teams, where the respondents themselves also had access.

The interviews were held in two phases: An introductory and a specific phase. The interviews in the first phase aimed to uncover overarching insights on the research topic. In this phase we conducted three interviews where we used the same interview guide with some small adaptions. During the first three interviews we uncovered some points that we considered to be especially interesting. We therefore made the decision to narrow our interview guide and proceed with the specific phase to gain knowledge directly connected to our research question. The second phase interviews were characterized by the fact that we had gathered great knowledge of the circumstances in the industry from the first three interviews. However, we found it important to keep the questions open to maintain flexibility and prevent losing important information from the different actors' perspectives. An overview of the informants and their description is presented in Table 3.

Table 3: Informant Description

Informants	**Description in the text**
Informant from large private real estate company	Client 1
Informant from large public real estate company	Client 2
Informant from large private consultancy company	Consultant 1
Informants from medium private consultancy company	Consultant 2
	Consultant 3
	Consultant 4
Informant from medium private architecture company	Architect 1
Informant from large private contractor company	Contractor 1

4.6 Data Analysis

After the data collection, we continued with the analytical procedure to structure and interpret the data according to the discussed topics (Saunders, Lewis, & Thornhill, 2019). In this process, the raw data is transformed into concepts or theories. Hence, we deliberately systemized and reduced the data collected from the interviews to optimize our data structure for further analysis, without losing important information (Tjora, 2021). The rest of this chapter will explain these processes, as well as evaluate the quality of the research and the ethical considerations we have taken.

4.6.1 Transcription

The first stage of our data analysis was the data preparation. This included transcribing the audio recordings of the interviews in their entirety, including both verbal and non-verbal communication such as laughter, hesitation, and other gestures. We found this to be especially important because we were using an abductive research approach (Tjora, 2021). The transcription process was time-consuming, and since we wanted to have the interview fresh in memory when transcribing, we set a deadline of two days to finalize the transcriptions. Transferring oral language to written language is challenging, as incorrect punctuation can change the meaning of an entire sentence. To avoid confusion, we were careful with punctuations and unfamiliar words, and discussed these together when unsure of its meaning. Moreover, to make sure that our interpretations of the interviews were aligned, we discussed the interview's key message before starting the transcription process. Additionally, we intentionally made sure both researchers were involved in the transcription process to ensure correct transcriptions and understanding of the topic (Saunders, Lewis, & Thornhill, 2019).

4.6.2 Coding

After the interviews were transcribed, we continued with coding to make sense of the large amount of data gathered. Coding is an analysis method used to categorize data with similar connotation by labeling every data unit with a code, meaning words, or phrases that describes a section of text (Saunders, Lewis, & Thornhill, 2019; Tjora, 2021). In our case the data units were quotes with varying lengths extracted from the conducted interviews. We decided to code every quote from the informants, except practical information or informal conversation in the opening questions to get exhaustive information and explore every possible meaning of the data to direct our research (Saunders, Lewis, & Thornhill, 2019).

We decided to analyze our data based on a coding method introduced by Gioia et al. (2012) that structure the data in first-order, second-order, and overarching concepts, respectively. The first-order codes represent the raw data material grouped by similarities. These are further processed into second-order codes centralizing the text sections into general themes. Finally, the topics are aggregated into overarching concepts representing the key contents of the data material. We coded each interview according to the Gioia method to identify the specific context and the forces for circularity and digital platforms, to provide a structured understanding of the findings. When developing the first-order codes we used color labeling to identify corresponding segments in each of the eight transcriptions. In the second-order codes we combined secondary literature to the primary first-order codes and structured these into more abstract themes. Applying both primary and secondary data in tandem, the Gioia coding seems appropriate in an abductive research approach to allow a more iterative analysis process. As a last step, we organized the second-order codes into even more abstract "overarching concepts", portraying the main themes of the data collection. The derived overarching concepts can be found in table 4.

Table 4: Derived Overarching Concepts

Overarching Concepts
Regulations
Collaboration
Digital Integration
Circular Infrastructure
Competence Development

A visual representation of the Gioia coding process can be found in Appendix C, which illustrates how our data analysis transformed raw data to overarching themes. This can be used to understand the origin of the overarching concepts elaborated in the findings in chapter 5. Moreover, the Gioia coding formed the basis for our theoretical understanding of the data material that enabled us to make data-to-theory connections in the discussion chapter.

4.7 Research Quality

In this section the quality of the research will be assessed based on the strengths and weaknesses of the methods used in the study. There are many different perspectives on how to measure research quality in the literature, which makes it important to choose the methods that are most suited to the characteristics of the study. According to Saunders et al. (2019), research quality is most often determined by measuring the validity and reliability of the study. Validity is measured in three dimensions, internal, external and construct validity, and reflects whether the study shows a causal relationship, the results can be generalized, and whether the study measure the intended variables. Reliability, however, measure to what extent the outcome of the study would be replicable if conducted by a different researcher (Saunders, Lewis, & Thornhill, 2019). Although some scholars argue that validity and reliability can be used both in quantitative and qualitative research (Johannessen, Christoffersen, & Tufte, 2011; Yin, 2014), an avenue of researchers claim that the standardized criteria are unhelpful in qualitative studies. Altheide & Johnson (2011) explains that since qualitive research is conducted in a different research paradigm, it complicates quality measurement with traditional methods.

In the 1980s, Lincoln and Guba developed what has become one of the most applied methods to measure qualitative research quality. Based on the four criteria credibility, dependability, transferability, and confirmability, they measure the "trustworthiness" of the study to investigate whether the findings can be trusted (Lincoln & Guba, 1985). Although the criteria include many of the same elements as validity and reliability, they are considered more flexible and sensitive to the nature and context qualitative methods (Tracy, 2010). This evaluation will therefore be based the four criteria of Lincoln & Guba (1985).

4.7.1 Credibility

Credibility refers to whether the research findings are convincing and plausible, and reflects the "truth-value" of the findings, and to what extent the researcher has interpreted the data and original views of the participants correctly (Lincoln & Guba, 1985). Thus, credibility assesses the internal validity of qualitative research. *Triangulation* is an important strategy to ensure credibility that involves using different data sources, researchers, and methods for data collection (Sim & Sharp, 1998). In our research we conducted interviews with 1-4 actors with experience from each part the construction industry's value chain to obtain diverse perspectives and increase the likelihood that our data represent the truth. We also made sure to interview both large and medium-sized actors to avoid systematic biases in our sample. However, as small companies were not within the scope of our thesis, some degree of bias might present. Since the topic of digital platform ecosystems in the construction industry is quite new, we intentionally selected informants with either high strategic positions or specialized knowledge within digitalization or sustainability to mitigate the risk of receiving insubstantial information.

Moreover, as we chose informants from different companies, we avoid that our data favored the view of a specific company or a part of the value chain. A weakness is that respondents were chosen based on our own judgement and knowledge of the topic, risking a selection bias in the sample. As our competence on the Norwegian construction industry improved throughout the study, other actors might have been chosen if the interviews were conducted later in the process. However, this risk was mitigated with extensive research on the industry prior to the interviews. All interviews and analyses were conducted by two researchers which increases the credibility that the data has been interpreted correctly. Furthermore, unambiguousness in the data material was discussed before drawing conclusions.

Another strategy we used to increase credibility was to send the quotes from the interviews and the findings back to the informants for clarification, also known as *member check* (Lincoln & Guba, 1985). However, as the nature of our interviews were open, we were able to clarify most unclarities during the interviews. Additionally, before conducting the interviews, we thoroughly examined relevant literature on the topic and characteristics of the industry to support the search for explanations (Guba, 1981).

4.7.2 Dependability

Dependability addresses the aspect of consistency in the analysis and interpretation throughout the study (Korstjens & Moser, 2018) and consider the extent to which the research is replicable in similar conditions (Stenfors, Kajamaa, & Bennett, 2020). Thus, dependability represents the reliability measure used in quantitative studies. All decisions regarding data collection and interpretation are carefully explained throughout this thesis, which enables the reader to examine the processes and consistency of the thesis through an *audit trail* (Guba, 1981). For quantitative studies, data of high dependability will be consistent and replicable (Saunders, Lewis, & Thornhill, 2019), however replicability is not a goal when conducting qualitative research. To strengthen consistency, we provided a detailed description of the case, context, and research process to each informant prior to the interview (Johannessen, Christoffersen, & Tufte, 2011). In addition, we used an interview guide to facilitate consistency in the interview, to the extent possible in qualitative research methods. Feedback from our supervisor and the DIG program further ensured that our interviews and theoretical interpretations were consistent with qualitative research.

4.7.3 Transferability

Transferability in qualitative research considers whether the results of a research projects can be transferred to similar contexts and settings with different informants (Lincoln & Guba, 1985), representing the study's external validity. This requires the researchers to withdraw data from their natural setting to apply it on a new phenomenon (Johannessen, Christoffersen, & Tufte, 2011). Guba (1981) argues qualitative studies are not intended to be representative and fully transferrable but seek to describe and uncover a topic in detail. By selecting a wide range of informants from different firms and parts of the value chain, we maximized the range and representativeness of information within the topic.

The exploratory nature of the study entails that the outcome is unknown, unique, and tied to the specific context, thus not easily be transferred to other contexts. However, the abductive approach assist transferability as the data collection is closely linked to existing literature and the contextual background. This enables the reader to compare the different settings and evaluate the findings considering a new context.

4.7.4 Confirmability

Confirmability refers to the extent of which the results from the qualitative research can be confirmed by other researchers in related studies (Johannessen, Christoffersen, & Tufte, 2011). This implies that the study should contribute within the field of study without being affected by the researchers' subjective opinions. To maintain objectivity, we ensured a well-planned research process in data collection, interviews and analyses that has been thoroughly described in this section. The transparency will assist scholars for repetition in future studies.

4.8 Ethical Concerns

Ethical considerations in research reflect the appropriate behavior of the researcher towards those who are involved in the study (Saunders, Lewis, & Thornhill, 2019). Maintaining a high ethical standard is particularly important when conducting a qualitative study that involves human participants. Since our study involves several people, and some from competing firms, ethical standards were a top priority throughout the whole study.

In doing so we were careful to enforce anonymity and handle data and personal according to guidelines from Norwegian Centre for Research Data (NSD). Prior to all interviews we provided detailed information about the study to inform the informants on what they were part in and what we expected of them. In addition, we created a consent form where the informants agreed to the terms of the interview and how their contributions would be handled in the study. All informants confirmed the terms either by writing or orally prior to all interviews. As the data collection could include sensitive information about participants or the businesses, all data was secured on password protected devices, and recordings were deleted immediately after transcription to reduce the number of data sources. In this way the data was only available to us and existed no longer than necessary.

5. Findings and Analysis

This chapter presents the findings of our study, structured in two sections. Firstly, we will elaborate on the overarching concepts that influences the construction value chain in the context of circularity. The concepts are consistent with the structure identified in the data analysis; regulations, collaboration, digital integration, circular infrastructure, and competence development, and will lay the foundation to answer our research question in the discussion in chapter 6. Secondly, we will present the fundamental attributes that need to be present in a digital platform ecosystem to offer an opportunity for circularity in the industry. An overview of our findings can be found in Table 5.

Table 5: Overarching Concepts and Main Findings

Overarching Concepts	**Main Findings**
Regulations	- Regulations are necessary to push actors to implement circular initiatives - The current regulations are outdated and not created for circularity
Collaboration	- Silo thinking and rigid frames for the actors' area of responsibility in projects - Circularity requires new and expanded collaboration - The current use of digital platforms is mostly project specific
Digital Integration	- Lack of standardized documentation prevents data integration - Lack of process coordination create inefficient searches for used materials - Lack of data sharing prevents time-matching of transactions in reuse - Need for integration of environmental elements on existing digital platforms
Circular Marketplace	- Isolated digital platforms prevent digital circular infrastructure - Limited facilities for storing materials restricts the market for reused materials
Competence Development	- Lack of competence prevents the exploration of alternative use for materials - Rapid development in circularity makes it difficult for actors to stay up to date - Traditional industry that is unwilling to change

5.1 Regulations Stimulating the Circular Development Rather than Preventing it

Our findings reveal that regulations and regulatory requirements are slowly emerging as sustainability is gaining a foothold in the industry. With national and international requirements for reuse, the industry actors can increasingly be held accountable for their climate impact. For instance, Consultant 1 explains how regulations push the market towards circularity by imposing requirements for the reuse of materials.

> *"I would say that it is mainly regulatory requirements that drive circularity. It has now come in the revised TEK17 that there is a requirement for reuse mapping (...). In addition, in 2023, there will be new regulations on the circular economy. That will push the market."* Consultant 1

5.1.1 Current Regulations are Weak and Outdated

Although regulatory requirements are found to be a source of motivation for implementing circularity, informants also express how regulations can constitute a significant challenge. A problem regarding the Norwegian construction regulations is that they appear too weak and backward to support circularity, as they are struggling to stay up to date with the rapid development of circularity. The informants portray numerous examples of regulations that aim to motivate circularity, yet they have limited impact. For instance, there is a regulatory requirement for carbon accounting, though no cap on emissions. Another example is the requirement to design for disassembly without a precise definition of what this includes and how it should be measured.

The informants argue that the governmental requirement of “reuse mapping” has a large potential to facilitate reuse in the industry. Reuse mapping is derived from the Norwegian concept "ombrukskartlegging" and is a system used to identify reusable building components in existing buildings. The requirement to systematically explore a building’s potential for reuse imposes actors to assess the question of reuse in all demolition projects. However, there is currently no obligation for actors to use, nor upload the information from the reuse mapping, to make it available for other actors to use. Moreover, there are no requirements for competence to perform the mapping. Consultants express that the lack of mandatory uploading and competence limits the quality of the mapping and the incentives to share its results, reducing its potential to facilitate reuse.

> *"Yes, they have a requirement for reuse mapping, but there's no requirement for competence, and there's no requirement that the findings of it - that you have to do anything. "Great, get a piece of paper in this format and you've done your job." At minimum, provide an Excel template that has to be uploaded to a public database."* Consultant 4

A second regulation that incentivizes circularity is the BREEAM certification that classifies a building's level of circularity from "pass" to "outstanding". According to the informants, the certification has increased awareness and demand for circular and sustainable buildings among customers and tenants. Moreover, the BREEAM system is frequently used by actors to obtain additional financing for sustainable building projects. However, the informants express that including BREEAM certifications in building projects are time-consuming as the necessary data collection, measurements and calculations are isolated from the main project platform. Due to the inconvenience, the certification is mainly applied in larger projects and projects with particular ambitions for circularity.

5.1.2 Current Regulations are not Created for Circularity

The relevance of regulations has also proven to be a central challenge for circularity in today's construction practice, as current regulations are often created, not bearing in mind circularity. For instance, most regulations are made to assure the safety of the construction. Informants express that regulations that prioritize safety often require the use of new materials, even though using reused materials could be just as safe. As a result, the regulations sometimes end up restricting reuse instead of facilitating it.

5.2 Collaboration on Digital Project Platforms Rather than in Private Silos

Our findings also describe a complex and fragmented construction value chain where each actor contributes with specialized knowledge to assist specific parts of the building process. Currently, there are rigid frames for each actor's area of responsibility, which restricts collaboration across the different actors and results in silo thinking during the construction process. The interviews portray that the contradiction between the required specialization and the need for collaboration makes it challenging to implement circularity in the industry today.

> *(...) especially regarding the circular economy, we are not talking about individual actors fixing this alone. There is an entire value chain, or perhaps even a new value chain to be created or transformed.* Consultant 3

On an overarching level, the interviews portray that implementing circularity requires more industry collaboration between actors and across projects. To uncover which types of collaboration already exists and which partnerships are still desired, we will elaborate on the specific actors' current use of digital platforms and their role in the contribution towards circularity in the industry value chain. Table 6 provides an overview of how the different value chain actors collaborate on digital platforms and implement circularity in the industry.

Table 6: Summary of Findings on Collaboration for Circularity

	Collaboration on Digital Platforms	**Contribution to Circularity**	**Collaboration for Circularity**
Clients	Oversee project status on platforms for projection based on requirements created in collaboration with consultants	Authority to set requirements for reuse and recycling in projecting and operation Incentives to choose high-quality materials due to ownership	Setting circular requirements require collaboration with consultants Reuse requires collaboration with industry actors to increase material availability
Consultants	Collaborate with architects and contractors in the BIM model Use separate environmental platforms to analyze and assess regulatory requirements	Broad knowledge and skill in environmental certifications, climate calculations, reuse mapping and design	Numerous initiatives which require collaboration with actors in all phases
Architects	Draw the building design in the BIM model in cooperation with consultants	Considerable influence through designs with reuse and designs for disassembly Assist with creativity in reuse mapping	Design with reuse and disassembly require collaboration with consultants and contractors Assisting in reuse mapping require collaboration with consultants

Contractors	Use the BIM model as a building manual	Strive for material minimization for cost purposes Assist with material feasibility in reuse mapping	Assisting in reuse mapping require collaboration with consultants

5.2.1 Project Collaboration on Digital Platforms Today

The interviews portray that digital platforms are frequently used for collaboration between different project actors to ensure they are aligned and work towards the same goals. One of the most comprehensive platforms is the Building Information Modeling (BIM), which is a digital representation of the construction based on contributions from consultants, architects, and different kinds of contractors. Each project actor continuously inserts their project work to share material information and project progress necessary for other actors to perform their tasks. In this way, the BIM model works as a coordination tool that enables collaboration and alignment of distinct project activities.

> *"…having such a platform [BIM] in such a large project is necessary. If we hadn't used the BIM model in this project, we would have… well, I cannot imagine how much longer it would have taken. Because it is so complex, using a BIM is crucial for us to coordinate."* Consultant 3

In addition, separate platforms exist to coordinate the economic situation of the project between the client and the consultants, and to ensure that the building is built within environmental regulations and requirements.

The clients are essential actors on every platform related to projection to oversee important decisions and ensure the progress of the construction. The BIM model is therefore an essential tool for the clients to stay updated on progress and the work of the project actors. The clients also collaborate closely with consultants in the planning and projecting phase to set premises for the project, perform financial analyses and create the overall project plan.

The consultants, on the other hand, are hired with unique competencies to advise the other actors in project decisions to increase the value of the delivery. Their tasks include assisting the client in setting the premises in a project's early phases, discussing design solutions with architects in the BIM model, and consulting the contractors on how to minimize costs in the building process. However, due to their specific expertise, the environmental consultants are usually not integrated with the leading project platform, restricting the environmental influence on other actors' activities.

The architects are the creative driver of the projection phase and draw the design of the construction. Their design is implemented into the BIM model in a 3D format and shared with actors to use in later phases. Thus, the BIM model is also used to ensure that the building design meets the ambitions and requirements of quality, costs and materials set by the client.

Since the contractors' main task is to physically construct the projected building, they depend on detailed descriptions of the building. The BIM model provides information about all the building elements in a construction, securing the workflow for contractors by providing a manual for guiding the building process. Throughout the construction the contractors update the BIM according to their progress and minor adjustments to the projected building are calculated into the model.

5.2.2 Collaboration for Circularity

The interviews depict that the implementation of circularity in construction projects increases project complexity. As distinct value chain actors provide different contributions for circularity, circular construction projects require closer and more iterative collaboration across actors and projects. In the following section, we will briefly summarize the different construction industry actors' contributions to circularity today.

The Clients Role as the Circular Decision-Making Authority

The clients significantly influence the level of circularity since they set the overarching requirements for the project and are involved in critical decisions during the construction process. The interviews clearly express that, in most projects, circular initiatives will not be implemented without a special requirement from the client. Further, setting requirements for reuse in the early phase of the project organization will significantly affect the construction's circularity. Thus, the implementation of circularity depends on the client's overarching requirements in the building's projection. The informants underline that circular requirements must be set in close collaboration with consultants with special environmental expertise.

According to the clients, there are two reasons why requirements for circularity are challenging to implement today. Firstly, when setting requirements that are difficult for project actors to realize, the likelihood of poor project performance increases. As a result, clients are hesitant to implement absolute requirements for reuse in their projects as the high uncertainty related to the availability of used materials still carries a significant risk of cost blowouts. The clients explain that they work with reuse in a long-term perspective with the intention to make materials available to be used in constructions in the future.

> *"So, we would have liked to require reuse in our constructions, but we have to get hold of the used materials first. So, I think the used building materials must be made available on the market so there can be some predictability in getting hold of the building materials." Client 1*

Secondly, the clients express that the lack of standardized measurements for circularity makes it difficult to set precise and appropriate requirements. According to the informants, current circular measurements are too general to guide decision-making in later phases of the construction project. For instance, with abstract requirements, it becomes difficult for the consultant and architects to plan the building to meet the set requirements. Hence, more precise measurements to support requirements needs to be developed in collaboration with all industry actors to implement perspectives on reuse buildability, reuse design and reuse climate impact in the measurements.

Without efficient requirements for circularity, few projects prioritize circular initiatives in projects today. In the few projects where reuse is implemented, used materials are located from the clients' own projects or from sporadic, network-based arrangements with other clients because there are no processes to coordinate reuse, and material searches are conducted manually. Client 1 argues that digital platforms that assemble data on reused materials will be an important tool to assist the manual material searches:

> *"I think digital platforms will be central for circularity. We are testing out some of those platforms now, and I think a marketplace for the sale of used building materials must be an important key in achieving this [circularity].* Client 1

Due to the lack of industry collaboration for sharing reused materials, reuse is mainly conducted in renovation projects today. In this way, the materials that are available for reuse are already present on the property, which removes the need for collaboration for material searches. As many clients often operate buildings and rent out space to different tenants, there is also considerable potential for reuse when renovating spaces according to tenants' individual requests.

> *"So, we work quite a lot with circular solutions both in our projects that we have now, but also in the administration. Because what happens with our buildings is that we have a tenant who has a lease for ten years. When they move out after ten years, a new tenant will come in, and they may want a completely different expression on the floor. They may want lots of meeting rooms where there were no meeting rooms before, so they require new adaptations. So, working with reuse in that phase is really interesting, to try to minimize waste from the tenant's adaptations."* Client 2

The Importance of Environmental Consultants to Unite Action for Circularity

Environmental consultants greatly influence the circularity of projects through their role as advisor and their knowledge and skills on circular initiatives. Their tasks span across all phases of a construction project and they are increasingly included in core decisions at all stages.

> *"So, it is the projects that we are involved in, they have a huge, huge, potential for circularity. So that's where we can contribute, not in terms of what we as a company can do, but what we can do in the projects."* Consultant 1

Especially important is the consultants' responsibility to link the architects and contractors to the client's demand for circularity and consult the different actors on how to fulfil the client's goals for circularity. At the same time, the consultants assist in ensuring circular development in the other parts of the value chain. By using and developing their specific knowledge on circular solutions, reuse mapping, and requirements, the consultants contribute to the implementation of circular initiatives such as reuse, material minimization and design for disassembly in cooperation with the architects and contractors. They also facilitate clients to conduct more environmental projects by collecting data for environmental certifications and conducting carbon accounting on clients' requests. However, even though the environmental perspectives have become of more interest to clients and customers, many environmental sources of information and calculations are still isolated from the main project platform and the BIM model.

"Firstly, we have people who can do all the mapping by seeing what a building consists of, what a project consists of, what an urban space consists of, and thus contribute to building up the knowledge of the values we already possess. Then we can use that knowledge of what is out there when building something new or when a change is planned somewhere. Then it [existing materials] can be included as new resources in a new project. If a project does not use reused materials, we can make sure to design and plan a building so that it is actually demountable and can be included in a cycle afterwards. There are actually quite a few roles we can play in this." Consultant 3

Furthermore, the consultants highlight the need for collaboration across the value chain in reuse mapping to understand the full potential of used materials.

"(...) and a reuse group where you have got somebody from architecture, landscape architecture etc. And it is their job to keep up to date on what's going on in their field and spread that to their group. Then when I'm out doing reuse mapping, they've made a checklist of "this is what you look at in a ventilation canal etc.". Because it takes a team of people to build a building, and it takes a team of people to know what can be used again." Consultant 4

The Architects Role as Designers for Circularity

Several informants point out that the architects have a significant potential to facilitate circularity by including reused materials in their design. However, designing with reuse is an iterative and time-consuming process, due to ambiguity of which materials are available and at what time. The designs must therefore be flexible and adaptable according to changes in material availability, often referred to as "loose fit designs". This way, the designs can easily be reprojected when used materials become available. The iterative design processes require close collaboration with consultants and contractors to help identify the used materials and map their quality and features.

"Because in a standard design process, you can say, "I would like windows of this size", and the windows will show up on-site on time. Whereas this[reuse] is much more iterative, like: "OK, well, I would like windows on this side, what do we have available for windows? OK, I can design the facade to work with that. Do those meet all requirements? OK, not quite - start again"." Consultant 4

Architects can also contribute by creating "designs for disassembly" to make it easier to reuse materials in the future. Multiple informants portray the importance of designing more modular buildings that consist of materials with more predictable sizes and assembling methods. Modular buildings will make it less time-consuming to demount materials in the future and make reuse from existing building stock more predictable.

The possible third contribution the architects provide to circularity is applying their creative ideas to convince other value chain actors of reuse. For instance, the consultants request creative solutions for alternative purposes for existing materials in reuse mapping.

> *"(...) the architects, they're quite a creative bunch, and I think we should involve them more in like our reuse mapping and such. Because I'm an engineer, we go: "Yes, this beam can be used as a beam again", or "no it cannot be used as a beam again". But an architect can look at it and say: "Oh, but maybe we could use it as like an outdoor installation"."* Consultant 4

In this way, the architects can take a more proactive role and use their designs and creativity to share examples of what the reuse of materials can look like in projects. Thus, portray the residual value of materials that other actors would not have discovered. The architects' advice can help convince clients to take the leap and implement more reuse in projects and show consultants and contractors how it can be done.

> *"(...) we try to convince about reuse in itself. We see the quality in building materials that already exist and try to put them in a new context in order to preserve them. (...) Also, seeing residual value in materials, because not all materials are perfect, but perhaps you can use them for a while longer?"* Architect 1

The Importance of Contractors to Enable Circular Construction

The contractors' most significant contribution to circularity is minimizing material use and identifying the feasibility of reusing materials in projects. As the contractors are the ones who constructs buildings to the clients for a fixed price, they are interested in reducing material consumption to cut costs. Therefore, optimizing the use of materials, such as concrete, will significantly impact costs and the overall resource consumption in the industry.

> *"Everyone who works in a general contractor has an interest in minimizing the use of products. This is because we have given a fixed price, and then it is up to those who*

give a fixed price to reduce the size of elements and the size of products we use inside the building to save money. But it [material minimization] also affects the environment, so things go hand in hand. The big thing for us is, of course concrete, and it makes up 80% of a building. And the fact that we manage to optimize the use of, and the size and quantity of concrete is what makes the big difference, and that is what we spend a lot of time on" Contractor 1

The contractors also play an essential role in identifying the buildability and feasibility of reused materials. Multiple informants state the importance of involving contractors earlier in the projection to provide knowledge on the physical dimension of reusing materials when the consultants are searching for materials and when the architects are designing the building.

"Yes, what we see as extremely useful is to involve architects, technical subjects, and contractors, those who will carry it [the construction] out. Because the architect may well say, "oh, we want to reuse it; it was nice". They can say that because they are interested and think conversion is fun and have received that requirement from the client. But it is important that you have contractors with you who say something about it, because they are the ones who will do it. So, the architects can say as much nonsense as they want, with as many suggestions as they want, but if you don't get the contractors who actually walk on the construction site and put this ceiling back up, which is not standard or anything like that, you will never know the buildability" Consultant 2

"Reuse requires expertise in the construction itself, i.e., craftsmanship. Craftsmanship is needed differently than it has been in recent years. Because until now, it has been very much like copy-paste because you use new materials, and they are always the same, but with reuse, the materials are not standard, so you have to think new in each case." Client 2

The contractors' practical experience and knowledge about different materials are therefore crucial when projecting with reused materials. In collaboration with environmental consultants, the contractors can use their experience to identify the additional costs and time related to the implementation of unstandardized and used materials in constructions. The need for collaboration to facilitate the circular development in the industry is portrayed in in Figure

3. The Figure illustrates in which project phases the different circular initiatives transpire, and with whom the industry actors need to collaborate to enhance the potential for circularity.

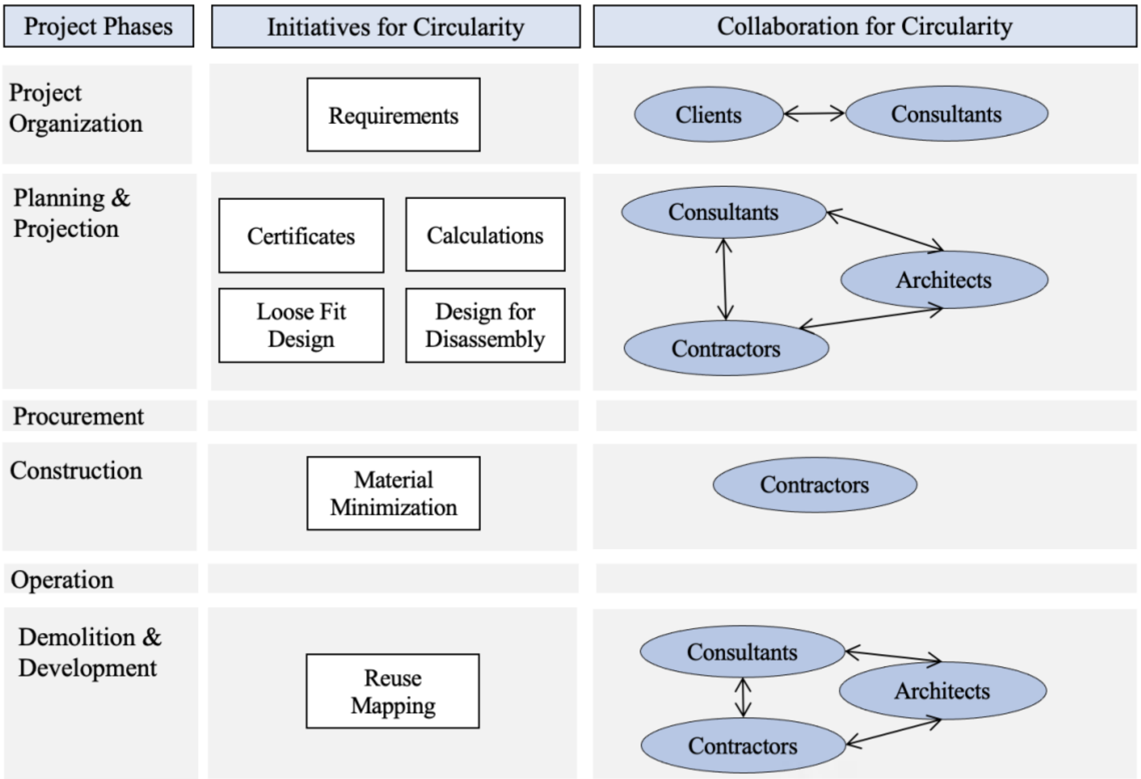

Figure 3: Collaboration for Circularity in the Project and the Value Chain

Our findings suggest that some industry actors and project phases are more involved in the implementation of circular initiatives in projects, indicating their relative importance for the circular development of the industry. Firstly, Figure 3 illustrates that most of the circular initiatives are located in the planning and projection phase of construction projects, implying that this phase has the largest influence on circularity. Secondly, the consultants and contractors are identified as the most crucial actors for circularity due to their frequent involvement in circular initiatives throughout construction projects. Furthermore, many of the initiatives require iterative collaboration between several industry actors, indicating that the actors in general needs to be even more involved throughout the construction process. For instance, reuse mapping in the demolition phase needs to be a collaborative process between consultants, architects, and contractors to maximize the potential of the existing building stock. Moreover, the architects depend on the assessed reuse mapping and mapping of material feasibility to create designs for circularity. Thus, the architects need to collaborate closer with consultants and contractors to make design decisions that supports reuse.

5.3 Industry-Wide Digital Integration Rather than Locked Data Systems

Our informants explain that the current low degree of digitalization across the industry prevents actors from accelerating circularity. To enable the iterative process of reusing materials, detailed information in material passes, including material dimensions and qualities, must flow between different tasks, data systems and actors in the industry value chain. However, the informants express that actors currently document the reuse mapping in different data formats, preventing information sharing in the industry. Seamless digital integration will facilitate the transfer of material documentation and will be instrumental in enabling an efficient reuse process both within projects, and in the industry. Accordingly, Consultant 4 argues that material data is of no value unless it is shared and available for those who need it.

> *"And then other people could have access to that information, because now that is still quite a barrier, trying to figure out how… What is good is this information if nobody can find it?"* Consultant 4

However, standardized documentation is presently difficult to obtain because older buildings are not well documented and existing documentation is unstructured and inconsistent. Many of the buildings that exist today were built at a time with fewer requirements for material documentation. As a result, most older buildings do not meet the material requirements of the industry today, which causes several problems in the effort to apply circular initiatives. Firstly, multiple informants argue that materials without an identity might as well be considered waste, as the uncertainty regarding the materials' quality restricts the opportunity for reuse. With no guarantee of the material quality, the actors are often forced to demolish because they are not willing to take the risk of using low quality materials in their constructions. Secondly, limited regulatory requirements and legislation of used materials further complicate the task. Thus, to reuse materials, actors must often collect additional documentation on the materials, described by the informants as both time-consuming and costly, since the quality of the materials needs to be tested in detail.

> *"(…) you have to test the materials, take samples of them to check what it is. But even then, you can't really know. If you have an outer wall, you must open the wall to see what's in there. So, it is much more demanding than a new building because then all*

the suppliers always attach documentation, and everything is digital and searchable." Client 2

In the fragmented construction industry, the necessary cooperation is seemingly harder to achieve since different data is owned by different actors and kept in locked data systems. Closed systems prevent reuse as material needs and excess materials are rarely communicated between projects and actors to explore the opportunity for reuse. Moreover, as the lifetime of a construction usually exceeds the actors time in employment, the actors often lack motivation to document beyond requirements as they will not be there during the eventual renovation or demolition. Thus, in the few cases where reuse of materials is explored, the process of locating the materials is currently a non-digital, unstructured communication process driven by word of mouth. The consultants refer to this process as manual material searches where a dedicated person identifies, matches, and redistributes each material.

"(...) it is usually not the same contractors who work on the other buildings. Thus, if you are going to have some reuse, say from one project to another, as of today, there are no good processes and systems for this to go seamlessly. It's real jump and bounce and word of mouth: We have some stuff here, do you want it? You must tell us before 4 pm, otherwise we will throw it away." Consultant 3

In addition to manual material searches, the lack of digital integration creates a barrier to reuse as building projects currently need to match in time to enable reuse from one project to another. If a building is to be demolished and materials are kept for reuse, there needs to be another renovation project ready to receive those same materials within a limited time frame. A complication in this regard is that material requests are often specific regarding the number and size of materials needed, which makes it even more challenging to coordinate reuse.

Essentially, actors need to be encouraged and able to share information on materials and experiences to enhance the prevalence of reuse in the industry. Digital integration will help involve actors in new project phases, thus creating new spaces for information sharing that could facilitate innovation.

"A digital platform connects all the actors, so everyone gets ownership and gets involved in the sustainability part [of the building]." Client 2

5.4 Circular Marketplace for Reuse as Opposed to Manual Material Searches

Our findings portray that the current market for reuse materials is characterized by low volumes, high costs and high uncertainty. The informants explain that even though construction projects are constantly running, the process of acquiring reuse materials is unstructured and network dependent. In addition, there are currently not enough materials available to meet the demands, which makes reuse procurement more expensive than virgin materials. Client 2 describes the market as a vicious cycle that prevents high volumes of reuse materials to emerge:

> *"If there is a very large supply of offers and many people want to use the used building materials, then I think it [reuse instead of waste] will work. (...) It depends on getting a large volume, but how will you get there when there is very little or almost no volume at the moment."* Client 2

The lack of physical infrastructure for reused materials is a second aspect, of the market for reuse materials, that currently creates a barrier to facilitate a circular industry. This is caused by the low turnover rate in trading reused materials which increases the time materials spend in storage, leading to high costs related to storing. Consultant 3 elaborates that the large sizes and varying shapes of building materials make them even more difficult and expensive to store.

> *"You actually have to have a place to store these things. There are things that take up a lot of space, i.e. if you are going to repurpose 100 meters of system wall, then you need large volumes of space to store it, and it is both cost-driving because you could use the area for something else, also it's just hard to get enough space."* Consultant 3

In the same way as the lack of digital integration, the lack of storage restricts reuse to projects that match in time, further reducing material availability and the material turnover rates in the storages. Thus, current storage facilities in the industry are often restricted and company-specific, making it difficult for other actors to locate secondhand materials across the industry.

5.5 Competence Development Rather than Rigidity

Several informants have described a traditional and reluctant construction industry lacking competence in initiating circular solutions in their projects. For instance, many actors do not have the competence to explore alternative uses for materials, nor the time to acquire this competence. Thus, used materials are often either given away for free or paid to have removed because the clients and contractors are not aware of the range of possibilities for reuse. The informants express a need for competence development in the industry and explain that the fast development of circularity makes it hard for the actors to keep up with the current regulations and possibilities. In particular, smaller actors in the industry are struggling to follow the development of circular initiatives.

In addition to the rapid development, the informants describe a rigid industry with little willingness to change current construction processes. For instance, Consultant 1 explains that the industry will continue its usual course without requirements.

> *"Very often, if there is no requirement for it, then you just do the easiest and the cheapest, so to speak. And with reuse this is not always the case. Often one doesn't even investigate the opportunity for reuse. You just do what has been done before."*
> Consultant 1

Hence, a reluctant industry, the rapid development of circularity and lacking competence creates negative attitudes towards reuse, preventing new ways of reuse from emerging within the industry. Competence development must therefore be initiated to accelerate the implementation of the circular economy.

5.6 Multidimensional Digital Platform Ecosystem

Our findings indicate a great potential for implementation of circularity in the construction industry. However, a low degree of coordination, and an immature material market warrant the need for a change in current construction processes. Based on the highlighted inadequacies defined in the overarching concepts, we have inductively derived a multidimensional digital platform ecosystem, illustrated in Figure 4, that serves both as a platform for collaboration and a market platform. The proposed digital platform ecosystem includes three attributes we have identified as fundamental for a digital platform to stimulate circularity in the construction industry.

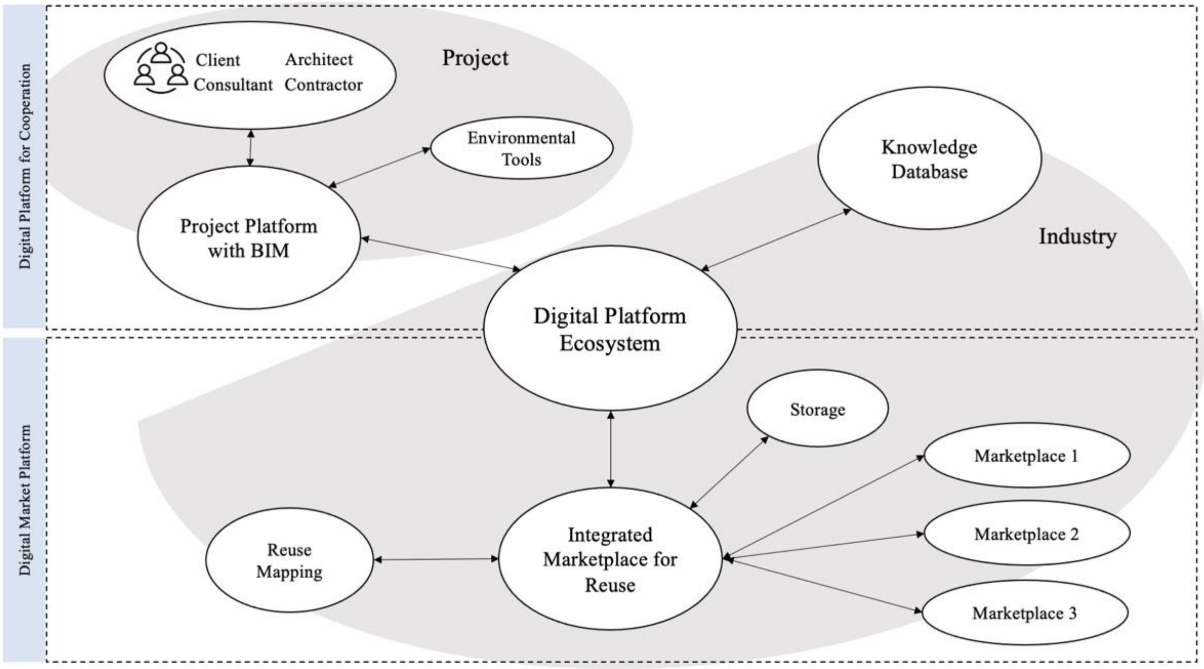

Figure 4: Multidimensional Digital Platform Ecosystem

Overall, the proposed ecosystem consists of a project-specific platform for internal cooperation and an industry-wide platform that enables cooperation across projects and a marketplace for reuse. When asked to consider using a separate digital platform for circularity, our informants expressed resistance to introducing an additional tool, as there are already many platforms for the construction itself. Thus, our informants argue that platform attributes to stimulate circularity should be applied to an already existing platform, such as the BIM. In this way, every actor involved in the construction project can cooperate on circular initiatives in every step of the construction process.

In addition, to facilitate close and iterative collaboration across actors within projects, the digital platform ecosystem can also enable cooperation between actors in the industry. For instance, industry-wide digital integration can serve the purpose of sharing experiences and knowledge, which can result in the migration of best practices in tasks such as material quality examinations and reuse mapping. Information from the industry-wide knowledge database is available to all actors to support decisions and implementation of circular initiatives in projects.

The market dimension of the ecosystem consists of an integrated industry marketplace. Here, information from the reuse mapping and the digital marketplaces are integrated and made available to all industry actors. The integration enables an efficient circular infrastructure, which is especially important in the construction industry where multiple projects are running, and a wide range of actors are involved. Hence, the digital platform ecosystem ensures integration of new processes and environmental tools on the project level, as well as connects actors across different projects to share knowledge and the market for used materials.

To describe the mechanisms constituting the digital platform ecosystem, we will elaborate on three fundamental attributes that compose the desired digital platform ecosystem to support circularity in the industry. The fundamental attributes are *flexibility*, *data accumulation* and *interaction.*

5.6.1 Flexibility

Our findings portray that digital platform ecosystems can support the effort for iterative processes through flexible connections of actors and processes. For instance, projection with reuse often requires continuous redesign depending on the availability and selection of used materials. Thus, connecting actors on a flexible digital platform can facilitate the inclusion of different actors more frequently in different project phases to discuss alternations and develop new solutions for reuse.

> *"We see that when you involve people who have not usually been involved, you get one place where everyone works together. This leads to innovation as professional groups that may not often meet see what the others keep in mind which can give unexpected effects. And the digital platforms help with that "* Consultant 2

Moreover, our informants highlight the importance of including all project actors in the same BIM model to secure workflow in high-complexity construction projects. A digital platform ecosystem can enable the integration of the environmental entities on existing digital platforms and facilitate information exchange between isolated data flows. However, as the market for reuse is still immature, the platform must be adjustable according to changing needs. Hence, a flexible digital platform ecosystem, where entities can be added and adjusted to generate synergies for circularity on the platform, is crucial. Therefore, flexibility can be considered a critical attribute that connects the different actors, currently not cooperating, in an industry where cooperation is necessary to implement circular solutions.

5.6.2 Data Accumulation

A digital platform ecosystem can also accumulate and store information which can scale the availability of reused materials and create a market to make it easier to plan for reuse. The interviews clearly highlight a need for more supportive infrastructure to make it easier and more convenient for actors to choose and implement circular initiatives. Through the accumulation of material passes and reuse mappings, and integration of isolated marketplaces, a digital platform ecosystem can increase the information and material availability by connecting digital and physical infrastructures for reused materials.

> *"But they [the platforms] must talk to each other so that there are not 15 different tools in our small Norwegian market; there is no room for that. What we need is one, or at least someone who talks together and go across. So that if we use one program and X uses another, we can still communicate."* Client 2

Presuming standardized data formats for materials are imposed by the regulations, a digital platform ecosystem can serve as a tool to improve the inefficient material searches. Digital integration of the current material search will enable cooperation across all industry actors, promoting a digital marketplace for procuring reused materials. Contrary to the inefficient procurement process, digital platform ecosystems can solve the time-matching issue, currently preventing reuse, through searchable data formats where the selling parts can upload their used materials, while the buyers can locate these through simple searches.

In addition, centralizing available materials will contribute to reducing the costs related to storing materials. By integrating the digital marketplaces to the storage facilities, the digital platform ecosystem can provide a complete overview of which materials are available for reuse during planning and projection. For instance, Client 2 explains that a complete register of available materials will help avoid materials from being left and forgotten in storage for years. The digital platform ecosystem will also function as a database for materials still bound in existing buildings that can be reused in the future. By providing a shared space for uploading reuse mapping and the remaining building lifetime, the digital storage entities can create predictability for the industry actors when planning for reuse.

According to the interviews, a weakness with centralizing the marketplaces, is that it will reduce competition in development of market platforms for reuse. Nevertheless, the informants highlight that increasing the volumes of materials should be prioritized to reduce costs and increase adaptation, instead of focusing on competition in an immature marketplace. Thus, data accumulation can be considered the attribute that enables reuse materials to be shared between relevant actors to create a circular market for reuse.

5.6.3 Interaction

A digital platform ecosystem can also contribute to educating the industry on the possibilities that lie within constructing with reuse. On a digital platform ecosystem, actors can gather and share information and experiences to develop guidelines and examples of how circularity can be implemented.

> *"(...) to sum up all of what has been done (...) and just get the information out there because it's hard to search for on your own. You end up searching for answers like: "Has anyone ever cut out a brick in panels? How do you reuse this? Can you reuse that? What year is the cutoff for windows?" So, I think there's been much work done on getting this information but not much on spreading it."* Consultant 4

The informants explain that knowledge sharing is crucial in construction as the industry is highly fragmented, with actors with high levels of specialization that need an arena to contribute their knowledge. For instance, Client 1 points out how a digital platform ecosystem can provide the correct information to the right actors.

> *"(...) what we are working on is getting information out there to several actors, i.e., within the organization and other organizations that work with us, who are not experts in climate and greenhouse gas calculations. (...), but we are working a lot on using key information and not making it too complicated for the project management, for example, so that they can get the overview they need without having to go into too many details. At the same time, environmental consultants need to have very detailed insight, so it [digital platforms] must be able to support different roles."* Client 1

In this way, interaction in terms of knowledge sharing can diminish the uncertainty of material quality between distinct industry actors and help stimulate mutual trust regarding the quality of reused materials. Moreover, new perspectives, synergies, and innovative solutions will likely emerge by combining and sharing specialized knowledge on a digital platform ecosystem.

5.6.4 Limitations of the Multidimensional Digital Platform Ecosystem

Although our proposed digital platform ecosystem assesses many perspectives considering the use of digital platforms to induce circularity, it has its limitations. One limitation of the derived platform is that it requires data standardization and data flow between separate projects and actors in the industry, which is not present today. The development of an industry-wide material pass is identified to be an important step towards dataflow, but there is still work to be done in terms of standardization to realize the potential of the digital platform ecosystem.

Another limitation is the digital platform ecosystem's limited influence on regulations. Since regulatory authorities first and foremost decide regulations, the platform do not directly stimulate change in the regulatory landscape. However, the informants imply that the digital platform ecosystem will indirectly push regulations through stimulating volumes and an infrastructure for circularity and reuse, as regulations are likely to follow from broader industry adaptation of circularity.

6. Discussion

In the following, we discuss our empirical findings on the topic of CE and DPEs and situate them in the relation to the contemporary literature on these concepts. Specifically, to discuss the ideal organization of industry actors, we will elaborate on the empirically derived multidimensional model in Figure 4 in the context of internal and external digital platforms. We will also propose a new framework in Figure 5 that highlights the role of flexibility, data accumulation and interaction in enabling DPE to facilitate CE by reassessing the preliminary framework. Through this discussion, we aim to contribute to a deeper understanding of the connections and dynamics between CE and DPEs.

6.1 How Should Industry Actors be Organized on Digital Platfoms for Circularity?

Our study reveals that the industry requires both a project-specific and an industry-wide platform to successfully carry out circular construction projects. The need for a project-based organization of actors on such platforms, is due to the high complexity of construction projects which necessitates vertical integration for the client to coordinate activities. For instance, we find that clients must set circular requirements for the implementation of circularity throughout the project, and architects must consult with consultants and contractors about the feasibility of their circular designs. Therefore, in line with Gawer and Cusumano (2013), the actors in the construction industry are not fully autonomous and require a governmental mechanism to coordinate their activities to align value creation with circularity. In this way, our study indicates that fragmented and complex value chains should be coordinated on internal platforms and governed by one or a few actors.

In addition, our findings suggest that separate environmental platforms and measures for circularity should be integrated on the project platform to make it more convenient to implement circularity. For example, our informants express a desire to integrate the circularity component to the BIM system to avoid the use of multiple digital platforms in construction. However, as there is no standardized process for circularity, all building projects will need their own circular solutions based on the specific material availability, function, customer demands and client requirements in the project. Thus, the need for custom solutions for circularity contradicts the fact that internal platforms create value by "reusing" product components in production (Gawer & Cusumano, 2013). Hence, we argue that the implementation of circularity also requires an external platform with stronger innovative abilities to develop the custom circular solutions.

External platforms, as described by Gawer (2014), have open interfaces that allow connectivity between complementary firms, whose contributions create mutual benefits for the whole ecosystem (Jacobides, Cennamo, & Gawer, 2018). According to our findings, industry actors are willing to share knowledge and materials across projects to raise the overall industry competence and to develop an infrastructure for reuse. Since the complementary actors in the industry do not necessarily cooperate on specific projects, they are autonomous in the sense that they do not depend on each other. Therefore, in line with Jacobides et al. (2018), the autonomy of the complementary actors will create strong innovative capabilities on the external platform. By including a larger network of actors on this platform, the likelihood of developing appropriate solutions for circularity in each project increases. These results align with the concept of a symbiotic relationship between interdependent actors, as described by Iansiti and Levien (2004). Consistent with theory, we argue that a marketplace for materials and a knowledge database should be enabled through the use of an external platform, also known as a digital platform ecosystem, where all actors have incentives to cooperate to increase the benefit for all. Furthermore, given the existence of complementarities within the ecosystem network, Jacobides et al. (2018) argue that there is no need for a centralized governance mechanism. Thus, we argue that connectivity on external platforms is essential for the development of circular solutions in the industry and can be implemented in the industry without a formal leading actor.

6.2 What are the Fundamental Attributes of a Digital Platform Ecosystem for Circularity?

In the following we will discuss the three identified fundamental attributes in relation to our preliminary framework. Our findings suggest that flexibility, data accumulation and interaction are essential for inducing circularity in the industry through the use of digital platforms. First, the flexibility attribute enables iterative collaboration between value chain actors during construction projects to implement processes for reuse. Second, data accumulation involves the collection and storage of data information, which helps scale and facilitate the development of a circular infrastructure. Third, interaction enables the sharing of knowledge and experiences among industry actors, to educate and stimulate the adoption of circular practices.

The new framework in Figure 5 illustrates the relationship between the empirical findings (shown in orange) and the preliminary framework The framework highlights two key connections: 1) How the principles of the circular economy can be achieved through digital platform ecosystems that are flexible, accumulate data and facilitate interaction, and 2) how the fundamental attributes relate to our preliminary conceptualization of DPEs. The numbers behind the attributes reflect the number of circular principles related to each attribute and indicate their relative importance in contributing to circularity.

Hence, the framework provides a comprehensive overview of which fundamental attribute has the greatest impact on circularity based on the total number of circular principles they support, as well as illustrating the DPE feature with the largest impact on CE. The numbers next to the DPE features has been modified based on our empirical findings and indicate how they support the three empirically identified attributes.

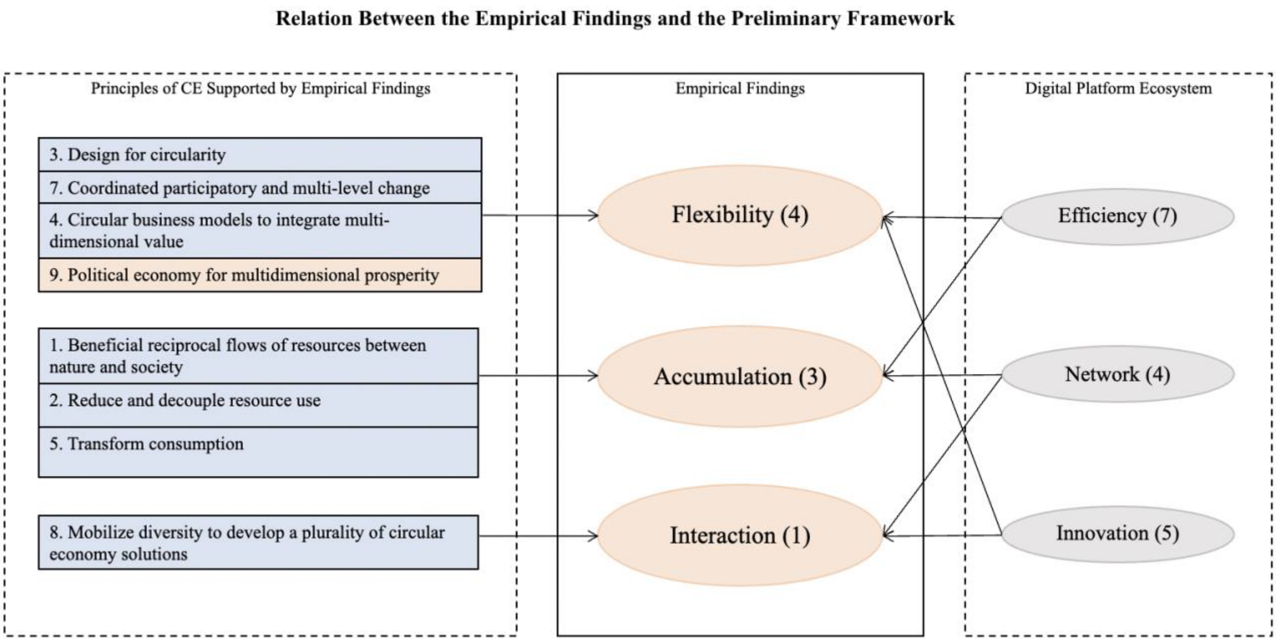

Figure 5: Preliminary Framework Modified by Empirical Findings

Our study indicates that efficiency, with seven connections to CE, is the most influential feature of a DPE in driving circular development in the construction industry. These findings are inconsistent with the preliminary framework, which suggests that network is the most important, and efficiency the least important, feature for circularity. We argue that the identified importance of efficiency in our study is due to the early phase of the circular development of the industry. Currently, the implementation of circular initiatives is unprofitable and time-consuming as the market and infrastructure for circularity are still immature. Hence, our study reveals that the efficiency feature of the DPE will be critical to establish circularity in the industry. However, we believe that in the long run, the DPE's capabilities for innovation and network will become increasingly important to fuel circularity, which aligns with existing literature.

The empirical findings illustrated in Figure 5 imply that nine of the ten CE principles can be assisted using DPEs. The only principle identified to have a weak link to DPE is "*Citizen participation in sustainable transitions"*. Since the clients are the only value chain actor directly influenced by the desired needs of tenants and buyers, our findings suggest that including citizens and external actors on the platforms will be of little use to inducing circularity in the industry. Moreover, our findings suggests that the DPE will, in its entirety, support the principle "*Whole system assessment"* as the three fundamental attributes will together stimulate implementation of circularity in a whole system perspective. In the following section, the DPEs' relation to the other principles will be elaborated in detail.

6.2.1 Flexibility

According to our findings, the flexibility attribute supports the effort for iterative processes through flexible connections of actors and processes, which is considered critical to support circularity. Our study indicates that the platform's flexibility is enabled by the DPE features *efficiency* and *innovation* and contributes to four theoretical principles for circularity: "*Design for circularity", "Coordinated participatory and multi-level change", "Circular business models for integrating multidimensional value",* and *"Political economy for multidimensional change"*.

Design for Circularity

The study's participants argue that the architects in the design phase greatly influence the level of circularity due to their impact on how a building's design meets the goals of circularity. The findings are consistent with existing literature, which highlights the importance of circular designs to reduce material use (Kirchherr, Reike, & Hekkert, 2017) and close the resource loop (Geissdoerfer, Savaget, Bocken, & Hultink, 2016), to align environmental harmony with industrial prosperity (McDonough & Braungart, 2002).

The informants portray a need for increased cooperation with entrepreneurs and consultants in design to enable the development of loose-fit designs and designs for disassembly. According to the literature, both the efficiency and innovation feature of DPEs contribute to flexible cooperation between different stages in the value chain. For instance, an efficient platform reduces transaction costs in communication between the actors as the cost of material searching and the need for coordination decreases (Asadullah, Faik, & Kankanhalli, 2018). Additionally, the modular architecture promotes innovation of circular building designs, as the platform can be easily adapted to enable new areas of cooperation (Jiao, Simpson, & Siddique, 2007). Thus, we find that cooperation to develop circular designs can be facilitated by digital platforms.

Contrary to our preliminary framework, the findings do not portray a significant need for a network in the design of circular buildings. Since the workflow of construction projects often only involves specific actors hired by the client, the circular design primarily depends on iterative cooperation between the internal project participants. Therefore, the study contributes to the literature by identifying that the network feature of ecosystems is of lesser importance in implementing circular designs in the industry. However, the results propose that the project platform should be integrated with other industry actors to share materials and knowledge. As a result, we argue that the network will, to some extent, influence designs for circularity in projects.

Coordination of Participatory and Multi-Level Change

Our findings reveal that streamlining cooperation within projects reduces fragmentation and can help improve coordination between specialized actors. By utilizing the specialized knowledge of contractors in design and allowing architects to apply their creativity in reuse mapping, interdisciplinary competence can be applied to map out potential reuse materials.

Consistent with the preliminary framework, the platform's innovative abilities are essential to support coordinated development, as it helps connect independent actors with complementary knowledge. Hence, when actors coordinate their activities, new combinations of knowledge facilitate the formation of new solutions, in line with Jacobides et al. (2018) definition of unique complementarities. However, the preliminary framework does not consider that streamlining cooperation is also obtained from efficiency. Our findings indicate that platforms will make coordination easier and more convenient which can be understood as an effect of the DPEs' efficiency. By reducing transaction costs and using standardized interfaces, coordination between actors will become more efficient. Therefore, our study extends the current literature by including efficiency as an important contributor to the "*Coordination of participatory and multi-level change"*.

Circular Business Models for Integrating Multidimensional Value

Our findings indicate that the flexibility attribute of the DPEs contribute to "*Circular business models to integrate multidimensional value"* since the development of new business models is contingent to new actors being able to connect to the platform ecosystem. The modular infrastructure of the DPEs allow for easy integration of new actors and systems, due to its efficient and innovative features. These features make it both convenient and possible for actors to join the ecosystem, facilitating a thriving environment for new actors to explore opportunities for value creation (Pomponi & Moncaster, 2017). Hence, in line with the preliminary framework, our findings imply that efficiency and innovation will stimulate this principle.

However, in contrast to Benachio et al. (2020), we found that digital platform ecosystems will not assist circularity in all phases of the value chain. For instance, the proposed digital platform ecosystem will to a limited extent contribute to circularity in the operation phase. As circularity is still in the infant stage in the industry, we cannot exclude the possibility that actors from the operation phase will join the ecosystem eventually.

Political Economy for Multidimensional Change

Our study finds that governmental regulations and legislation play a significant role in promoting circularity. Multiple scholars within the field highlight the influence that political solutions have on circularity, both in general (Velenturf & Purnell, 2021), and in the construction industry (Pomponi & Moncaster, 2017). However, the literature on DPEs does not consider the impact of integrating authorities in platform ecosystems.

Nevertheless, our findings underline the importance of regulatory push to enable the transition towards circularity, and that a flexible platform can be an important contributor. Currently, information related to BREEAM, carbon accounting, and reuse mapping is scattered across various systems and paper documents. The modular architecture of a DPE can integrate current and future regulations and certifications related to circularity on the platforms, making it easier and more convenient for actors to incorporate the certification processes in their workflows. The flexibility feature is found to be particularly important in the construction industry as new regulations and requirements are constantly emerging. The integration of these regulations will help promote the adaption of governmental certifications aimed at advancing circular development across all industry actors. Thus, our findings portray multiple ways in which DPEs can contribute to the political dimension of circularity, establishing a connection between political influence and DPEs that is yet to be discovered in contemporary literature.

6.2.2 Data Accumulation

Our study also identifies that circularity requires data accumulation to store information and scale the availability of reused materials to create a market for it. Digital platforms can create a digital flow of material identities through *efficiency* and *network*, thereby contributing to three CE principles: "*Beneficial reciprocal flows of resources between nature and society", "Reduce and decouple resource use"* and "*Transform consumption"*.

Beneficial Reciprocal Flows of Resources Between Nature and Society & Reduce and Decouple Resource Use

Our study finds that the connection between the market for used materials and the physical storage facilities supported by DPEs is essential in making reuse materials accessible for purchase. The efficiency attribute of the DPEs facilitate economies of scale in supply by centralizing the volumes of available reusable materials. Furthermore, the DPEs' standardized interfaces help keep materials in a closed loop for as long as possible (Benachio, Freitas, & Tavares, 2020), by enabling the uploading of reuse mapping. In addition, the modular architecture allows for the integration of different marketplaces for used materials, further expanding the volume of available materials. When a building reaches the end of its optimal lifetime, materials can be kept in circulation through the digital market for reuse, rather than discarded as waste, reducing the need for new resources. Enabling digital flow of resource data between industry actors, can also be generated through the network feature as more actors join the platform. Thus, by improving the consumption process of reuse materials the market for reuse will grow, limiting resource exploitation (Kirchherr, Reike, & Hekkert, 2017).

Transform Consumption

The platform's potential to create an industry-wide market for used materials can also be argued to stimulate new consumption patterns for used materials. Our findings portray that when volumes of available used materials increases, it becomes more predictable and profitable for industry actors to replace virgin materials. According to the literature, the accumulation of material data on digital platform ecosystems makes it easier to create new ownership models for reuse materials (Leising, Quist, & Bocken, 2017). For instance, the efficiency feature of the DPEs allow for the creation of temporary ownership, where the buildings act like material banks. By using standardized interfaces, ownership can shift from being held by a specific company to being shared among all industry actors. Thus, through data accumulation, the DPEs can create a transparent and predictable market that will stimulate a demand-driven consumption. In this way, the platforms can contribute to making it easier, cheaper, and less risky for actors to purchase reuse materials.

6.2.3 Interaction

A digital platform ecosystem can also contribute to educating the industry on the possibilities that lie within constructing with reuse. Our findings indicate that interaction to raise competence on circularity is a fundamental attribute of digital platform ecosystems. Our study portrays that *network* and *innovation* are features of a digital platform ecosystem that can contribute to the CE principle: "*Mobilize diversity to develop a plurality of circular economy solutions*".

Mobilize Diversity to Develop a Plurality of Circular Economy Solutions

Informants express that the lack of competence on circular solutions makes it difficult for actors to adopt circularity in construction projects. By connecting the actors through an ecosystem, the actors can learn from each other's experiences and develop a variety of circular solutions based on their unique competencies. Thus, in line with Boulding (1966), the network feature of the DPEs can help overcome resistance to this transition by facilitating communication between industry actors.

The innovation feature of a DPE also encourage the development of a wide range of new solutions, as the knowledge of the ecosystem actors complements each other. This aligns with previous research on ecosystems, which explains that a group of loosely interconnected actors can increase value creation through a symbiotic relationship of mutual dependencies (Iansiti & Levien, 2004). Our findings confirm the importance of both the network and innovation features in the preliminary framework. However, we found that the efficiency attribute is less significant, as ecosystem innovation and development of new solutions are mainly driven by the complementarities of actors' specialization rather than the efficiency of the ecosystem itself.

7. Conclusion

This final chapter summarizes the key findings of the thesis, including how industry actors should be organized on digital platform ecosystems and fundamental attributes of a DPE to support circularity in the industry. In the second part of the conclusion, we discuss the theoretical and managerial implications of our findings. The theoretical implications consider how our research addresses important gaps in the literature regarding industry organization on digital platforms, as well as the platforms' application of a whole-system perspective on circularity. We also offer managerial implications for the circular development of the Norwegian construction industry, highlighting the importance of network, standardization, and industry-wide cooperation. Finally, we assess the limitations of our study and suggest avenues for further research.

This study explored how digital platform ecosystems (DPEs) can offer an opportunity for the development of a circular economy in the construction industry. Through an exploratory case study, involving key actors in the Norwegian construction industry value chain, we collected data on the use of digital platforms for circularity and analyzed it using existing literature on the circular economy and DPEs.

Based on our findings, we revised and supplemented the predefined relations between the circular economy and DPEs and adjusted our preliminary framework accordingly. We proposed a multidimensional DPE where construction project platforms are integrated into a larger platform ecosystem, allowing for the necessary the coordination and collaboration for circularity. We also identified three fundamental attributes; *flexibility*, *data accumulation*, and *interaction*, that are critical for a DPE to support the development of circularity in the industry.

We argue that a DPE has the potential to facilitate an external adaptation among industry actors, allowing them to adapt to each other's needs and create a well-functioning dynamic market that do not depend on centralized governance. However, this requires that regulations follow and clearly communicate the requirements for circularity, and that industry actors adapt to standardized documentation. Overall, our study provides insights into the potential of DPEs to support the transition to a circular economy in the construction industry.

7.1 Theoretical Contribution

Existing literature on digital platform ecosystems and the circular economy have not dealt with how value chain actors should be organized on digital platform ecosystems to support the development of circularity. While studies in other industries demonstrate the importance of value chain collaboration on platforms for enabling circularity, there has been no research to date on this topic specifically within the construction industry. Our findings suggest that the actors in the construction industry need to be organized both on a project-specific platform and on an industry-wide platform to stimulate the circular development. Integration on the project platform will stimulate iterative collaboration between specialized roles in which innovative solutions for circularity can be developed in interdisciplinary groups. However, the development of circularity demands an industry-wide infrastructure and knowledge base to enable reuse of materials across projects, which requires integration of the project actors on an industry-wide platform to share material information and experience. Hence, our study contributes to the research field on digital platforms for circularity by arguing that the ecosystem must consist of an internal platform for project cooperation and an external platform for industry cooperation.

Moreover, our findings suggest that project work in different project phases needs a high level of alignment and coordination to succeed, arguing that the internal platform requires a centralized governance mechanism. On the external platform, however, the actors are more autonomous and contribute to the ecosystem as they have a mutual benefit in increasing the volumes of used materials and knowledge. Hence, our study contributes to the digital platform literature by arguing that internal platforms for project work require centralized governance, whereas an external platform for mutual sharing will be aligned through mutual complementarities.

Secondly, our study identifies fundamental attributes which compose a digital platform ecosystem to support the circular economy from a whole system perspective. Previous studies in the research field have mainly focused on how digital platform ecosystems support one or a few aspects of the circular economy, failing to address the effect on circularity in its entirety. The inductively derived framework for a circular DPE addresses the current research gap by connecting fundamental attributes of DPEs to holistic principles for a circular economy. Our study suggests that digital platforms that are flexible, accumulate data and facilitate interaction contribute to nine out of ten principles for circularity. Contingent on our preliminary framework, our findings reveal that in contrast to existing literature, political governance for circularity in the construction industry can be assisted using digital platform ecosystems. Furthermore, our findings contradict existing theory in that citizen participation for circularity will to little, or no extent, be facilitated by digital platform ecosystems in construction.

7.2 Managerial Implications

The managerial implications aim to provide direction for how leading industry actors and stakeholders in the Norwegian construction industry can take advantage of the opportunities for using digital platform ecosystems to support circularity.

First, our findings indicate that industry actors and stakeholders must help push regulations and standardization of data formats to enable the development of a DPE. Regulations and standardized data formats are identified as crucial to align different project platforms and must be updated to follow the rapid circular development in the industry. Although the literature review does not portray a direct link between DPE and regulations, our study suggest that industry actors and stakeholders can take an active role in pushing for standardized data formats to enable data aggregation in the ecosystem. In this way, they will play an important role in the establishment of the ecosystem in the early phase of the circular development.

In later phases of the development towards circularity we argue that the ecosystem will be less dependent on managerial involvement from industry actors. When the circulation of materials and knowledge on the platform increases, it will create two-dimensional value as the individual actors will maximize their own value, and additional value will be generated from network effects. Our study suggest that the actors' complementarities will ensure alignment in value-creation, reducing the need for a governing actor. Hence, we argue that in the long run, the industry ecosystem will be a self-propelled entity without the need for centralized ownership and governance from an industry actor or a stakeholder.

Furthermore, our study highlights the importance of expanding the physical infrastructure for circularity in parallel to the development of a digital platform ecosystem. Centralizing material availability and knowledge on DPEs will be of no use unless there is a physical storage for the materials. Hence, our study suggests that industry actors and stakeholders must invest in physical infrastructure for circularity in order to realize the potential of DPEs to induce circularity.

Finally, the derived framework in Figure 5 can benefit industry actors in their attempt to understand how attributes of digital platform ecosystems can support the CE principles. As the principles have been created on a general basis for circularity, we have provided industry-specific examples of how the three main features of digital platform ecosystems can support circularity in the construction industry. The examples intend to provide guidance for the industry actors to implement reuse, as well as present the advantages of collaboration to create a digital marketplace on a digital platform ecosystem. Industry actors, in particular clients and consultants can use this model as an inspiration to manage the different actors in construction projects and reap the benefits of participating in a platform ecosystem.

7.3 Limitations and Recommendations for Future Research

Even though our thesis is thoroughly conducted in agreement with methodological and practical choices, the study has several limitations worth mentioning. This section will discuss the limitations and how these can be addressed in future research.

Due to the thesis time constraint, we only conducted eight interviews with informants from the industry. Future research would benefit from a larger informant selection, and thereby more extensive research can assist in confirming or denying tendencies that our study uncovered. A more extensive informant selection will also assist in generalizing the results and strengthen the credibility of the contribution.

Further, our study is limited to the DPEs' contribution to circularity at a given point in time, which reduces the influence of our findings in later stages of the transition toward circularity. Although many actors are aware of circular initiatives in the industry, few practical examples of reuse and circular constructions are present today. As the construction industry is still in the early phase of circularity and digitalization, the identified concerns and mapped attributes will likely evolve in time. However, our conclusion points to concerns that have been critical up to the current stage, which will provide valuable insights for the overall circular development. It could also have been valuable to include informants from smaller companies, as these likely have different needs and contributions in relation to digital platforms and circularity. Due to reasons of time and the scope of the tasks, we had to set limitations for the study. Nevertheless, we see that perspectives from smaller companies are an interesting aspect for further research.

Another limitation is that the construction industry value chain is simplified and restricted to four main actors for the scope of our thesis. However, many large companies in the industry often have the competence to fill several roles, likely impacting the network on the ecosystem. This can sometimes change the nature of the depicted relations and the need for collaboration on digital platforms indicated by the study.

Lastly, given the limited research on the connection between CE and DPE, we developed a conceptual framework linking these two concepts as a basis for our contribution to existing theory. During our analysis, we identified connections between the informants' descriptions and the preliminary framework we developed in the conceptualization. While we believe these connections are important and valid, we acknowledge that they may not be exhaustive and that other factors may also have an impact. Thus, an idea for future research is to explore and strengthen these relations to provide a more comprehensive understanding of the connection between CE and DPE.

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9. Appendix

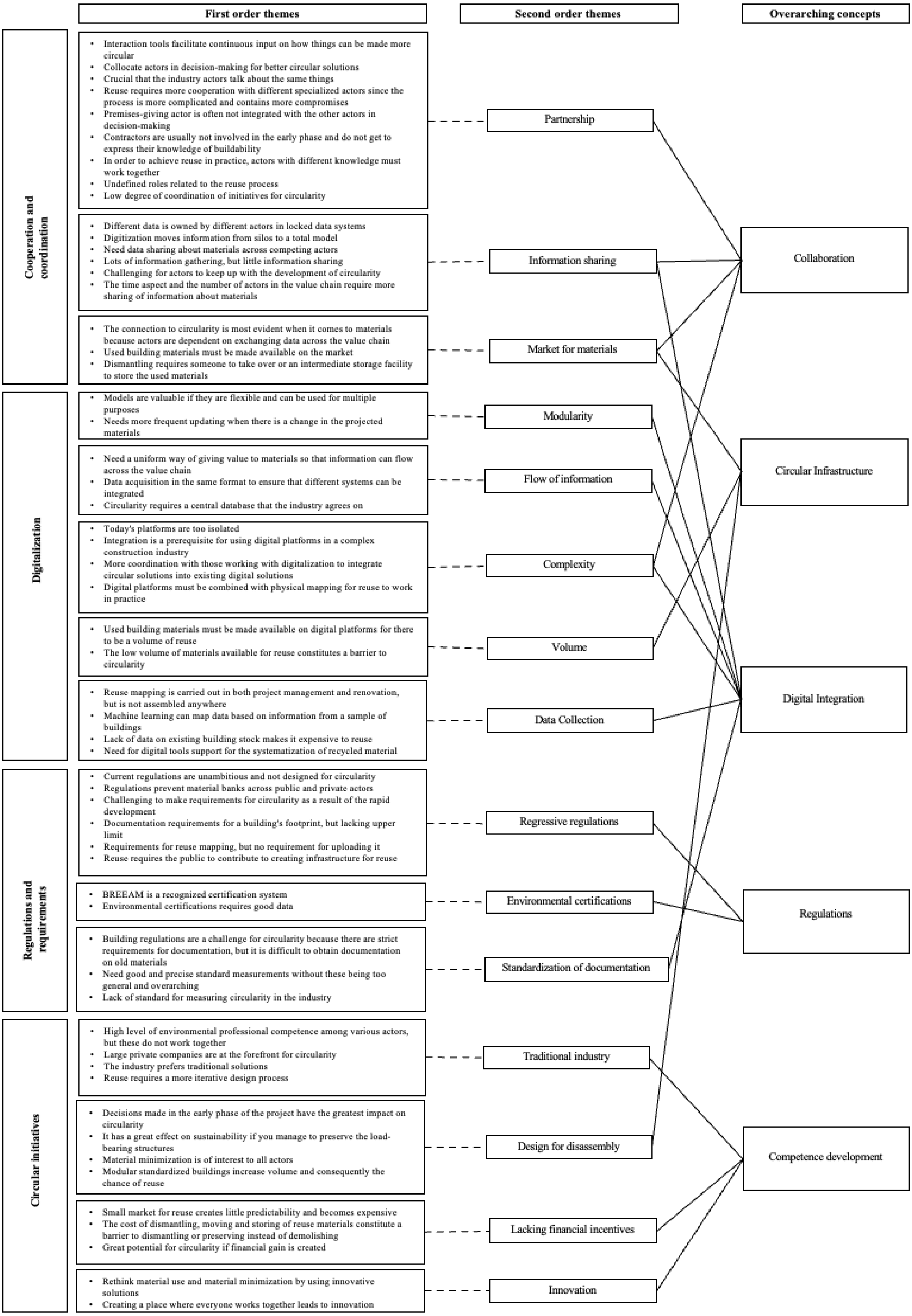
9.1 Appendix A: Definitions of the Circular Economy

Author(s)	Definition
(Ellen MacArthur Foundation, 2015)	*"A circular economy is restorative and regenerative by design and aims to keep products, components and materials at their highest value at all times, distinguishing between technical and biological cycles."*
(Geissdoerfer, Savaget, Bocken, & Hultink, 2016)	*"Circular economy is a regenerative closed loop system which can be achieved through appropriate design, maintenance, refurbishing or reuse."*
(Pomponi & Moncaster, 2017)	*"A building that is designed, planned, built, operated, maintained, and deconstructed in a manner consistent with CE principles."*
(McDonough & Braungart, 2002)	*"Resources are ideally never turned into waste but are kept in the loop for as long as possible with minimal loss of quality."*
(Leising, Quist , & Bocken, 2018)	*"CE is a life cycle approach that optimizes the building's useful lifetime, integrating the end-of-life phase in the design and uses new ownership models where materials are only temporarily stored in the buildings that act as a material bank."*
(Preston, 2012)	*"A circular economy is an approach that would transform the function of resources in the economy. Waste from factories would become a valuable input to another process – and products could be repaired, reused or upgraded instead of thrown away."*

9.2 Appendix B: Definitions of Digital Platform Ecosystems

Core Concept	Author(s)	Definition
Digital platform, technological perspective	(Ceccagnoli, Forman, Huang, & Wu, 2012)	*"A set of components used in common across a product family whose functionality can be extended through applications".*
Digital platform, technological perspective	(Tiwana, Konsynski, & Bush, 2010)	*"The extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate"*
Digital platform, market-based perspective	(Evans, 2003)	*"A multi-sided platform enables coordination of demand between distinct groups that need each other in a specific context"*
Digital platform, market-based perspective	(Øverby & Audestad, 2018)	*"Multi-sided platforms where two or more distinct groups of users cooperate to create mutual benefits for each other"*
Ecosystems	(Iansiti & Levien, 2004)	*"Characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival"*
Ecosystem	(Adner, 2017)	*"Alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize."*
Digital platform ecosystem	(Adomavicius, Bockstedt, Gupta, & Kauffman, 2008)	*"Sociotechnical networks of interdependent digital technologies and associated actors that are related based on a specific context of use."*
Digital platform ecosystem	(Hein, et al., 2020)	*"A digital platform ecosystem comprises a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers."*
Digital platform ecosystems	(Jacobides, Cennamo, & Gawer, 2018)	*"An ecosystem is a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled."*

9.3 Appendix C: Gioia Coding



9.4 Appendix D: NSD Interview Approval

Meldeskjema / Masterutredning ved NHH / Vurdering

Vurdering

Referansenummer	Type	Dato
937148	Standard	21.11.2022

Prosjekttittel
Masterutredning ved NHH

Behandlingsansvarlig institusjon
Norges Handelshøyskole / Institutt for strategi og ledelse

Prosjektansvarlig
Tina Saebi

Student
Runa Fløtre Øfsti

Prosjektperiode
22.08.2022 - 20.12.2022

Kategorier personopplysninger
Alminnelige

Rettslig grunnlag
Samtykke (Personvernforordningen art. 6 nr. 1 bokstav a)

Behandlingen av personopplysningene kan starte så fremt den gjennomføres som oppgitt i meldeskjemaet. Det rettslige grunnlaget gjelder til 20.12.2022.

Meldeskjema

Kommentar
OM VURDERINGEN
Personverntjenester har en avtale med institusjonen du forsker eller studerer ved. Denne avtalen innebærer at vi skal gi deg råd slik at behandlingen av personopplysninger i prosjektet ditt er lovlig etter personvernregelverket.

Personverntjenester har nå vurdert den planlagte behandlingen av personopplysninger. Vår vurdering er at behandlingen er lovlig, hvis den gjennomføres slik den er beskrevet i meldeskjemaet med dialog og vedlegg.

VIKTIG INFORMASJON TIL DEG
Du må lagre, sende og sikre dataene i tråd med retningslinjene til din institusjon. Dette betyr at du må bruke leverandører for spørreskjema, skylagring, videosamtale o.l. som institusjonen din har avtale med. Vi gir generelle råd rundt dette, men det er institusjonens egne retningslinjer for informasjonssikkerhet som gjelder.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til den datoen som er oppgitt i meldeskjemaet.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake.

Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
Personverntjenester vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen

formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke behandles til nye, uforenlige formål dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet

lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), og dataportabilitet (art. 20).

Personverntjenester vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned

FØLG DIN INSTITUSJONS RETNINGSLINJER
Personverntjenester legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

Ved bruk av databehandler (spørreskjemaleverandør, skylagring eller videosamtale) må behandlingen oppfylle kravene til bruk av databehandler, jf. art 28 og 29. Bruk leverandører som din institusjon har avtale med.

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til oss ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde: https://www.nsd.no/personverntjenester/fylle-ut-meldeskjema-for-personopplysninger/melde-endringer-i-meldeskjema

Du må vente på svar fra oss før endringen gjennomføres.

OPPFØLGING AV PROSJEKTET
Personverntjenester vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

9.5 Appendix E: Consent Form and Interview Guide

Informasjonsskriv

Hei,

Vi er to masterstudenter fra Norges Handelshøyskole (NHH) som skriver masteroppgave om digitale plattformer på tvers av aktører i byggebransjen. I den forbindelse vil vi veldig gjerne samle inn ulike synspunkter og erfaringer fra sentrale aktører i bransjen. Dette er et spørsmål til deg om å delta i forskningsprosjektet. I dette skrivet vil gir vil deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg. Forskningsarbeidet gjennomføres i samarbeid med det nasjonale forskningsinstituttet Digital Innovation for Growth (DIG) og førsteamanuensis Tina Saebi ved Norges Handelshøyskole.

Formål

Formålet med forskningsoppgaven er å studere behov og utfordringer ved bruk av digitale plattformer på tvers av aktører i byggebransjen og potensialet slike plattformer har for å øke sirkulariteten i bransjen. På et overordnet nivå vil fokuset være viktige kriterier og utfordringer med digitale plattformer basert på ulike rollers sentrale aktiviteter. I tillegg til selskapers bærekraftstrategier knyttet til sirkulærøkonomien. For å kunne analysere problemstillingen vil det være av stor verdi å intervjue større og mindre aktører med ulike roller i verdikjeden. Vi skal derfor ta kontakt med store og mellomstore aktører som er byggherrer, konsulenter, arkitekter og entreprenører i bransjen som gjerne har noe erfaring med sirkulærøkonomi.

Hva innebærer det for deg å delta?

Vi ønsker å gjennomføre mindre strukturerte intervjuer for å sikre en åpen tilnærming til problemstillingen. Det er viktig at intervjuobjektet skal kunne snakke fritt og at egne synspunkter og erfaringer skal komme tydelig frem. Intervjuet vil gjennomføres på norsk.

Det er frivillig å delta

Dersom du skulle oppleve noe ubehag under intervjuet kan du når som helst trekke deg uten at det får noen negative konsekvenser. Det er også mulig å trekke seg uten å ha noen spesiell grunn Intervjuet er derfor helt frivillig.

Ditt personvern

For å sikre at vi fanger opp all informasjon og at vi som forskere skal kunne følge med på hva intervjuobjektet sier under intervjuet, ønsker vi å foreta lydopptak. Det er kun forskere og veileder som har tilgang til lydopptaket og det vil slettes umiddelbart etter transkribering. Filene med opptak og transkripsjoner vil lagres med benevnelsene «Byggherre 1, Konsulent 1, Konsulent 2» osv, for å sikre anonymiserte titler. De enkelte deltakerne i studien vil derfor ikke kunne gjenkjennes i en eventuell publikasjon i studien. Ved prosjektslutt 20. desember 2023 vil alt datamateriale fra datainnsamlingen slettes.

Hvis ønskelig kan vi sende transkribert intervju til intervjuobjektet for å samtykke til at dine perspektiver fremstilles korrekt. For å sikre anonymitet for deltakende i studien vil vi i masterutredningen referere til intervjuobjektet som stor eller liten aktør og deres rolle i verdikjeden.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke. På oppdrag fra NHH har Personverntjenester vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

- NHH ved Tina Saebi, kontaktinformasjon: 55 95 94 62, Tina.Saebi@nhh.no.
- Vårt personvernombud: personvernombud@nhh.no

Hvis du har spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Prosjektansvarlig *Eventuelt student*
(Forsker/veileder)

Samtykkeerklæring

Samtykkeerklæring i forbindelse med intervju om «Digitale plattformer for sirkularitet i byggebransjen».

Forskere: Runa Fløtre Øfsti og Kristin Vagle
Veileder: Tina Saebi

Samtykke: Ved signatur av dette dokumentet bekrefter jeg (intervjuobjekt) å ha mottatt og lest informasjonsskrivet tilsendt fra Runa Fløtre Øfsti og Kristin Vagle. Jeg gir med dette mitt samtykke til innsamling av data i forbindelse med masterutredning ved Norges Handelshøyskole (NHH). Dette inkluderer:

- Digitalt opptak av intervju
- Transkribering av intervju
- Forskernes og veileders tillatelse til bruk av transkripsjon etter transkribering
- Anledning til å lese gjennom transkribert intervju før publisering av masterutredning
- Sitering i anonymisert form referert med rolle i verdikjeden i masterutredningen
- At transkripsjonene fra intervjuene slettes ved avslutning av forskningsprosjektet 20.12.22

Intervjuet vil bli gjennomført av Runa Fløtre Øfsti og Kristin Vagle.
Jeg (intervjuobjekt) bekrefter med dette min frivillige deltakelse i studien. Samtidig bekrefter jeg at jeg har blitt informert om egne rettigheter overfor mine personopplysninger, og at jeg kan trekke meg fra deltakelse av fri vilje.

Sted og dato: ________________________

Signatur prosjektdeltaker: ____________________________

Intervjuguide

The interview guide is in Norwegian as all interviews were conducted in Norwegian. An English version and transcripts of the interviews can be provided upon request.

Introduksjon:

- Presentere oss selv
- Forklare formålet med studien
- Nevne samtykkeerklæringen

Innledende spørsmål:

- Kan du begynne med å gi en overordnet beskrivelse av din rolle og arbeidsoppgaver i bedriften?
- Hvor mange år med arbeidserfaring har du fra bransjen?

Hovedspørsmål:

Har bedriften din gjort tiltak for å fremme sirkulær økonomi? Hvordan og hvilke tiltak?

Hva er typiske barrierer som dere opplever ved implementering av sirkulærøkonomi i deres arbeidsoppgaver?

- Oppfølgingsspørsmål: hvordan kan digitale plattformer bidra til å løse dette?
- Oppfølgingsspørsmål: hva med offentlige reguleringer? Hvordan føler dere at det offentlige bidrar til å øke sirkularitet i byggebransjen, og har de introdusert noen digitale plattformer?
    - Digitale plattformer vil vel kanskje kreve en del standardisering, hva ser du som fordeler/ulemper med standardisering knyttet opp mot sirkulær økonomi på digitale plattformer?

Hva med drivere for sirkulær økonomi? Hva ser dere på som de mest betydningsfulle driverne for implementering av sirkulærøkonomi?

- Oppfølgingsspørsmål: og hvordan kan digitale plattformer bidra til dette?

Hvilke digitale plattformer bruker du/dere i dag? Og hva er fordeler/ulemper med disse?

- Oppfølgingsspørsmål: kan du si noe om informasjonsdelingen mellom disse plattformene, typ vi har hørt med andre aktører som beskriver flere siloplattformer hvor mye av den samme informasjonen blir lagret, men ikke kan brukes sammen med de andre

Hvis du ser for deg alle stegene/fasene i et prosjekt, fra tidligfase og prosjektering til bygging, drift og riving, hvor er det størst potensiale for å bli mer sirkulære?

- Oppfølgingsspørsmål: i denne fasen, hvem er det viktigst for deg/dere å samarbeide med, eller hvilken aktør ser du den største gevinsten av å samarbeide med?
- Oppfølgingsspørsmål: Anser du det som realistisk at hele verdikjeden skal kunne samles på samme digitale plattform?
    - Oppfølgingsspørsmål: og hva tror du er de største gevinstene ved det?
    - Oppfølgingsspørsmål: ser du noen ulemper ved å samle hele verdikjeden på samme plattform?

Hva mener du er det viktigste som skal til for at bedrifter skal tørre/være villige til å satse på nye sirkulære metoder i byggebransjen?

Hvis vi tar utgangspunkt i byggebransjens verdikjede, hvor tror du de største mulighetene og utfordringene ligger mtp datadeling og sirkularitet?

Hvordan jobber deres bedrift med modulbaserte bygg og resirkulering og gjenbruk?

Avslutningsspørsmål:

- Basert på det vi har snakket om i dag, er det noen andre innspill eller tanker du tenker kan være relevant å dele?

Takke for at de ønsket å delta på intervjuet