IIIEE Theses 2022:24

Orchestrating Industry Transition:

A case study of value chain collaboration strategies to enable urban mining in the Danish building industry

Mathias Peitersen

Supervisors

Philip Peck

Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, May 2022

Published in 2022 by IIIEE, Lund University, P.O. Box 196, 221 00 LUND, Sweden,
Tel: +46 222 00 00.

ISSN 1401-9191

Acknowledgements

Finishing this project is a big deal for me as it marks the end of two great years at IIIEE. I am grateful to have had the chance to geek out learning about the many faces of sustainable transition and to have met all the great people of B27.

A thank you goes to Philip for de- and rerailing in and out of interesting alleys that ultimately resulted in this paper, friends of the institute for keeping motivation moderately high, and the institute innebandy team for dragging me away from the computer every once in a while. Kathrine deserves a peace medal for seeing me through this project and reminding me that there are other things to life than an approaching deadline. I will do my best to return the favor in a year! Also a huge thanks goes to my coffee maker, the insti-bar, all the lovely Gilleleje rye bread bakers, and Clements Falafel. A co-authorship was considered for without these inputs there would be no thesis, but the institute rules did not allow it.

I am incredibly thankful for everyone who have contributed to the project through meetings and interviews. Particularly, the respondents from the case companies. Taking the time to talk to students with a growing interest in the field is a fantastic deed considering how busy you are. It is much appreciated!

Abstract

Production of building materials is connected to a great deal of environmental degradation, and demand for materials is expected to increase. Currently, the construction industry is responsible for 23 % of the global GHG emissions, 40 % of the raw materials consumed globally, and 32 % of the waste generated in Europe. With urbanization and an increasing population, more buildings are needed in the future, leading to an increased demand for building materials. Meanwhile, high-value building materials are systemically downcycled, i.e. as road fill, leading to a significant loss of value. Urban mining (UM) is proposed as a solution, utilizing anthropogenic material waste streams to minimize virgin material input and the adverse effects connected to raw material extraction and material production. Business models for UM (BMUMs) are implemented in the building industry mainly at a small scale due to a combination of industry barriers, however, value chain (VC) collaboration is proposed as a key driver for overcoming them. Collaboration has mainly been investigated from a project-specific point of view, largely neglecting long-term partnerships across the VC, for example in the form of supply chain (SC) partnerships.

This thesis applies an abductive research design, conducting in-depth case studies of two pioneering organizations working with BMUMs in the building industry: Lendager Group and Gamle Mursten. Based on these case studies the following research questions will be answered:

> **RQ 1:** How do the case companies organize their SC to facilitate BMUMs?
>
> **RQ 2:** What aspects are influential when developing and operating a collaborative strategy for UM?
>
> **RQ 3:** How can VC collaboration influence industry transition toward large-scale implementation of UM principles and reuse of building materials?

The thesis finds that collaborative strategies vary depending on product characteristics and organizational goals. Partnerships are often developed fluidly with the implementation of incremental ad hoc initiatives. Building on an analytical framework put forward by Leising et al. (2018) the abductive analysis identified six important aspects of medium- and long-term VC collaboration: A shared vision for the future, Actor Learning, Network dynamics, and value creation, Business model innovation and inclusion, Automated action, and Optimal integration. The study argues that when engaging proactively with VC actors, companies may take the role of transition leaders by purposefully orchestrating the six collaborative aspects. A framework for how to do so is provided based on transition management theory. Further studies within BMUMs are suggested exploring how organizational aspects influence the successful operationalization of UM principles, as the research area is understudied.

Keywords: Urban Mining (UM); Circular Construction; Circular Business Model Innovation (CBMI); Value Chain Collaboration; Supply Chain Partnerships; Transition Management Theory.

Executive Summary

The construction industry is responsible for 40 % of the global energy consumption, 23 % of the global GHG emissions, and 40 % of the raw materials consumed globally. Furthermore, construction and demolition waste amount to 32 % of the total waste generated in Europe. Materials that could have been reused in new buildings are therefore regularly downcycled, i.e. as low-value road filling, leading to significant value loss. Circular economy (CE) is proposed as a new paradigm changing the building industry toward more resource-efficient practices such as increased reuse and recycling of secondary building materials. Specifically, urban mining (UM) is proposed as a practice that through selective demolition practices and circular design principles may offer an alternative for virgin materials, thereby decreasing the demand and the associated adverse effects on the environment. However, putting the principles of UM in practice takes a fundamental change in the current business models (BMs) and value chains (VC) for buildings and building materials. In the industry there are several barriers to implementing UM on large scale: insufficient information flows, practical issues related to reverse logistics, legal barriers, structural industry fragmentation, and a status-quo preserving industry culture to name a few. However, increased collaboration across the building value chain is proposed as a central aspect of overcoming these barriers, however little is known about how to facilitate such collaboration. Leising et al. (2018) have developed a framework for engaging in effective inter-organizational collaboration in project clusters during building planning and project execution. This framework highlights four important aspects: a shared vision, actor learning, network dynamics, and business model innovation. Project clusters are temporary organizational structures oftentimes dissolving at project finalization. As such, little is known about how to ensure effective collaborative partnerships over the medium- and long-term when operating business models for UM (BMUMs).

Research aim

By undertaking a literature review, it was found that there is a dual knowledge gap:

i) There is a limited practical understanding of how organizational aspects can enable successful BMUMs;
ii) There is a limited theoretical understanding of UM within business and organizational studies.

To fill these gaps, this thesis project aims to investigate which aspects are influential in designing effective medium- or long-term collaborative schemes to enable BMUMs. Furthermore, it will investigate the role of value chain collaboration amongst industry actors in initiating an industry transition at large. In pursuing this aim three primary research questions will be answered:

> **RQ 1:** How do the case companies organize their supply chains to facilitate business models for urban mining?
> **RQ 2:** What aspects are influential when developing and operating a collaborative strategy for urban mining?
> **RQ 3:** How can supply chain collaboration influence industry transition toward large-scale implementation of urban mining principles and reuse of building materials?

Methods

This study applies an abductive qualitative research methodology in conducting a case study of two UM pioneers in the Danish building industry. The first company is Lendager Group (LEG), an architectural agency engaged in building material design and development, and Gamle Mursten (GAM), a brick recycler. Both companies are engaged in upcycling construction waste and have experience operating reverse cycles and material remanufacturing processes.

Through a combination of document analysis, web scraping, and semi-structured interviewing the companies' operational activities and collaborative partners were mapped out delineating their approaches to intra- and inter-organizational supply and value chain collaboration.

Through abductive coding and data analysis, the experiences of the case companies informed a theory adjustment proposal to enable the Leising framework to fit the context of medium- and long-term value chain collaboration.

Findings

RQ 1: The study has found that what makes a collaborative scheme effective is highly dependent on the product characteristics and the value chain configuration. Improving inter-organizational collaboration is a learning-by-doing effort in the companies as networks, partnerships, and alliances emerge in an incremental development rather than a strategic desktop exercise to identify the optimal collaborative structures.

RQ 2: The abductive analysis resulted in an adapted framework proposing six aspects that are influential to the success of medium or long-term partnerships: A shared vision for the future, Actor Learning, Network dynamics, and value creation, Business model innovation and inclusion, Automated action, and Optimal integration. This carries on the four categories from the Leising et al. (2018) framework but adds new data-driven perspectives supported by the literature.

RQ 3: In answering this RQ, transition management literature informed an investigation of how collaborative schemes can influence industry transition toward large-scale implementation of UM principles and reuse of building materials. In answering this, transition leadership theory was applied, arguing that by engaging in SC alliances, circular design pioneers can take the role of transition leaders by engaging purposefully in facilitating the six collaborative aspects proposed in RQ 2. As such, a framework is developed for creating innovation communities and transition arenas, based on the transition management phases of Frantzeskaki et al. (2012).

Relevance of findings

These findings show that orchestrating industry transition is not only a task for policymakers, but pioneering industry actors can also initiate a grass-root level commitment across industry actors to enable a transition toward material reuse in the built environment. When pioneering companies to take the role of transition leaders, inter-organizational innovation communities can be initiated, engaging more private resources and capabilities in the explorative development of solutions for UM and reuse of secondary building materials. This call for a dual change of mindset in the industry and academia: Industry actors are encouraged to participate in the industry transition more proactively, and policymakers are encouraged to see industry actors as part of the solution to increase the market uptake of UM solutions in the industry.

Future research

During the research process, more knowledge gaps were found which lay beyond the scope of this project. Resultingly, the following are suggestions for future research in the area. BMUMs is a new research area and seminal research is lacking. Expanding the knowledge base and providing an overview of BMUMs by developing a typology would be relevant. Furthermore, the demand side of UM was understudied in this research project. Thereby, it is suggested to further explore how the design of BMUMs and downstream collaboration schemes could increase demand for secondary building materials. Lastly, it would also be relevant to test how well the findings from this study can be transferred to other industries. Specifically, testing the relevance of the collaboration framework and the transition management roadmap in industries with a reasonably similar value chain is encouraged.

Table of Contents

List of Figures

List of Tables

Abbreviations

BM	Business Model
BMI	Business model innovation
BMUM	Business Models for Urban Mining
CBM	Circular business model
CBMI	Circular business model innovation
CC	Circular construction
CE	Circular Economy
C&DW	Construction and demolition waste
GHG	Greenhouse-gases
LEG	Lendager Group
LEG CA	Lendager Group, Circular Advisory
GM	Gamle Mursten
SC	Supply chain
SCC	Supply chain collaboration
TMP	Transition management phase
UM	Urban mining
VC	Value chain

1 Introduction

Buildings are responsible for a great deal of environmental degradation through greenhouse gas (GHG) emissions and land disruption from raw material extraction. Circular economy (CE) is proposed as a new paradigm changing the building industry toward more resource-efficient practices. Specifically, urban mining (UM) is proposed as a practice that may offer an alternative for virgin materials, thereby decreasing the demand and the associated adverse effects on the environment. However, putting the principles of UM in practice takes a fundamental change in the current business models (BMs) and value chains (VCs) for buildings and building materials. Little is known about business models for urban mining (BMUMs) within the built environment, however, collaboration is proposed as a central aspect of the implementation of CE principles and thereby presumably also principles of UM:

> "One of the most important factors for accelerating circular thinking in the built environment is partnerships across the VC. Circular construction demands that you from the drawings, to the construction process itself, and the demolition collaborate on how to utilize the resources in the best possible way and avoid material waste" (Realdania, n.d.)

This subject will be the topic of investigation in the thesis project – to understand the role of VC collaboration in operating BMUMs in the built environment.

A Wicked Problem of Urban Expansion

Globally, the construction rates are growing at an unprecedented speed. With urbanization and population increase being the main driver, the built environment poses a wicked problem of meeting the social demand for safe and healthy homes while also being a significant contributor to global environmental degradation. The increased demand for housing drives urban development, ultimately leading to a significant increase in the built-up area (United Nations Environment Programme, 2017). And with new buildings, environmental degradation will follow. Currently, the construction industry is responsible for 40 % of the global energy consumption, 23 % of the global greenhouse gas (GHG) emissions and 40 % of the materials consumed globally (Benachio et al., 2020; Heesbeen & Prieto, 2020; Huang et al., 2018; J. Nußholz, Rasmussen, & Leonidas, 2019; Senaratne et al., 2021) and 32 % of the total waste generated in Europe (Castell-Rüdenhausen et al., 2021; European Commission, 2018). With more buildings these numbers are expected to increase despite the current efforts within sustainable construction.

To curb this trend, use-phase energy efficiency has been the primary lever targeted by industry actors and policy makers, however, emissions related to this is just one aspect of the environmental footprint of a building (Ding, 2014). The remaining are attributed to other aspects of the building industry and other life cycle phases of the building. While some are attributed to the use phase of a building (i.e. through energy consumption and heating) a large share of the life cycle footprint is embodied in the materials themselves through raw material extraction, transportation, and material production. Embodied carbon is proposed to be responsible for 40 % of the life cycle emissions of a single-family house (Fröberg et al., 2018) and is generally assessed to account for 10 to 60 % depending on the building type and material composition (Ding, 2014). As such, the production of construction materials alone constitutes a significant threat to human and ecological well-being through global warming, land disruption, and eco-system degradation with air, water, and soil pollution (Ding, 2014; Fröberg et al., 2018; Lomite & Kare, 2009; Marsh, 2017). And as demand for new buildings increases, so does the demand for construction materials, yielding an increasingly important role for embodied emissions in transforming the construction industry to meet the need for sustainable practices (Ding, 2014).

In the industry, the determining factors for choosing construction materials in the industry remain use-phase performance, aesthetics, price and convenience (Chang & Yujie, 2017; J. Nußholz, Rasmussen, Whalen, et al., 2019). The modus operandi of the industry is informed by a linear mindset, suggesting that material management follows a pattern of »take, make, waste« - take resources as cheaply as possible, make materials that meet the external requirements and discard them at end of service life (EoSL) as conveniently as possible. Resultingly, most industry actors have neglected to make holistic assessments of the building footprint as the steering instrument to inform decisions made in the design phase (Jones & Comfort, 2018). However, at the current rate, more natural raw materials are being extracted than what the natural systems can regenerate, pointing to an uncertain future in terms of material supply (Adams et al., 2017; Heesbeen & Prieto, 2020; Lange et al., 2022). Resultingly, builders experience increasing prices of building materials and supply chain volatility which combined with increased pressure from internal as well as external stakeholders have inspired a new wave in the industry going toward circular material management (Acharya et al., 2018, 2020; Adams et al., 2017; Lange et al., 2022; wbcsd, 2021). The increased interest in circular construction is also visible in the legislation and policy interventions and guidelines which are developed at an international, regional, and national level (Castell-Rüdenhausen et al., 2021). As such, some policy communities acknowledge the importance of the built environment in achieving a sustainable society, including the European Union (EU) which lists the construction industry as one of the priority sectors in their Circular Economy Action Plan (Bourguignon, 2016; Castell-Rüdenhausen et al., 2021).

The Potential of an Industry

Buildings and building materials are designed for long-lasting performance with a functional lifespan of at least 50-70 years and often even much more if maintained properly. However, most are demolished well before that as a result of a change in demand (Marsh, 2017; Munaro et al., 2021; Senaratne et al., 2021). With their façade, envelope, and load-bearing structure buildings are composed of multiple layers each with an individual expected lifetime (Leising et al., 2018). Ultimately, when buildings are demolished using destructive methods a vast amount of material value is oftentimes wasted. With the emergence of circular construction practices, an alternative setup based on the principles of the circular economy is proposed as a means of decreasing the environmental degradation associated with buildings by keeping the material at the highest possible value (Benachio et al., 2020; J. Nußholz & Milios, 2017). It does so by implementing circular principles and technologies in the construction processes, facilitating either upstream or downstream reuse of construction components and materials (Benachio et al., 2020; Çimen, 2021).

This yields a position for the construction industry among those with the highest potential for implementing circular strategies (Ajayabi et al., 2019; J. Nußholz & Milios, 2017). But designing a business model (BM) that can fulfil this potential is connected to a series of challenges (Adams et al., 2017). To name a few: Most buildings are not designed for disassembly so identifying and reclaiming the materials in good condition is a challenge. Current practices tend to degrade the material value, wasting high EoSL use-value resulting in low salvage value at end-of-service life. Each material and component have a series of technical challenges regarding reuse depending on its original design product specifications (Böckin et al., 2016). The unstable supply of secondary materials of specific quantities and product specifications is a challenge in designing buildings using reclaimed materials on a large scale (Ajayabi et al., 2019).

Multiple approaches are taken to implement circular principles within the construction industry: Performance economy, industrial ecology, regenerative design, UM, material upcycling, etc. (Senaratne et al., 2021). To effectively introduce these principles into the core of business practices, circular business models (CBMs) are proposed as an essential tool (N. M. P. Bocken et al., 2016; Lewandowski, 2016; J. Nußholz, 2017). When coordinated properly, systems for enabling the use of secondary materials can be implemented through business model innovation, delivering high-quality buildings with the same structural strength and with a significantly lower environmental footprint (Ajayabi et al., 2019; Çimen, 2021). Ultimately, CBM innovation is an essential lever for implementing circular strategies at the heart of organizational operations by reassessing core aspects of the business processes.

Denmark – A Circular Economy Innovation Hub

In this thesis project Denmark will provide the frame in which the question of how BMUMs are implemented.

In Denmark, the construction industry is due for 40 % of the national GHG emissions (Frederiksen & Johansen, 2022). The Danish built mass constitutes a resource bank of 820 mio. M2 and since 1986 the built-up area has increased by 70 %. Each year an estimated 2-3 mio. M2 is demolished which produces approximately 5 mio. metric tonnes of construction waste. That is 40 % of the total waste generated at a national level. (Teknologisk Institut, 2021)

The building and construction industry is therefore considered one of the most important industries to implement systemic change by the Danish Environmental Ministry and a key industry to transform to fulfil the climate law from 2020, pledging to decrease GHG emissions by 70 % by 2030 compared to the 1990-levels and to be fully climate neutral by 2050 (LOV nr 965 of 26/06/2020). Echoing the EU, Denmark has implemented an Action Plan for Circular Economy, also acknowledging the built environment as a key action area for creating value and mitigating climate risks through the implementation of circular design strategies (Miljøministeriet, 2021a, 2021b).

With ambitious pilot project utilizing UM and circular strategies such as Upcycle Studios, Resource Rows, Upcycle House and the Constable School (Preisler, 2021; Vandkunsten, n.d.; wbcsd, 2021) and a set of innovative companies with a circular mission at the core (State of Green, 2016), Denmark has received international attention for its circular construction and UM practices. As a result. Copenhagen has been chosen as the World Capital of Architecture 2023 by the UNESCO and the International Union of Architecture to showcase pilot projects and inspire for knowledge transfer and dissemination of best practices for sustainable construction (World Architecture Community, n.d.).

To frame a study of BMUMs in the construction industry, Denmark may pose a particularly interesting case. The policy settings are elaborate compared to international standards (Gustafson, 2019; J. Nußholz & Milios, 2017) and ambitious policies in the pipe-line, aiming to further develop the market for circular construction, UM and an escalated use of secondary building materials. Innovation is a particularly important aspect of industry competition providing a comparatively strong innovative culture amongst the niche companies (Lange et al., 2022; State of Green, 2016).

1.1 Innovation but no transition – problem statement

Despite the building industry showing high potential for creating and capturing value by implementing circular principles, a large scale industry implementation has yet to materialize. There are ambitious applications of the principles of UM and circular construction in the Danish building industry, however, it is mainly at niche level operated by relatively small companies in small scale. A group of circularity front-runners in the industry have engaged in radical business model innovation (BMI), displaying intrinsic motivation for leading the way for the wider industry and to take on increased risks when experimenting with UM. In the broader audience CE is a growing topic, receiving increasing recognition and attention by industry actors (Adams et al., 2017). But while awareness of circular economy may be rather high across the construction industry at a conceptual level, industry diffusion of circular principles is slow (Benachio et al., 2020; Çimen, 2021). At an industry level, BMI to facilitate an increased application of circular principles amongst the incumbent firms remain only incremental (Chang & Yujie, 2017; Çimen, 2021). Resultingly, ambitious circular principle are not implemented industry-wide which prevent it from making a significant difference in the industry-wide environmental footprint.

A main reason for the slow industry diffusion is due to technological, institutional and cultural lock-ins to linear construction practices and a lack of understanding on how to implement circular principles in practice (Adams et al., 2017; Benachio et al., 2020). As the literature review of the present thesis project will show, the current body of academic literature and practical knowledge amongst practitioners have yet to identify how to move beyond the ambitious pilot projects and make reuse of construction materials and components mainstream.

Research suggest that a key tool to loosen the above mentioned lock-ins and engage in transformational innovation is increased collaboration across the value and supply chains (Ajayabi et al., 2019; Chang & Yujie, 2017; Jones & Comfort, 2018; J. Nußholz & Milios, 2017). Collaboration along the VC is a central tool for smoothing business operations which is an essential aspect enabling CBMs, considering that circular VCs often depend on much more complex networks, introducing reverse logistics, advanced and enhanced information networks, and life-cycle perspectives (Berardi & de Brito, 2021; Leising et al., 2018). As such, designing and operating a circular supply chain is a central part of operating a CBM and should be at the very center of any business model innovation (Frederiksen & Johansen, 2022; Geissdoerfer et al., 2018; J. Nußholz, 2017).

Looking at the Danish market for secondary construction material, you see that actors organize themselves and their supply chains differently to accommodate these needs (as will be illustrated in this paper). Some engage in more or less formal inter-organizational partnerships while others expand their internal operations across the VC. Yet others navigate informal networks of industry actors to accommodate their supply needs. Resultingly, organizations develop different collaborative capabilities which may be an influential factor for business success and industry impact (Berardi & de Brito, 2021). However, there is a limited understanding of how the different collaboration strategies influence the potential success and large scale implementation of CBMs. The knowledge gap is two-fold:

iii) There is a limited practical understanding of how organizational aspects can enable successful BMUMs;

iv) There is a limited theoretical understanding of UM within business and organizational studies.

This thesis project will aim to fill this knowledge gap, exploring the role of collaboration strategies in operating BMUMs. The danish building industry will be taken as a frame within which case companies will be chosen.

Specifically, I will investigate how these case companies has engaged in collaborative schemes and restructured their VCs to enable BMUMs. I will do so by conducting a comparative case study of two companies. It will explore how business model configurations and collaborative schemes can influence industry dynamics and transition pathways, increasing the industry-wide level of engagement within reuse of building materials and components.

1.2 Defining a study - Research questions

During the project, answers to the following research questions will be pursued:

> RQ 1: How do the case companies organize their supply chains to facilitate business models for urban mining?
>
> > SQ 1.1: What role does inter-organizational collaboration play in their supply chain operation?
> > SQ 1.2: Which collaborative strategies are employed by the case companies?
>
> RQ 2: What aspects are influential when developing and operating a collaborative strategy for urban mining?
>
> > SQ 2.1: How well does the conceptual framework developed by Leising et al (2018) fit long-term collaborative supply chain strategies?
>
> RQ 3: How can supply chain collaboration influence industry transition toward large scale implementation of urban mining principles and reuse of building materials?

Answering these questions is a gradual process where answering one question is instrumental for answering the next.

The first questions seeks to describe what is happening on the Danish market for reused construction materials. It seeks to explore operational aspects of BMUMs and how this relates in interorganizational collaboration. This is the primary arena for presenting empirical data, applying an explicit focus on the case companies, their context, and experiences in operating BMUMs.

The second question aims to unfold the cases by applying selected theoretical frameworks. Through the case studies, influential aspects for operating supply chain partnerships will be identified and their relevance to effective collaboration will be explained. As the outcome of this section a theoretical framework for SC collaboration is presented.

The third question will explore how VC collaboration can influence industry transition patterns based on transition management theory (Frantzeskaki et al., 2012; Hansen & Schmitt, 2021) highlighting important aspects of accelerating transformation processes toward a more mainstream use of secondary construction materials through grass root commitment based on this particular theory. Perspectives from transition management theory will found the basis of a roadmap for how pioneering companies can operationalize the collaboration framework developed by answering RQ 2 to take a role as transition leader.

In section 2 a review of relevant literature will situate the thesis, and describe current practices and knowledge related to collaborative initiatives to enable CE in the building industry. Following, in section 2.7, is a presentation of the theoretical framework used for analysis. In section 3 the methodology behind the analysis is described, followed by a presentation of the results from data collection in section 4, presenting the two case studies (thus answering RQ 1). Section 5 initiates the conceptual analysis, first by presenting the adapted Leising et al. (2018) framework for effective collaboration (answering RQ 2), then by relating it to transition management theory, providing a tool for initiating industry transition through SC and VC collaboration (answering RQ 3). Section 6 will discuss the relevance of the findings and suggest future research and section 7 will conclude the thesis.

2 Current knowledge – A literature review

The following sections will provide an account of the current literature, exploring the practical and academic context in which the project will be placed. It will form a review of relevant literature, providing an overview of the current industry practices and the potential for implementing BMUMs. As such, it will present the current consensus found in the reviewed literature and identify underexplored areas and knowledge gaps that this thesis project will aim to fill.

Section 2.1 will introduce the concept of CE and CBMs in relation to UM in the built environment. This is followed by Section 2.2, which is an overview of the literature reviewed as part of this project. Then the dynamics and characteristics of the construction industry are presented in Section 2.3 . This will be followed by Section 2.4, presenting the Danish settings in terms of industry trends and the policy context. Section 2.5 introduce the concept of value chain (VC) collaboration in the building industry, followed by a presentation of the knowledge gaps identified in during the literature review. Lastly, an analytical framework used during the data collection will be presented.

2.1 Circular economy in the building industry

The circular economy (CE) is proposed as a concept for achieving sustainable development by enabling resource-efficient prosperity by minimizing resource input, waste generation, energy consumption, and the environmental degradation associated with it (EMF, 2015; Geissdoerfer et al., 2018; Senaratne et al., 2021). While multiple definitions of CE prevail, the one from Geissdoerfer et al. (2017) is widely used. They define CE as:

> "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling". (Geissdoerfer et al., 2017)

In a broader context, CE is an industrial-economic approach founded on three main pillars: i) the removal of pollution and waste along the life cycle, ii) keeping products and materials in use as long as possible, and iii) regeneration of the natural systems in the process (Çimen, 2021). A key objective of CE is to design out waste by discontinuing linear material flows, replacing them with technically or biologically cyclical processes maintaining the material value throughout the processes (EMF, 2015).

Business models (BMs) in the building industry are proposed to have a central role in mainstreaming principles of CE across the industry and integrating circular practices at the core of business operations. Since its initial development by Osterwalder & Pigneur (2010), the business model concept has been adapted to the context of sustainable development under the names Business Models for Sustainability (Breuer et al., 2018; Roome & Louche, 2016a) and circular business models (CBMs) (Bocken et al., 2016; Lewandowski, 2016; Nußholz, 2017, 2018).

While multiple definitions of CBMs are provided in the literature, this thesis project applies the following definition proposed by Nußholz (2017):

> "A circular business model is how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending *the* useful life of products and parts (e.g., through long-life design, repair, and remanufacturing) and closing material loops" (Nußholz 2017)

Essentially, CBMs align their value proposition to the core principles of CE making it feasible through supportive value creation and delivery, and value capture mechanisms (Heesbeen & Prieto, 2020; Nußholz, 2017) ultimately slowing, narrowing, and closing resource loops (Bocken et al., 2016). As such, circular construction provides an approach to creating value from building projects while minimizing its associated lifecycle energy consumption, natural resource extraction, and waste generation. Leising et al. (2018) propose a definition in which circular construction is:

> "a lifecycle 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 the building that acts as a material bank" (Leising et al., 2018)

In the context of buildings, CE is to use practices throughout all life cycle stages of a building, to keep the building materials in a closed loop as long as possible, and to reduce the extraction of virgin natural resources associated with a building project (Senaratne et al., 2021).

While multiple typologies exist outlining the different approaches to implementing circular construction (ARUP, 2016; Lange et al., 2022), one in particular explicitly applies a business model perspective on the matter. Heesbeen & Prieto (2020) have developed a typology for how CBMs are implemented in buildings, offering five distinguishable approaches for slowing, narrowing, and closing material loops: Smart input, smart output, stewardship model, adaptable buildings, and never-ending buildings (for an elaborate outline of the strategies see Appendix I - Business models for circular construction). The Archetypes are rarely operated in isolation and actual BM within circular construction may include several of them. Narrowly focusing on only one may lead to suboptimal life-cycle performance. Resultingly, to ensure a net-positive impact from the implementation of the CBM, a holistic assessment of how it relates to the archetypes is crucial (Heesbeen & Prieto, 2020).

Urban mining (UM) is proposed as a key strategy for closing the technical material loops, by utilizing anthropogenic material stocks to provide feed-stock for new buildings (Aldebei & Dombi, 2021; R. Arora et al., 2017). Researchers have yet to agree on a common definition of UM, but this thesis chooses to apply the following. UM is:

> "Utilizing anthropogenic urban material stocks to its fullest, redirecting material flows" (J. Nußholz, Rasmussen, Whalen, et al., 2019).

UM itself is the act of retrieving material from an anthropogenic environment, however, this is mainly relevant if they are reused or recycled upon extraction, redirecting material flow through circular design and upcycling. As such a key target for BMUMs, according to the Heesbeen & Prieto (2020) framework, is to ensure smart input and smart output. This has the potential to decrease the environmental footprint of buildings significantly while continuing to generate value in the form of new building projects, thus minimizing the dependency on virgin materials when building new houses (Aldebei & Dombi, 2021; M. Arora et al., 2020). Resultingly, the industry can »grow from within« which is in the pursuit of sustainable city development (Ajayabi et al., 2019). However, while the concept of CBM is well developed and some BM frameworks are also developed in the context of the building industry (Eberhardt et al., 2020; Heesbeen & Prieto, 2020), the subject is largely understudied when it comes to UM. Chesbrough argues that: "a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model" (2010), suggesting the power associated with a solid BM. They are proposed to play a key role in balancing efforts to provide environmental benefits, operational effectiveness, and economic viability offering full-scope win-win value propositions across the VC (Debacker et al., 2017; J. Nußholz, Rasmussen, Whalen, et al., 2019). This is a crucial aspect of commercializing material reuse and achieving the potential to make large-scale changes in the industry (Bidmon & Knab, 2018; Debacker et al., 2017). This indicates that to make UM applicable beyond niche level pilot projects, careful consideration should be put into how BMUMs are configured.

2.2 Current literature

This overview is based on an elaborate review of literature related to UM and circular economy (CE) in the building industry. It has been found that literature on UM is highly connected to the literature on CE in general, and the topic is mainly explored in connection to other CE strategies. The review will there take a starting point from a broader perspective on CE in the built environment.

The review found that studies arguing for the relevance and urgency of implementing CE strategies in the built environment are the most frequent research type in the body of literature related to circular construction. This includes studies displaying the environmental impact of linear construction patterns and drivers and barriers to implementing the CE principle in the built environment. Such studies are found in academic literature (Eberhardt et al., 2020; Hart et al., 2019; Lomite & Kare, 2009; Marsh, 2017; Ness & Xing, 2017; Zanni et al., 2018) and grey literature (Acharya et al., 2018, 2020; ARUP, 2016; Lange et al., 2022; State of Green, 2016; Thelen et al., 2018; wbcsd, 2021). These studies are instrumental to support interest diffusion and create a sense of urgency within the topic, which can help introduce it to new research communities and industry actors. These studies often take a macro perspective discussing CE at a conceptual level and societal development at large.

Contrary to this, is the literature assessing the circularity of individual initiatives at a micro-scale. This research is often conducted by independent university researchers doing case studies of companies, and technologies showcasing the actual implementation of circular principles (Ajayabi et al., 2019; Böckin et al., 2016; Nußholz & Milios, 2017; Zanni et al., 2018). The technological research communities have been engaged in R&D to develop specific marketable solutions manifesting circular strategies in product innovation. Research in this field develops technical solutions facilitating the implementation of circular principles in the development of new products and technologies. This includes research on circular materials applying an industrial ecology perspective by utilizing (industrial or municipal) waste streams as construction material input or designing building techniques that enable value preserving end-of-service-life reuse of built-in materials and components. Various actors contribute to this end, including architectural firms developing flexible and circular building designs incorporating innovative solutions (i.e. GXN, Vandkunsten, ERIK, Lendager Group, etc.) or technical universities exploring properties and performance of the materials using life-cycle analysis (LCA) and various modeling techniques (Ajayabi et al., 2019; BUILD, n.d.; Ding, 2014; Fröberg et al., 2018; Teknologisk Institut, 2021).

A group of researchers has identified barriers that must be overcome for the large-scale implementation of the above innovations to take place. These highlight specific challenges within the industry culture, structure, and dynamics and are mainly explored by a social scientists (Adams et al., 2017; Castell-Rüdenhausen et al., 2021; Debacker et al., 2017; Hart et al., 2019; Rohracher, 2001). Furthermore, industry surveys have been conducted, showing the current state of mind within the industry. These show that many companies are aware that implementing circular solutions is important to position the company in a futures market, which is more environmentally conscious and in which resource scarcity leads to more volatile prices for virgin materials and greater threats to the supply chain stability. However, they also show that many actors do not know how practically develop successful business models based on circular principles (Adams et al., 2017; Benachio et al., 2020; Çimen, 2021; Hart et al., 2019).

Scholars of business have developed practical and conceptual frameworks for how the lock-in effects can be mitigated by the use of management theory, organizational theory, and business model innovation (N. M. P. Bocken et al., 2016; Lewandowski, 2016; J. Nußholz, 2017). They aim to develop methods for operationalizing technological innovation in a socially realistic, just, and efficient way. The CBM theory provides a suite of theoretical frameworks for visualizing the alignment between the value proposition, value creation, and delivery, and the value capture mechanisms according to the circular principles of slowing, narrowing, and closing resource loops. Some researchers have applied CBM theory specifically to the construction industry (Eberhardt et al., 2020; J. Nußholz, Rasmussen, & Leonidas, 2019; J. Nußholz, Rasmussen, Whalen, et al., 2019; J. L. K. Nußholz & Milios, 2017) and they have found that while the overall CBM framework applies to the industry, the established CBM archetypes are ill-fit for buildings due to wildly different use phase characteristics compared to conventional products and consumables (Çimen, 2021; Heesbeen & Prieto, 2020). Theoretical archetypes better fitting to the characteristics of the construction industry have therefore been developed (Heesbeen & Prieto, 2020; Superti et al., 2021).

To consolidate the knowledge produced in the above research streams, literature reviews have collected the otherwise scattered information ultimately contributing to defining a robust and important research area (Antwi-Afari et al., 2021; Benachio et al., 2020; Çimen, 2021; Munaro et al., 2021).

The role of collaboration in enhancing circular construction has been investigated by researchers from social science, business, and supply chain (SC) management (Berardi & de Brito, 2021; Hansen & Schmitt, 2021; Leising et al., 2018; Senaratne et al., 2021). They find that systemic change toward closing the loops of building materials takes systemic collaboration across many actors over a long time horizon (Chang & Yujie, 2017; Frederiksen & Johansen, 2022; Leising et al., 2018; J. Nußholz & Milios, 2017; Senaratne et al., 2021) and that increased collaboration is often connected to improved market performance (Heimeriks, 2008; Leischnig & Geigenmüller, 2018). Particularly inter- and intraorganizational SC collaboration has been proposed by SC scholars to be a means of ensuring alignment between the SC activities, increasing BM efficiency and effectiveness. The issue of transaction costs has been raised in this literature and key aspects for engaging in meaningful inter-organizational partnerships have been proposed (Barratt, 2004; Geigenmüller & Leischnig, 2017; Khalfan et al., 2004; Leischnig & Geigenmüller, 2018; McDermott & Khalfan, 2012). Later research intersects collaboration theory and circular buildings, highlighting the need for interacting across various life cycle stages in the development of circular building projects (Chang & Yujie, 2017; Leising et al., 2018; Munaro et al., 2021; J. Nußholz & Milios, 2017). However, this has mainly been focusing on project-based collaboration, taking specific construction projects as cases. More research could be done in understanding the broader strategy of how companies in the construction industry are organizing themselves at a BM level to enable the implementation of UM and circular principles. From a business model perspective, circular buildings are still a relatively new research field with a rapid increase in interest during recent years (Çimen, 2021; Leising et al., 2018), and UM is an even newer field of study in the context of the building industry. This research stream is primarily investigating technological solutions for identifying and utilizing secondary materials through digital solutions such as geographic information systems (GIS), Building information modeling (BIM), artificial intelligence (AI), and machine learning. Business models based on UM principles are largely underexplored and mainly mentioned as an example in more general CBM typologies (Aldebei & Dombi, 2021; Heesbeen & Prieto, 2020).

Multiple frameworks for understanding CBMs have been developed, but case studies of successful implementation strategies within circular construction are lacking (Munaro et al., 2021). Resultingly, while many companies within the construction sector have CE on their radar, they are reluctant to implement circular strategies in their operations due to uncertainty on how to do it and how this will influence their competitive position in the market (Adams et al., 2017). While the importance of collaboration across the VC is well established in the CBM literature, actual collaboration strategies implemented in pioneer companies are under-studied and how these relate to transition theory and broader societal transition pathways could benefit from being elaborated (Leising et al., 2018).

2.3 Characteristics of an industry

While buildings in many ways transcend what is usually thought of as a product, applying product terminology may reveal some characteristics which are influential to the potential success of BM configurations. Thinking of building with a product terminology shows that they have a long product lifecycle, are highly complex consisting of many layers and materials, often rather unique in their original design, material content, and state (Benachio et al., 2020; Munaro et al., 2021). These are all influential for the large-scale implementation of BMUMs. Raising the perspective from components and materials, and taking a look at the industry as a whole, a combination of informational, practical, legal, structural, and cultural aspects are barriers to the industry-wide application of UM.

2.3.1 Barriers to market creation for circular construction

The informational barrier makes it difficult to get the right information at the right time to enable decisions to apply selective demolition techniques or not. The long building lifecycle makes life cycle thinking and information exchange between relevant actors more challenging. Lack of information on the quality and content of the building stock and how to properly dismantle it at end of service life (EoSL) is a key issue in designing BMUMs in the building industry (Benachio et al., 2020). This emphasizes the role of detailed and systematic project and product documentation in facilitating the identification of construction materials and components that are fit for reuse (Benachio et al., 2020; Heesbeen & Prieto, 2020).

The practical barriers are highly related to the challenges faced at a material level. However, there is also the challenge of identifying potential secondary materials in time, utilizing selective demolition techniques to retrieve them while preserving their value, and finally orchestrating reverse logistics (Gorgolewski, 2019). Making the secondary materials available at the right place at the right time is a major challenge for providing a stable and steady supply chain (Eberhardt et al., 2020)). Furthermore, the presence of toxic substances such as asbestos, PCBs, and toxic heavy metals in construction waste is a major challenge in the large-scale reuse of construction waste (Teknologisk Institut, 2021).

In the case of CE, policy and legal instruments are both a driver and a barrier to systems transformation (Frederiksen & Johansen, 2022). The legal barriers are related to the quality assurance of secondary materials. As described above most construction legislation (including building regulations) tend to prioritize quality assurance, use-phase efficiency, and safety over the implementation of circular construction principles (Castell-Rüdenhausen et al., 2021). At a material level, the main challenge is the need to earn the European CE quality certification[1] to make it legal on the EU inner market according to product-specific European Harmonized Standards (Regulation (EU) 305/2011). While research shows that in many cases the construction materials can preserve structural strength if treated properly during the demolition (Ajayabi et al., 2019; Çimen, 2021), developing a methodology for systematically proving it is a significant challenge for industry actors, holding back the development of secondary construction materials (Debacker et al., 2017; Lange et al., 2022). Construction material

[1] Not to be confused with the abbreviation for Circular Economy.

legislation does not differentiate between virgin materials and recycled materials, which is a major barrier to large-scale implementation of secondary construction materials (Castell-Rüdenhausen et al., 2021; Debacker et al., 2017; Lange et al., 2022).

Furthermore, the materials need to prove performance in terms of fire safety and health and meet the requirements of the Danish Building Regulation (BR18). If the materials do not meet the requirements, the contractor can apply for exemption, however, this process can be demanding and time-consuming. While constituting a barrier to material reuse, BR18 also neglects to provide an incentive for circular innovation. It states no rules regarding the use of circular construction practices, creating no incentive for adapting to circular standards. Ultimately, while laws assuring the quality of construction materials may be necessary, there is a need for policies that support circular construction rather than holding it back (Frantzeskaki et al., 2012; Munaro et al., 2021).

As a structural barrier, the construction industry is large and consists of a complex network of interdependent stakeholders. Actors in the industry often engage in temporary project clusters based on a combination of contractual agreements and informal norms (Frederiksen & Johansen, 2022). During construction projects, there is often one main contractor, which then hires several subcontractors to deliver sub-tasks and project management work packages. While strict requirements are set to ensure that the work packages fit the rest of the building, seamless integration of cross-company information structure, data management standards, and shared objectives is rare (J. Nußholz & Milios, 2017; Senaratne et al., 2021). The other way around, because of this delegation approach, the agency of individual companies is often limited to one part of a building and one step in the building life cycle (Debacker et al., 2017). There is a lack of actor involvement and information transformation across sub-tasks and life cycle steps (Debacker et al., 2017; Senaratne et al., 2021). Change processes are often depending on systems collaboration across a diverse set of actors, across multiple life cycle steps, and during long time horizons, and resultingly, holistic intervention is often perceived as beyond the scope of most individual companies which yields no clear process owner of enforcing coherent holistic interventions. (Ajayabi et al., 2019; Çimen, 2021; Debacker et al., 2017; Frederiksen & Johansen, 2022; J. Nußholz & Milios, 2017)

The structural setting of the industry builds a cultural barrier preserving the status quo, which ultimately brings the second category of barriers to the implementation of UM – a fragmented and highly competitive industry culture (Munaro et al., 2021). The high competition between actors brings a rather one-sided focus on price, with actors aiming to out-bid competitors by pushing these prices as low as possible while still delivering on the agreed-upon deliverables (Nußholz, Rasmussen, Whalen, et al., 2019). This leaves little room for maneuvering in terms of reaching other goals than physical characteristics and budget, i.e. sustainability performance or the implementation of new techniques which enable value-preserving dismantling. Furthermore, any expenses that are considered non-essential for delivering on the agreed-upon deliverables, including research and development for new construction materials and techniques are often not prioritized, leaving a rather conservative industry position in terms of pushing for performance-improving innovation (Debacker et al., 2017; Miozzo & Dewick, 2004). Implementation of cost-driving attributes is mainly considered only to the extent where they are either necessary to meet relevant legislation or if it can lead to price premiums on the market to absorb any upfront increases in cost. Furthermore, construction projects are often operated with a tight project management schedule, where everything is interdependent and unforeseen events can therefore be a major headache. These dynamics foster a highly risk-averse management style, where certainty in the outcome, timing, and cost is key. As a result, the actors are often deeply embedded in the established way of doing things regarding designs, design processes, manufacturing and construction techniques, supply chains, and financial arrangements (Chang & Yujie, 2017; Debacker et al., 2017; Munaro et al., 2021).

A final category of barriers is the cognitive barriers. In the industry, there is a limited understanding of the benefits of from reuse of construction materials (Nußholz, Rasmussen, Whalen, et al., 2019). This creates a perception-reality gap hindering the industry from embracing circular practices (Debacker et al., 2017). Lastly, a lack of knowledge on how to implement efficient recovery infrastructure for secondary construction materials hinders the large-scale implementation of circular practices in general (Benachio et al., 2020; Debacker et al., 2017) but also specifically in Denmark (Frederiksen & Johansen, 2022).

Linear construction standards

⬇

Barriers					
Informational	**Practical**	**Legal**	**Structural**	**Cultural**	**Cognitive**
Lack of: • Data availability • Knowledge transfer	• Low R&D • Increased up front cost of demolition • Reverse logistics operation • Material toxicity & contamination (i.e. PCB)	• CE Quality assurance certification • BR18 safety requirements	• Industry fragmentation • Silo-thinking • Competition based • Lean project management	• Cost-consciousness • Status quo preserving elite • Power asymmetry • Risk aversion	Lack of • implementa-tion expertise • acknowledge-ment of urgency

⬇

Industry transition toward urban mining and circular buildings

Figure 1. Overview of barrier to the transition from linear to circular construction practices (Authors own visualization)

To summarize, building materials have a high potential for preserving value through the implementation of circular principles. However, it depends on a series of choices made throughout the material and building lifecycle. These choices are made by a diverse set of actors who are not communicating to the extent necessary to facilitate coherent change processes for the systematic implementation of UM principles. To implement circular strategies, such as UM and material reuse, a new way of thinking and doing things in the industry is needed (N. M. P. Bocken et al., 2016).

2.4 Construction in Denmark

Following the introduction of the building industry in general, this section will narrow the scope to the setting in which this case study is situated, Denmark.

2.4.1 Policy background

As indicated previously, the legal setting of an economy influences innovation and the speed at which industry transitions toward sustainable resource-efficient practices may occur.

The Danish policy targeting the built environment is highly influenced by that on the EU level, but to reach the climate law (LOV nr 965 of 26/06/2020) obligating the government to achieve emissions reductions of 70 % compared to the 1990 levels by 2030 and to by climate neutral by 2050, additional initiatives are taken individually by the Danish government as well.

The state plays a key role in the current development of sustainable construction practices by pulling on a combination of levers including direct building regulation, and indirect incentive mechanisms through subsidies, and waste management fees. The main legal instrument for the Danish construction sector is The Danish Construction Law (BL). BL is a Framework Law stating the overall principles of the building regulations. More specific regulations on minimum requirements are found in the Building Regulation 2018 (BR18), which is a performance-based construction standard stating a series of functional requirements that all buildings must achieve. The functional requirements neither provide nor enforce specific guidance on how to achieve the functional requirements of the building. Guidance for how to achieve the given requirements is specified in a subset of policy documents developed by relevant authorities including The Institute for Construction, City and Environment (BUILD) and Danish Standards (BUILD, n.d.; DS, n.d.). In 2023 a tightening of the requirements is expected to come with the introduction of Building Regulation 2023 (BR23), a policy update to BR18. BR23 is currently introduced as a volunteer trial period for industry front-runners before it enters into force. This includes strengthened requirements for the assessment of buildings' life cycle impacts, more elaborate documentation requirements, and a maximum carbon footprint of 12 kg pr. m2 for large buildings (Bolig & Planstyrrelsen, n.d.; Realdania, 2020). Compared to the international standards, the Danish policy environment is relatively well-developed and recognized as one of the most ambitious (Gustafson, 2019; J. L. K. Nußholz & Milios, 2017). But while legislation is well-equipped to incentivize some aspects of sustainability, measures for enhancing building circularity have largely been neglected, as legislation for construction waste is separate from the building regulations. The danish construction waste legislation is currently highly influenced by the EU standards. At an EU level, the construction industry is considered a priority industry in the first EU Circular Economy Action Plan (EC COM(2015) 614) which was developed to promote the implementation of circular solutions. Five years later, this was followed up in the second Circular Economy Action Plan (EC COM(2020) 98) in which the reuse of secondary construction materials is highlighted as a key action area to achieve the 2030 agenda (Castell-Rüdenhausen et al., 2021; Heesbeen & Prieto, 2020). This is echoed by the Danish government in its National action plan for CE pursuing the fulfillment of the Danish Climate Law. The EU Waste Framework Legislation (WFD 2008/98/EC, amended 2018/851) regulates the waste management flow of member states, aiming to redirect material flows to higher steps in the waste hierarchy. This legislation puts a national minimum boundary for material reuse, requiring EU member states to collect a minimum of 70 % of the construction and demolition waste (C&DW) for recycling. When transposed to danish legislation (which is done in VEJ nr 9139 of 25/02/2019) this is achieved by requiring on-site waste separation to facilitate appropriate management of the materials. In practice, this means that the waste streams are separated based on potential usefulness and intended end destinations. Further source separation is established at own initiative to minimize the costs associated to waste management which correlates to the quality and usefulness of the waste. To minimize the risk of hazardous substances contaminating the waste streams a screening for such substances is required during the pre-demolition planning. In the Danish industry, 36 % of the C&DW is reused or recycled in the production of new building materials, and 52 % is utilized for other material purposes including road filling (Lange et al., 2022). While this leaves the rate at 88 %, which is well above the EU target, and only leaves 7 % for energy recovery and 5 % for landfills, much of the reuse is low-grade recycling which fails to maintain the material value and does not significantly offer an alternative to valuable natural materials. Even though 88 % of the C&DW is recycled, far less ends up in new buildings (Lange et al., 2022). Ultimately, while performing well compared to the EU requirements, the legal system largely neglects to create an incentive for selective demolition and material reuse resulting in most demolition waste being downcycled.

To close this gap, legal measures are in the pipeline to increase incentives for circular construction practices following the Danish Circular Economy Action Plan mentioned earlier. Two initiatives in particular are can be central for the implementation of BMUMs. First, selective demolition is expected to be required by law from 2023 meaning that source separation is required from demolition sites yielding more clean waste streams that are more easily reusable and recyclable. Secondly, it is expected that the mandatory pre-demolition screening for hazardous substances (PCBs, asbestos, etc.) will be expanded to include a full pre-demolition audit to assess the reuse potential of the building components and materials. These legal initiatives are expected to increase the interest in UM and help push industry actors to engage more widely in selective demolition and material reuse. (Miljøministeriet, 2021b; VCØB, 2022).

At a municipal level, Green Public Procurement is a particularly important tool at a regional level, initiating change in the industry by setting high standards for public construction projects. One example is the Handbook for Circular Economy enforced by Construction Copenhagen, the construction developer responsible for all public construction projects, which states progressive requirements for material management and project documentation – including requirements to recycle bricks of sufficient strength from all public demolition projects (Byggeri København, 2022).

2.4.2 Industry practices

As discussed earlier, construction materials are well suited for reuse and value retention depending on how they are treated throughout their life cycle (Ajayabi et al., 2019). In the Danish building industry, the reuse of building components (windows, doors, etc.) is more common as they are easier to identify and extract without compromising their value. Furthermore, components are often produced in standard measures which makes direct reuse in new building projects easier (VCØB, n.d.). At the material level, wood and bricks are amongst the materials which are most commonly reused, primarily because of the simplicity of the products. Direct reuse of concrete slabs is theoretically possible but far from common practice, instead, concrete products are indirectly reused in crushed form as concrete aggregate for onsite concrete casting. However, composite sandwich slabs are more difficult to recycle due to complex material combinations. Steel and metal products are commonly recycled, however, oftentimes as low-value rebar due to the uncertainty of the alloy-specific properties of the material (VCØB, n.d.). The key lesson is that the potential reuse needs to be assessed at a material level considering general material attributes such as the exact content, but also site-specific attributes such as the material state, potential on-site treatments, or contamination during the original construction phase or the use-phase (Böckin et al., 2016). In the current practices of the Danish construction industry, materials that could have been upcycled are instead downcycled as road filling because they end up in the wrong pile during demolition (Lange et al., 2022; Teknologisk Institut, 2021).

However, a movement toward more circular construction practices has emerged in the industry, spearheaded by industry front runners. This creates a dynamic where a small elite of circularity front runners experiment to develop radical solutions for industry transition despite the systemic barriers, while the more conservative actors maintain the status quo, implementing only incremental performance improvements driven by external stakeholder pressure.

Multiple frameworks, rating protocols, and certification schemes have been influential in the development of sustainable construction in Denmark. This includes particularly the German certification scheme Deutsche Gesellschaft für Nachhaltiges Bauen (DGNB), which is the most influential building certification scheme in Denmark and is managed by the Green Building Council Denmark (GBC DK, 2022). However, also other certification schemes and protocols play a role, including the Building Research Establishment Environmental Assessment Method (BREEAM) and the US Green Building Council's Leadership in Energy and Environmental Design (LEED) (Castell-Rüdenhausen et al., 2021).

2.5 Collaboration as an enabler for urban mining

Collaboration is often identified as important for the successful implementation of CBM (Berardi & de Brito, 2021; Debacker et al., 2017; Frederiksen & Johansen, 2022; Hansen & Schmitt, 2021; Leising et al., 2018; J. Nußholz, 2017; Senaratne et al., 2021), and an integral part of managing business performance and operations (Khalfan et al., 2004; McDermott & Khalfan, 2012; Miozzo & Dewick, 2004).

Collaboration is a widely used term and across literature, it is linked to multiple meanings and definitions. This thesis project will use the following definition:

> "Value chain collaboration is the activity in which different steps of the value chain interact to align efforts to create synergies and maximize value creation." (Authors own definition)

This form of collaboration may occur as coordination internally between departments of a company (intra-organizational VC collaboration), or between multiple different companies (inter-organizational partnerships) depending on the organizational configuration of the company. Collaboration provides a framework to let organizations co-evolve over time to adapt to otherwise incomprehensible challenges through shared information flows, actor learning, innovation, inter-disciplinary stakeholder involvement, and a long-term and processual focus (Frederiksen & Johansen, 2022; Leising et al., 2018). Different theoretical perspectives have been taken on inter-organizational collaboration. Transaction Cost Theory (TCT) propose that companies should structure their collaborative networks in such a way that minimizes the cost of transactions (in terms of time and resources spent) and risk of opportunism and maximize the positive outcome of such transactions (Dyer, 1997; Williamson, 1979). On the other hand, Resource-Dependency Theory focuses more on inter-organizational power relations in managing the organizational structure, arguing that an organization should utilize external resources and capabilities while minimizing the dependency on individual external factors (Pfeffer & Salancik, 2003). Vertical integration is proposed as an important factor to consider in achieving these ends.

During the past decades, the construction industry has increasingly implemented measures related to these theories, with an increased focus on supply chain management theory, engaging in partnerships as a means to drive efficiency in operations and minimize uncertainty (Frederiksen & Johansen, 2022; Khalfan et al., 2004). However, since the emergence of the CE agenda in the construction industry, supply chain collaboration is proposed to have much untapped potential, reviving the discussion of TCT and RDT:

> "If a circular market is to be established, it can be necessary to activate the various competencies, resources, and development potentials, which are embedded in the external actor environment" (Frederiksen & Johansen, 2022, p. 206).

This calls for ways of utilizing external resources and competencies and increased coordination of workflows across the SC to enable circular market creation. Miozzo & Dewick (2004) argues that Denmark has comparatively strong collaborative networks in the industry, spearheaded by governmental demonstration projects to encourage process innovation, which the recent

TRUST- and DSP-plus-alliances (Jakon, n.d.; TRUST, n.d.) initiated by the City of Copenhagen is a great example of. Furthermore, there are examples of private initiatives from architects and material developers to engage in collaborative projects aiming to coordinate better, pool resources, and share risks to enable circular product innovation (Frederiksen & Johansen, 2022; Lange et al., 2022; Matrai, 2019; Miozzo & Dewick, 2004; State of Green, 2016; Teknologisk Institut, 2021). But while collaboration is by no means new within the construction industry, strategies for engaging in collaborative networks and how this may enable CBM innovation are not studied in greater depth (Berardi & de Brito, 2021).

2.6 Specifying a knowledge gap

Secondary material sourcing brings new requirements to the communication and cooperation across the material journey. Inter-organizational collaboration is proposed as an important aspect and a potential game-changer for implementing innovative and successful CBMs and BMUMs (Frederiksen & Johansen, 2022; J. Nußholz, 2017). Different collaborative strategies have appeared across the industry, however, little is known about the industry actors' experience of operating such collaborative schemes and how this might influence an increased uptake of UM practices in the built environment.

In a Danish context, collaborative alliances have been investigated at a project or project portfolio level (Frederiksen & Johansen, 2022). But efforts in identifying long-term success criteria are largely not available: "It is surprising that a more strategic and long term perspective has not been implemented across the value chain. However, the innovative collaborative network can serve as an empirical knowledge bank and a foundation for a broader circular and innovative market creation" (Frederiksen & Johansen, 2022 - authors own translation).

Leising et al. (2018) provide a framework for understanding the dynamics between collaborating organizations in construction projects, but no such framework exists for long-term supply chain collaboration. However, adapting the Leising framework may make it capable of assessing medium- and long-term collaboration schemes as well. This could bridge two theoretical frameworks (the CBM framework and the collaboration assessment framework) which are highly relevant for understanding the company's perspective of the transition to circular construction.

Research is preoccupied with project-based collaboration and new perspectives could arise from taking a long-term BM perspective on supply chain collaboration to enable CBMI and circular market creation. The present thesis project aims to fill this gap by testing a framework for assessing medium- and long-term collaboration schemes.

2.7 A research Framework

To analyze the case companies and explore the research gap, a research framework has been developed. This framework will form the foundation and structure the findings. It consists of a Value Chain Map, that will provide a framework to indentify and analyse collaborative partners according to, and a theoretical research framework.

2.7.1 A Value Chan Map

The Value Chain Map consists of an adapted VC and a collaboration typology framework to analyze the partnerships the case companies with. These two components will form the base of the supply chain mapping exercise which is crucial to answering RQ 1.

2.7.2 An adapted value chain

To enable material management structures based on UM, the steps along the VC are changing. Particularly structures in the upstream material management change, going from linear material management initiated with raw material extraction in mines, to circular material management retrieving salvage materials from existing buildings. The change in material origins brings new workstreams such as selective and value preserving demolition, reverse logistics, and secondary marketplaces. Furthermore, it requires changes in already existing material management, by emphasizing quality control to avoid toxic elements (asbestos, PCBs, heavy metals, etc.) and flexible architectural design.

Miljøministeriet (2021) has developed a framework describing the VC steps for circular construction and UM. The framework describes the material journey from an existing demolishing project until it is built into a new building. It describes how materials go through the following steps: demolition, material management, marketplace, reuse and recycling, design and production of construction materials, and finally the construction of new buildings or refurbishment of existing ones which at end-of-life (Miljøministeriet 2021).

Based on the literature review, the two additional aspects in proposed to be added: Pre-demolition planning and architectural building design. The literature emphasize the lack of data on built-in materials and the current state of buildings as a key barrier to UM and building material reuse (Benachio et al., 2020). To remedy this, a careful assessment of the reuse potential of the materials is proposed as a key driver for material reuse (CIRCuIT, Forthcoming). To investigate this further a step containing a pre-demolition audit is added as the first step of the analytical framework. Furthermore, building design is proposed as a central venue for initiating material reuse in the construction industry (Castell-Rüdenhausen et al., 2021; Debacker et al., 2017; Jones & Comfort, 2018). To include this perspective, an additional VC step is added between Material design and production and Construction.

This results in a final Value Chain Map, which will form the foundation for mapping the VC steps of the case companies in this thesis:

1. Pre-demolition management, in which materials are mapped and valuable secondary materials are identified in demolition projects and their reuse potential assessed;
2. Selective demolition in which the valuable materials are carefully extracted from existing buildings;
3. Post-demolition management, in which the materials are collected, source-separated, and registered;
4. Marketplace, in which the materials are put on a marketplace with varying degrees of formality and public presence;
5. Pre-processing, which includes quality control of the materials to ensure structural strength and safety;
6. Material production, in which construction materials are designed and produced according to the principles of UM;
7. Architectural design, which implements the material component in a holistic building design based on functionality and aesthetics;
8. Actual construction, in which the materials or component is embedded into the buildings by construction companies and builders.

Note that this is a generic theoretical construct and that the nature of the individual steps and the order in which they appear may vary slightly depending on the specific material and the BM and VC configuration. Furthermore, some steps (including the material mapping, the material design and production, the architectural design, and the final building construction and renovation (steps 1, 5, 6, 7, 8)) will interfere with the selective demolition and the material management and collection (steps 2, 3) by expressing demand, setting criteria for material characteristics and qualities, and providing guidance. Resultingly, the steps may also not always appear linearly, but overlap and influence each other. While the progress from left to right indicates the secondary material journey, the arrows on top indicate the flow guidance and criteria to enable material reuse.

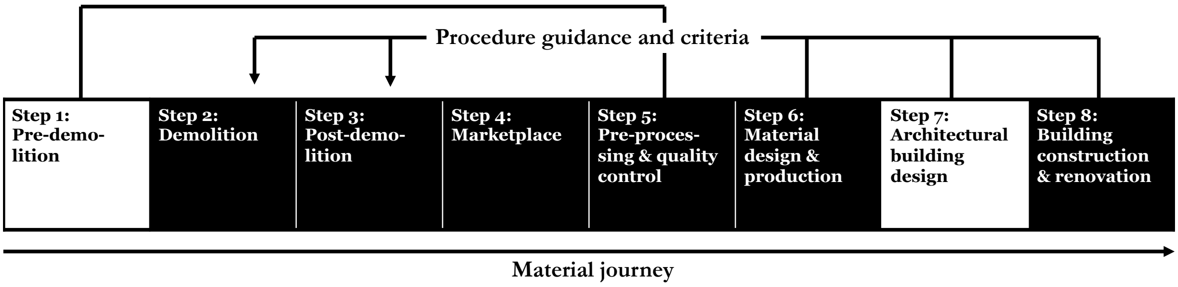

Figure 2: Adapted value chain for urban mining in the construction industry with internal dynamics. Adapted from Miljøministeriet (2021).

For an elaborated description of each step and main actors see the following table:

Table 1: Elaborated value chain for urban mining in the construction sector with descriptions and main actors.

	Step 1: Pre-demo-lition	Step 2: Selective Demolition	Step 3: Post demo-lition	Step 4: Marketplace	Step 5: Pre-proces-sing and quality control	Step 6: Material design and production	Step 7: Architectural building design	Step 8: Building construction
Description	Identifying valuable materials and assessing reuse potential. Set criteria develop guidance for selective demolition and material management to enable reuse.	Extracting valuable materials through targeted effort to preserve material value during the demolition.	Secondary materials are collected, source separated, and registered through reverse logistics schemes.	Stocks and flows of secondary materials are communicated to the industry. Through formal marketplaces or informal transaction agreements.	Ensure non-toxicity and structural material quality through the application of cleaning techniques and tests.	Produce quality construction materials through urban mining principles	Include secondary materials and components in the design of the buildings	Build in secondary construction materials into construction or building transformatio n projects.
Main actors	• Circularity experts and advisors • Waste management authorities	• Demolition companies	• Demolition companies • Waste management companies	• Demolition companies • Waste management companies • Second-hand forums and marketplaces	• Waste management companies • Construction material manufacturer s	• Construction material manufacturer	• Architectural firms	• Builders • Construction companies

2.7.3 A value chain integration typology

Across the literature, terms are used differently to describe alignment procedures. In the following section, the meaning applied in this project will be defined. This paper focus on vertical collaboration strategies applied to align interests and coordinate efforts along the SC and VC. As such, value co-operation in this sense can be cross-organizational, but it could also be collaboration across multiple functions within the same organization (internal VC collaboration) because of VC integration strategies.

The below figure visualizes four different activities for securing alignment along the VC:

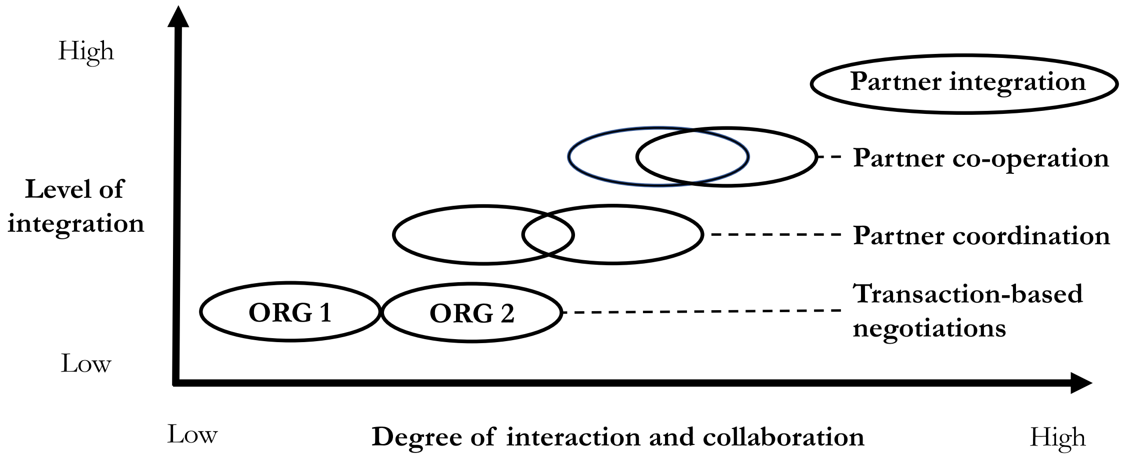

Figure 3 Value chain alignment strategies illustrated with Organization 1 and 2, adapted from Khalfan et al. (2004), McDermott & Khalfan (2012).

Partner integration is the process of integrating steps along the VC in the organization. This can be through acquisition or start-up and can be operated as formally distinct sub-companies or through a network department structure. This strategy is characterized by strong formal ties, uniform values and goals, elaborate actor learning systems tweaking and improving teamwork during long-term collaborations, and a well-developed information infrastructure.

Partner coordination is the process of two or more legally distinct organizations engaging in to form medium to long-term partnerships to achieve a common goal. It includes a high level of knowledge transfer and high internal and external trust amongst partner organizations. The medium- to long-term nature of the collaboration allows for mutual actor learning and communicative and coordinative efforts are more efficient as the collaboration develops.

Partner co-operation is when two or more organizations coordinate efforts to achieve individual goals. It has some of the same benefits of partner co-operation, however, the mutual relationship is weakened by not sharing a common goal. This results in less trust, and less communication which can prevent cross-organizational synergies to take place.

Finally, transaction-based negotiations are the weakest form of ensuring supply chain collaboration. The organizations coordinate efforts through episodic negotiation of transactions and agreements are documented in legally binding sales contracts. There is a general distrust amongst the actors as each is assumed to display opportunistic behavior to achieve individual goals.

Each strategy is described below in Table 2 with list of characteristics and scales to differentiate the categories.

Table 2 Strategies for supply chain collaboration (Khalfan 2004).

	Transaction-based negotiation	**Partner co-operation**	**Partner coordination**	**Partner integration**
Characteristics	• Individual goals • Trust through contractual obligations • Coordination through the negotiation of purchasing criteria • Opportunistic behaviour	• Individual goals • Individual rewards • Trust through contractual obligations • Opportunistic behaviour	• Shared goal • Shared rewards • Resource pooling • Long term commitment	• Shared goal • Systematic information infrastructure • Shared resources • Strong formal ties
Scales	Low trust Low knowledge transfer Low actor learning Low coordination Low transparency Episodic commitment High transaction cost			High trust High knowledge transfer High actor learning High coordination High/full transparency Long term commitment Low transaction costs

The central contribution of this collaborative theory is the multifold perspective of collaboration and partnerships. There is no fixed format for how such partnerships can unfold as it is a result of a social process between actors. The above archetypical collaboration strategies are theoretical constructs used to describe a complex social setting. Empirically, you will find a gradual scale in between each category, and oftentimes companies engage in a combination of different collaboration strategies across different VC partners.

2.7.4 A theoretical framework

The theoretical research framework which forms the point of departure for the abductive research process is based on the framework from Leising et al. (2018). The framework consists of four aspects that are crucial for ensuring effective collaboration between industry actors on construction projects: A shared vision, actor learning, network dynamics, and business model innovation.

A shared vision is an important aspect of aligning expectations across actors, to make sure activities are not counterproductive and that there is an agreement as to what goals the collaborative effort aims to achieve. It can form a shared understanding across otherwise heterogeneous actors with wildly different workflows. Actor learning is the process of engaging actors across the collaborative scheme to utilize on experiences and competencies of the organization. Facilitating such learning processes takes inter-organizational communication and process evaluation. Network dynamics include the social aspect of collaboration, in which actors connect across organizations and positions. Effective collaboration is achieved through social development and understanding this can help when engaging in purposeful change processes. As established above, business model innovation is key to implementing principles of the CE in business operations of the industry. Implementing CBMs is dependent on multiple other companies to cooperate and to ensure these BMs are to be implemented in a way where value is created along the entire VC. (Leising et al., 2018)

The four categories are mutually influential and affect each other, meaning that the implementation of a collaborative scheme should holistically assess activities across the four categories.

3 Methods

This thesis applies a pragmatic worldview, conducting a comparative case study to understand the current market situation within secondary construction material producers in Denmark. Pragmatic research follows the philosophical school of pragmatism and devotes itself to exploring the applied nature of things by looking at concrete actions and situations, and assessing their consequences. The main goal is to identify practical experiences formed by actors embedded in the applied situations, finding concrete solutions to experienced problems (Creswell & Creswell, 2018a). In the context of this thesis project, applying a pragmatic worldview means that I will aim to uncover the tacit knowledge developed by industry actors and learn from their experiences. Furthermore, it means that rather than applying a well-tested methodological framework, I apply a flexible approach guided by abductive analysis (Tavory & Timmermans, 2014) to learn from the case companies based on what is possible in this particular situation while acknowledging the consequences this may have for the findings generalizability (an acknowledgment which will be discussed in Section 3.7). A qualitative research design is applied to engage with industry actors to understand their experiences of operating BMUMs and engaging in collaborative schemes. The qualitative approach is particularly well suited for exploring the nuances of the individual BMUM configuration, their context, and the behavioral aspects of what may have influenced choices made regarding BM configurations.

The specific research design chosen to explore these industry actors is case-based research. Case-based research develops in-depth descriptions of targeted cases (Creswell & Creswell, 2018a; Yin, 2018). These descriptions aim to present a bounded depiction of the case BMs and collaborative configurations, which will be the main content of the analysis. In the context of BMUMs, case studies are a particularly relevant research design due to the highly contemporary nature of the topic (Aldebei & Dombi, 2021; R. Arora et al., 2017; Yin, 2018). Circular construction in general, but in particular UM, is still fairly new and the market is still in an exploratory phase regarding its implementation. Pragmatic case studies building on the experience of some of the pioneering companies is expected to reveal best practices for the rest of the industry to learn from. Furthermore, a benefit of conducting case-based qualitative research is that it provides a framework for exploring the social and behavioral aspects of business operations and industry transition by exploring the experiences of the industry actors (Yin, 2018). I aim to explore these by open-mindedly investigating the positions of the practitioners, and subsequently relating them to the theoretical perspectives. Specifically, the research will apply a multi-case theory building based on a phenomena-driven research justification, theoretical sampling, rich data presentation, and clear links between case evidence, the emerging theoretical framework and the supportive theories form literature (Eisenhardt & Graebner, 2007; Želinský, Dominik, 2019). This approach aligns with the abductive approach to qualitative research, positioning itself between inductive theory building and deductive theory application (Tavory & Timmermans, 2014; Vila-Henninger et al., 2022). Abductive analysis originates from Peirce (1978) but has recently been reintroduced by Tavory & Timmermans (2014) as a bridge neutralizing the otherwise established dichotomy of inductive and deductive research (Vila-Henninger et al., 2022). While the empirical foundation is not big enough to build entirely new theoretical frameworks, as the aim is for grounded theory (Creswell & Creswell, 2018b), the theory-building element of this research is to use a combination of empirical data and theoretically informed reasoning to enrich selected established frameworks (in this case the Leising et al. (2018) framework). The abductive approach is explorative and engages in theoretically pluralistic meaning-making (Peirce, 1978). As such, the data analysis is problem-driven and rests on a wider body of literature in explaining anomalies in the data-set compared to the initial coding book. "Abduction is this speculative process of fitting unexpected or unusual findings into an interpretive framework." (Tavory & Timmermans, 2014). Abductive research aims to benefit from past research but leaves space for surprises during data collection, applying a logic of discovery (Tavory & Timmermans, 2014). To further explore these surprising finding theoretical pluralism is applied in the data analysis phase, which ultimately contributes to the final theoretical framework. Leising et al. (2018) is used to unfold the data to extend where it contributes to an increased understanding, however, when it does no longer suffice, other theories take over in providing explanations. In this research these theories are well-tested seminal theories applied for decades to explain business strategy and organizational behavior., namely transaction cost theory and resource dependency theory.

3.1 Background and motivation

The sheer volume of the building sector and the mass of materials used bears testimony to its importance in transitioning society toward the CE. The construction industry poses a wicked problem of meeting social demands for safe, healthy, and affordable housing while also leading to excessive environmental degradation. Interventions in the built environment depend on social processes of change, which are not sufficiently enlightened by the predominantly technical community of researchers and practitioners. Resultingly, to understand the social environment of the sector, and to identify potential leverage points for creating systemic change, outside perspectives from social science and business management are important to consider. This is the task the present paper aim to take.

3.2 Aim of the research

This theses project will explore how industry practitioners apply various collaboration strategies to achieve successful implementation of circular business models. In doing so, it will deliver knowledge on strategic choices made by practitioners in terms of entering into inter-organizational partnerships or not. The thesis aims to contribute to the development of effective collaboration schemes by exploring the nature of supply chain collaboration and secondary material cycles in the built environment and if and how this can enable a larger industry transition.

The research will furthermore aim to explore the grounds for extending the theoretical framework of Leising et al. (2018) to apply for medium- and long-term partnerships, as opposed to the project-based collaboration it was originally developed for. This will be done by applying selected seminal works from business management literature and testing the relevance in an applied context. As such, I intend to develop data and theory-driven theory alterations to fit the new context in which the framework is applied.

3.3 Literature review

To accurately position this thesis project within the current body of literature, a literature review was conducted on the current state of the industry, CBMs, and BMUMs within the built environment and supply chain collaboration. During the literature search, two approaches were taken: Explorative literature search and snowball literature search. The explorative literature search identified relevant articles within each of the above topics. Three databases were used (LUBsearch, Google Scholar, and Scopus) to identify relevant literature within each category. Prominent articles that either define one or more of the relevant areas or build bridges between them were selected. To see a list of search stings, see Appendix IV – Search Strings for Literature Review. Two-three pages of search results were considered pr. the search string, applying the following steps for selection:

> *First*, a generous selection was made based on the titles;
> *Secondly*, they were considered based on abstract and keywords;
> *Thirdly*, the introduction
> *Finally*, the full article was read and included in the literature review

The criteria for inclusion were to fulfill one or more of the below criteria. They should provide insights to:

- CBMs and urban mining in general
- linear and circular BMs in the building industry (current and potential)
- current practices to facilitate direct or indirect reuse of building materials and components (in particular in Denmark)
- industry dynamics, transition patterns, and change drivers in the building industry.

Subsequently, a targeted snowballing approach was taken for the literature search. This entails identifying relevant articles from either the reference list and going through the back-catalog of key researchers, organizations, and institutes. This was particularly useful for identifying seminal papers defining research areas.

3.4 Case study selection

The population of the study is companies engaged in circular construction strategies in Denmark. This may include actors working in different steps of the value chain (VC). As the aim is to understand the relationships along with the VC, the case selection will allow to include businesses at different steps in the VC. The project applies a targeted theoretical sampling strategy (Creswell & Creswell, 2018b; Eisenhardt & Graebner, 2007). The cases are chosen based on an initial understanding of their business models from publicly available online resources digested in a thesis pre-study, and through dialogue with industry experts and interest organizations promoting circular economy in the construction sector.

Besides the above described theoretical sampling strategy, a few qualifying criteria were applied when identifying potential case companies:

- The company must be engaged in UM by offering a product or service that enables demolition waste for direct reuse or as feedstock for the production of new building materials..
- The CBM must be in operation in Denmark, ensuring a uniform external environment across the cases supporting the comparability of the cases.
- The business model configuration must have been in operation for more than two years to ensure a certain level of experience and reflection.

Eight companies were invited to participate in the project, of these three companies agreed to participate, however, to minimize scope one case was later excluded, leaving a final number of two cases: Lendager Group and Gamle Mursten. Within each case, informants were selected based on their area of responsibility and expertise seeking employees who are knowledgeable about the strategic elements of engaging in CBMs and the operational aspects of managing take-back schemes, partnerships, and the daily production and operations.

3.4.1 Case companies

Lendager Group

Lendager Group (LEG) was founded in 2015 by Anders Lendager to develop cost-neutral solutions to mainstream material reuse in the built environment. 50 employees work with the vision of enabling change in the construction industry, LEG is an internationally recognized front-runner within circular building design, nominated for the prestigious EU Prize for Contemporary Architecture - Mies van der Rohe Award 2022 (Lendager Group, 2021) and winner of the Danish Design Award three times during the four years.

The company, which initially started as an architectural agency, has launched sub-companies each enhancing construction circularity within a specific field. Lendager ARC is the original business providing architectural services, designing circular buildings and areas under the concepts of building metabolism and urban metabolism. Lendager UP is a construction material manufacturer highly engaged in the research and development of upcycled construction materials, utilizing waste streams and feed-stock materials. Finally, Lendager The Circular Way (TWC) is a consultancy agency that conducts research and concept development showing clients the potential of utilizing circular principles. (Lendager Group, n.d.).

Lendager Group	
HQ	Copenhagen, DK
Employees	50-60
Turnover (FY20)	4,3 MDKK (0.58 MEUR)

Gamle Mursten

Gamle Mursten (GAM) is a brick recycler located in Svendborg, Denmark. They utilize used bricks, which are otherwise mainly crushed for low-value road filling, by sourcing masonry waste fractions directly from demolition projects or municipal waste fractions. The bricks are restored at the component level for direct reuse with semi-automated technology. Their product line consists of hand- or machine-cleaned bricks and brick slips, and until 2021 roof tiles were also part of their product offering. (Gamle Mursten, 2021c; Rebrick, n.d.-a, n.d.-b)

The company operates a social policy, in which they employ half of the workforce amongst the workforce with limited physical or mental work capacity (Gamle Mursten, nda). GAM has received several innovation prizes including The Gazelle Prize, a Danish innovation prize for fast accelerating companies, in 2009, 2016, and 2017 (Gamle Mursten, 2014, 2017, 2018, 2021a, 2021b, nda, ndb).

Gamle Mursten	
HQ	Svendborg, DK
Employees	20-25
Turnover (FY20)	0.8 MDKK (0.11 MEUR)

3.5 Empirical data

In the process of exploring the above case companies empirical data was collected and processed, to describe how each company engages in intra- and inter-organizational collaboration schemes.

3.5.1 Data collection

The research applies a abductive research strategy, bridging inductive and deductive approaches. While the deductive approach will be the main driver for initiating the analysis, the open-minded approach from inductive research will be a central approach during the data collection phase. The theoretical frameworks identified in the research design phase were central in informing the research questions and interview guides (in line with the deductive approach), however, an open mindset was applied during data collection allowing the interviews to unfold as needed to depict the empirical situation (in line with the inductive approach) (Creswell & Creswell, 2018a).

This combination of an inductive and a deductive approach makes it possible to test the analytical framework as was developed originally while also collecting data that suggests theory adjustments (Tavory & Timmermans, 2014).

Multiple data collection techniques were utilized to gather data on the case companies. The primary data collection techniques were semi-structured interviews, however, this supported other data collection techniques including web scraping and document analysis. The combination of data collection techniques aims to triangulate by having multiple data sources, combining public data (from social media posts, public articles, and project descriptions) and the experiences of company representatives. The public data has the advantage of providing a broad but arguably also superficial view of *what* the companies are doing and with *who* they are doing it. The private data (collected through interviews) on the other hand provides insight into *how* they are doing it, while also providing an opportunity to follow up on findings from the public data analysis. Thus, the combination of public and private data balances the general and specific information sources, which ultimately can provide a holistic view of the company's operations. Below is an elaborate description of the applied data collection techniques.

Web scraping

To identify and analyze the digital presence of the case web scraping (Marres & Weltevrede, 2013) was used. Web scraping is an automated online data collection method that captures online data (such as blog posts, social media posts, newsletters, etc.) systematically from selected websites. The method was applied on the case company websites (incl. their news sections) and their LinkedIn to identify partners and inspire targeted interview questions. The software Octoparse was used for the purpose and then the data was exported to an Excel spreadsheet listing original content, tags, interactions, comments, etc.. The final step was manual data analysis and coding.

Web scraping captures preselected and formatted data that may not mirror the actual situation. Nonetheless, the tool can be valuable in social science to conduct discourse analysis and provide initial data input to be analyzed using other qualitative methods (Marres & Weltevrede, 2013). As such, the data generated through web scraping in this project do not figure in the final report without being discussed with the informant. Thereby, the image presented online was challenged during the interviews to enable deeper reflection by the informants. The method allowed to build an informed foundation for the interview process.

Document analysis

While the interviews were the main source of data, internal and publicly available documents assisted in creating a holistic image of the company. The internal documents (internal reports, notes, process charts, internal and non-published communication, etc.) were provided by the informants, while the publicly available documents (incl. grey literature, white papers, secondary interviews, newspaper articles, previous case studies of the companies for secondary analysis) were found at own initiative. As time was a concern for all case companies, these documents provide a superficial understanding of the BMs allowing the interviews to be more focused, exploring relevant details and gaps in the written materials.

Interview

A semi-structured interview style will be applied to ensure that certain topics are discussed while also leaving room for unexpected findings to be further explored. Informants will be interviewed one to three times depending on availability and for each case. The interviews were 30-75 minutes and were either conducted in person or online via Zoom. The interviews were conducted and transcribed in Danish, the native language of both researcher and informants. Quotes were translated to English when included in the report.

In line with abductive research, the interview questions were informed by the theoretical frameworks which the initial form (namely, Leising et al. (2018), Barratt (2004), and Geigenmüller & Leischnig (2017)) and initial data from the web scraping exercise and the initial document analysis. However, an open-minded approach was applied to explore themes that were not part of the original theoretical frameworks but relevant to the holistic experience of the informants. The explorative follow-up questions which emerged during interviews were in turn converted to additional data codes as will be elaborated in section 3.5.2.

The below table describes the desired output of each data collection method:

Table 3 Data input and desired output

Data collection method	**Semi-structured interview data**	**Web-scraping**	**Document analysis**
Data source	Case informants	Company websites LinkedIn profile posts	Internal documents Public documents Project documentation
Tools	NVivo	Octoparse	NVivo
Analytical method	Abductive analysis Thematic analysis		
Desired output	• Detailed understanding of informants experience • Insight to strategic elements • Understand long-term goals	• Superficial understanding of collaboration networks • Inspiration for interview questions	• Detailed understanding

3.5.2 Data analysis

The data management software NVivo was used for data analysis and coding. The analytical phase were designed according to abductive analysis (Tavory & Timmermans, 2014).

Coding method

During the data analysis, an abductive coding technique (Tavory & Timmermans, 2014; Vila-Henninger et al., 2022; Želinský, Dominik, 2019) was applied, initially adopting codes from the frameworks that inspired the interview questions and then allowing new themes to emerge by creating a new framework. For a full coding table see Appendix II - Final coding table. After completion of the coding process content of each was synthesized and presented to answer the research questions.

To operationalize the abductive theory in the coding practices four steps were applied, inspired by Tavory & Timmermans (2014).

i) Initial theory consultation: Initial theory-based codebook were developed to inform the interview guide. In line with abductive research, an initial analytical framework was informed by the initial theory consultation undertaken during an elaborate pre-study of the current knowledge in the area. This process narrowed the scope of from the literature review into a specific area of interest leading to a theoretical framework and an initial deductive codebook that informed the data collection.

ii) Mid-data collection approach: In the mid-data collection phase an inductive approach was taken, following leads and surprising findings which ultimately gave way for an abductive codebook with emerged codes that were used during the data analysis phase, thereby widening the scope again based on the data.

iii) Secondary theory consultation: New theories were consulted to yet again narrow the scope and find explanations to the emerged codes applying a theoretical pluralism.

iv) Merge codebook: Initial and emerging code are combined forming the new framework. In the analytical phase, the abductive codebook (the initial deductive codes and the emerged) was used to extract findings that were then put on paper by answering the research questions during the data interpretation phase. Project findings and conclusions were then seen in broader perspective.

This process is illustrated in the research framework in Section 3.6.

Data validation

Informant quote approval, where essential quotes and data were sent for confirmation by the data source, were applied as a data validation technique in this project. This process aims to confirm that no essential meaning was lost in the translation from Danish to English and that the content was correctly understood.

3.6 A final research framework

The illustration below describes the research process and how the individual elements lay the foundation for answering the research questions.

The analytical perspectives was applied in a way where the supply chain mapping exercise took a micro perspective in understanding the case companies and their collaborative networks (see section 0), then, in the conceptual analysis, collaborative network theory (the Leising et al. (2018) framework plus two emerged categories) took a meso perspective in developing and test the expanded analytical framework (see section 5.1), and finally, a transition theory perspective was taken in a discussive analysis considering supply chain collaboration skills as a potential organizational capability that could aid the macro-scale transition toward UM in the built environment (see section 5.2).

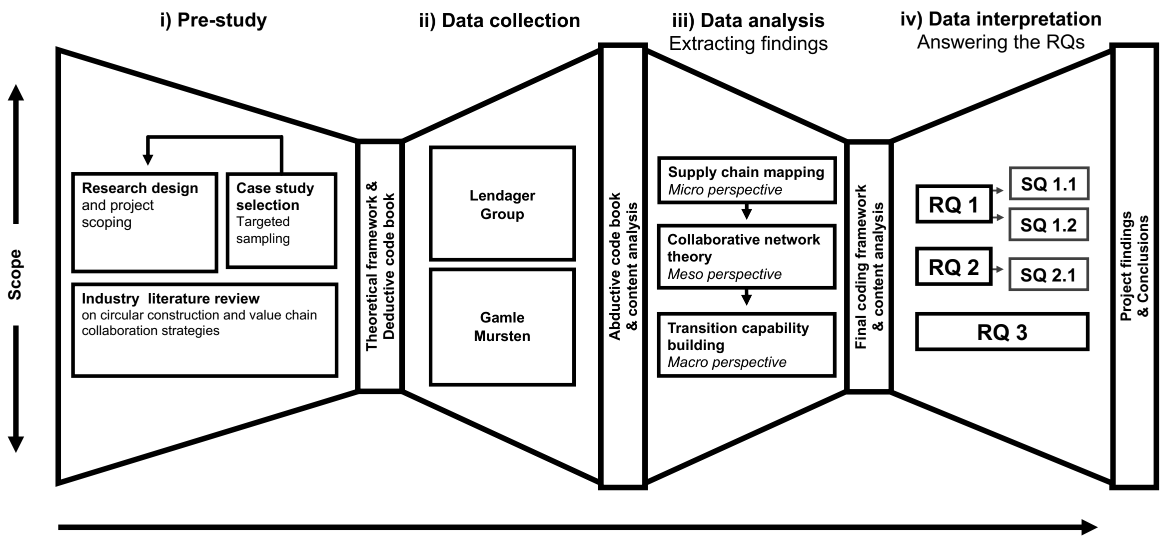

Figure 4 The final research framework of the thesis

3.7 Scope and limitations

Present research rests on an elaborate literature review and a limited case study. The two case companies are not representative of the entire industry so important details and BMUM variations will therefore most likely are not represented in this study. Therefore, it is important to emphasize that the project does not attempt to generalize its findings to a broader population or develop a BMUM typology. A key feature of abductive theory building from qualitative data is to generate hypotheses (as opposed to grounded theory based on data saturation) (Tavory & Timmermans, 2014; Vila-Henninger et al., 2022). Abductive theory is a: "creative inferential process producing new theoretical hypotheses on the basis of surprising evidence, and for such hypotheses we then need to gather more observations." (Tavory & Timmermans, 2014). As such, this thesis aims to raise important questions that may lead to new perspectives on the topic of supply chain collaboration for operating UM and secondary material cycles in the building industry and proposes theory alterations to established theoretical frameworks rather than building theory from scratch.

Furthermore, it is important to state that the case studies rest on a bounded body of data. Time was a concern for all case companies, and the availability of informants was therefore limited. Besides, the availability of written material was different from case to case. The findings of the research are therefore based on a limited set of data, however, steps were taken to ensure the validity of the content.

3.8 Ethical consideration

To ensure a common understanding of the research output a non-disclosure agreement was developed (Appendix III - Non-disclosure agreement (in Danish)), stating a) how the data would be treated during the research project, b) how the data is stored afterward, c) data ownership and rights in terms of representation in the final research output. Furthermore, the document asks about preferences for anonymity in the publicly available thesis report. None of the companies requested anonymity, despite being offered it at an individual and an organizational level. While all informants agreed to be identified by name, title, and organization, the name of the informants were omitted as they carry little informational value and does not strengthen the research output.

Participation in the study is voluntary and informants have been informed of their right to withdraw at any time with no obligation to provide a reason why. Informants furthermore were informed of the right to withdraw statements and request information to be omitted, should they deem it confidential. While the content of the interview was considered the intellectual property of the informants, the interpretation is considered the intellectual property of the researcher. Thus informants would not be in the position to control the outcome of the research project directly.

4 Delineating collaboration strategies

The goal of this section is to systematically describe the way each case engages in collaboration schemes specifically focusing on value chain (VC) collaborations. In doing so, the first research question will be answered:

> *RQ 1: How do the case companies organize their supply chains to facilitate business models for urban mining?*
>
> > *SQ 1.1: What role does inter-organizational collaboration play in their supply chain operation?*
> > *SQ 1.2: Which collaborative strategies are employed by the case companies?*

In section 4.1 and 4.2 a description the case companies will be presented based on the collected data to answer RQ 1. As part of these sections SQ 1.1 will be answered in the case description and in the supply chain map, and SQ 1.2 will be answered under the title Collaborative strategy.

4.1 Lendager Group

Lendager Group (LEG) is an architectural firm founded with the mission of contributing to achieving a sustainable transition within the built environment. Since then they have become an acknowledged knowledge hub on circular design within and beyond the construction industry (Hill-Hansen, 2021).

> "Lendager group is a company which combines architecture, design, and strategy by gathering multiple branches under one roof with the purpose of enabling a transition of the built environment" (LEG Informant #1, personal communication, February 21, 2022).

What started as an architectural firm, has since developed into a multidisciplinary company producing upcycled building materials and components, offering strategic consulting within a circular economy and implementation of circular principles. Urban mining (UM) is a central concept within their strategy, specializing in upcycling waste materials and designing business models and concepts around discarded materials. This is seen directly in the materials, components, and building designs developed over the years in which they have enabled the reuse of materials and components that would have otherwise been downcycled, incinerated, or landfilled. A non-exhaustive list includes various designs enabling direct material reuse in building envelopes by layering discarded double-glazed windows making them quadruple thermal insulated windows. For external wall cladding, they have used locally sourced discarded roof tiles, wood, and steel, and have developed a system for reusing brick walls at a component level by cutting out cement-mortared brick walls[2] to be reused as patchwork external brickwork. As load-bearing structures, LEG has engaged in a direct reuse of steel or wood beams, and on-site concrete casting using recycled concrete aggregate. (*Lendager UP*, n.d.) The circular solutions are often custom-designed to the specific building yielding a highly dynamic and fluid workflow in terms of managing the supply chain of secondary materials. While the consultancy business undertaken by Lendager The Circular Way (TCW) is highly diverse as relates to VC configurations and collaborative practices, this case study will limit its scope to processes related to their business of designing buildings and upcycled building materials and components.

[2] In the 1970's chalk-based brick mortar was outcompeted by cement-based mortar which is much stronger. How strong binding ability of the brick also mean that they were unable to be separated, cleansed and reused using the conventional methods.

4.1.1 Collaboration strategy

Compared to the conventional architectural firms, LEG had with its subsidiaries developed a diverse company covering a bigger part of the VC than the norms prescribed. As such, they included building material development and manufacturing in their organizational scope, managed by the subsidiary Lendager UP (LEG UP).

However, in September 2021 this strategy came to a close, as management decided to sell off that part of the business. At that point, LEG UP had developed a product portfolio that was financially stable and offered significant carbon savings, however, 4 out of 5 products made by LEG UP were made for internal use.

While the products display vast potential for economic success and environmental impact mitigation, there was an issue related to pushing sales across the industry which kept them from gaining large-scale market uptake (LEG Informant #1, personal communication, February 21, 2022). The task of scaling the operation is not one of LEG, instead, a set of private investors would undertake the challenge under the name A:GAIN. With the new organizational structure, LEG continues to develop materials, however, a different approach will be taken in doing so, leaning more toward external collaboration schemes and development projects. This managerial decision leaves the material manufacturing business free to engage more widely in the industry and the organizational scope of LEG is simplified. A managing employee explains: "The primary target was cut to the chase in what value Lendager creates, and not complicate the processes more than they already are" (LEG Informant #1, personal communication, February 21, 2022).

This decision illustrates a broader view on collaboration which may be changing in the organization. Where they may have attained a competitive advantage in the industry in the early year by offering multiple value propositions in-house – building designs, material and production, and strategic consultancy – they now aim to externalize selected processes, relying on external VC collaboration rather than internal (LEG Informant #1, personal communication, February 21, 2022). The new organizational structure brings new opportunities but also new requirements as to who LEG should collaborate with and how these partnerships are structured to ensure alignment across the VC and coordinate efforts for optimal business operations.

4.1.2 Collaborating partners

The interviews indicated that LEG is involved in all three collaboration dimensions and multiple types of collaborative schemes.

First, they engage as an architectural agency in industry-typical project collaborations. In these, they engage with industry actors across the entire VC to deliver a specific building project. These actors typically include the building owners, the builder, contractors, and the sub-contractors. The clusters are temporary inter-organizational project clusters that usually dissolve at project finalization and the specific configurations of the partnership commonly change from project to project.

LEG also participates in development projects including the EU-funded research project Circular Construction in Regenerative Cities (CIRCuIT) and smaller projects with local industry actors and research institutions. In these, they are developing solutions for circular construction, i.e. methods for selective demolition and non-destructive material quality assurance (LEG Informant #1, personal communication, February 21, 2022). These are also temporary configurations aimed at fostering innovation and facilitating learning processes.

A collaborative type that is more ambiguous is the operational value and supply chain partners contributing to operating the business models. This includes material suppliers, service providers for remanufacturing, and customers. It is in the VC partnerships the biggest change is happening compared to the conventional non-circular industry actors. Whereas linear material production has some stability in the supply chains, supply chains based on UM bring new challenges which transfer into the VC partnerships.

In the following section, the operational VC partners are mapped out using the adapted VC described above.

4.1.3 Value chain mapping

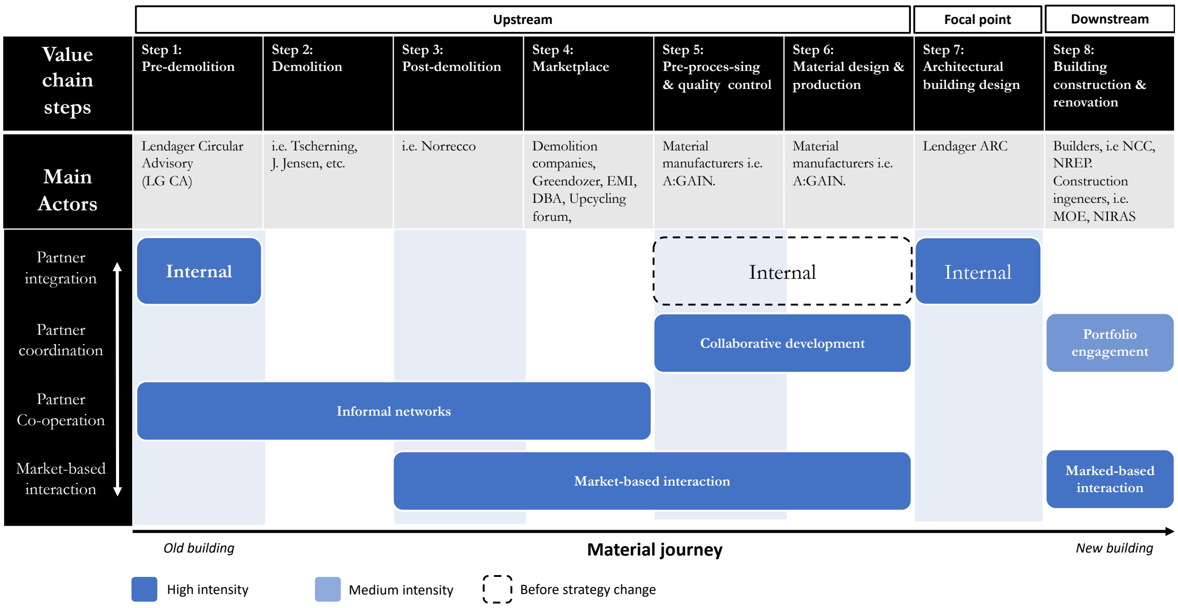

Figure 4.1.3 Value chain collaboration of Lendager Group divided into steps 1-8 and ranked according to the level of integration

As an architectural firm, the focal point of LEG is step 7, however, the subsidiaries and subdepartments of the company may engage in some of the preceding steps.

The following is a step-wise run-through of the VC step and how LEG engages in each step. First, the upstream activities (steps 1 to 6) are presented, then the focal point (step 7), and finally the downstream (step 8).

Upstream

<u>Step 1: Pre-demolition</u>

Circular Advisory (LEG CA) conducts material mapping and develops criteria and initial guidance for material reuse. They do so as a distinct consultancy service for external parties and as an initiating step for internal projects. The target of this VC step is to develop guidelines and set up the VCs by coordinating the efforts.

This includes developing criteria for reuse and identifying potential suppliers for secondary materials. In doing so, LEG CA engages a lot with demolition companies in informal networks or through formalized marketplaces.

In this step, two distinct approaches are taken, material mapping and material sourcing.

Material mapping is conducted in cases where the construction project is to take place at a site where another building is planned to be demolished completely or partially. In these cases, materials with potential for on-site reuse in the new building design are mapped out and guidelines for selective and value preserving demolition are developed to revive relevant materials.

Material sourcing is the activity of finding materials that qualify for material reuse from external sources. This activity happens in two ways: proactive, in which the materials are identified pre-demolition, and reactive, in which the materials are identified post-demolition. The main avenue for proactive material sourcing is informal social networks, in which LEG CA reaches out to industry actors (i.e. demolition companies or big property developers) manually to identify potential materials and negotiate a transaction for these. "Finding a price and landing an agreement is completely wild west" (LEG Informant #1, personal communication, April 13, 2022). In these efforts, there are no rulebook or fixed procedures.

As such, the project planning undertaken by Lendager CA provides insights that are instrumental during the subsequent steps related to selective demolition and material management. In material mapping and proactive material sourcing, LEG acts as a corresponding agent and knowledge hub, overseeing, coordinating, and participating in all the subsequent steps. Conversely, when conducting reactive material sourcing LEG enters the VC at step 4, leaving steps 1-3 to be handled completely by external organizations.

<u>Step 2-3: Demolition and post demolition management</u>

Alignment within the demolition and material management phase is secured by developing criteria and guidelines in step 1, which are then executed by the demolition companies and waste management companies (LEG Informant #1, personal communication, February 21, 2022).

<u>Step 4: Marketplace</u>

This step is the main point of activity related to reactive material sourcing. Here LEG CA utilizes formalized networks and marketplaces to find secondary materials post-demolition (LEG Informant #1, personal communication, April 13, 2022). In recent years, these marketplaces have become more common with each demolishing company operating their own and some international marketplaces opening.

Also informal marketplaces are a source for reactive material sourcing. These include secondary markets for private consumers (i.e. Den Blå Avis), LinkedIn, or blog posts in the network (i.e. Upcycle forum). The formal marketplaces for reactive material sourcing that take place are a sign of transaction-based collaboration, whereas the proactive material sourcing indicates a level of integration of a selected few industry actors with whom they have a shared understanding and shared interest in reviving secondary construction materials. With such organizations, informal relationships are developed as they get to know each other. (LEG Informant #1, personal communication, April 13, 2022)

<u>Step 5-6: Preprocessing and material design and production</u>

With the subsidiary, LEG UP, the company was engaged in pre-processing of secondary materials (step 5) and material design and production (step 6). However, since the new strategy entered into force and the subsidiary was sold off, these activities have been managed exclusively by external material manufacturers. A managing employee in the company explains that this decision was made with the dual purpose of streamlining the organizational efforts and utilizing material-specific expertise developed by the leading material manufacturers (LEG Informant #1, personal communication, April 13, 2022). By externalizing steps 5-6 they also externalize the task of operating the supply chains for bulk material production, meaning that LEG CA helps identify material suppliers initially for product development, however for the subsequent mass production it remains the material manufacturers' responsibility.

Since externalizing these steps, the partnerships with external manufacturers have been highly communicative in which the partner co-develops the materials and solutions, balancing what is conceptually ambitious in terms of circularity and what is technologically possible (LEG Informant #1, personal communication, April 13, 2022). The development of the materials is based on a mutual exchange of knowledge and capabilities, and terms and conditions for the production is negotiated on a case-by-case basis. Common collaborating partners include material producers specializing in UM and circular design such as A:GAIN and more conventional material manufacturers.

The focal point

Step 7: Architectural design

The focal point of LEG's main business is the development of circular building design to enable the reuse of secondary building materials. The nature of this work is highly project-based and custom solutions are often developed for individual projects, showcasing new ways of reusing materials as well as replicating solutions developed for previous projects. This stage is highly connected to material mapping and sourcing, as the design solutions depend on what materials are available.

At this stage, LEG is highly engaged with the particular project cluster (the owner, builder, and contractors) to meet project deliverables and coordinate changes to the original project plan. Internally, they coordinate with actors from the previous VC steps as described above to ensure operational alignment and that their designs are feasible in practice.

Downstream

Step 8: Building construction and renovation

The downstream VC step is where the architectural plans are carried into life and all the preceding steps come to fruition in the form of a building being either built or renovated.

The conventional architectural business models largely yield two sales options: firstly, one-off projects attained through competitive bidding in architectural project contests, and secondly, industrialized design of type houses to be replicated uniformly at a large scale. In both cases the primary actor is the builders, however, depending on the individual project, also the end customer plays a significant role in project tendering, development of building profile and success criteria, and approval of mid-project alterations to the agreed-upon objectives. This is especially the case in large and prestigious one-off projects for either private or public use. Though some development projects experiment with the development of type houses showcasing building material reuse and UM, the current market for circular construction mainly operates with one-off cases.

Taking a look at the project portfolio of LEG, there are indications that this is also the case here. Resultingly, the majority of Lendager's construction projects are won in project contests competing directly with conventional architectural studios. There are primarily two structures for such processes: firstly, a project-based one-off collaboration where LEG participate on conventional terms (market-based interactions), and secondly, longer informal relationships where LEG participates in developing a portfolio of buildings over longer timeframes. The project portfolio interaction often starts with a one-off pilot project in which synergies within the organizational values and workstream are assessed (LEG Informant #1, personal communication, February 21, 2022). Participating in a project portfolio allows LEG to take a broader perspective in their consultancy, also expanding the scope of the material mapping by integrating material streams from multiple buildings in the portfolio instead of limiting the scope to just a single building. This can enable better solutions in the architectural design by increasing the diversity of the material available in the material mapping phase and increasing the potential for economies of scale in material development and production. Furthermore, prolonged interaction between the companies improves the circumstances for better alignment and collaboration in the subsequent projects. The informant explains about prolonged portfolio partnerships:

> "You can go a step deeper - peel a layer of the onion – and think more long term. To have built the first houses makes the machinery well-adjusted so you are better prepared going forward. You build experience in collaboration, making it possible to start even closer to the core of the next project." (LEG Informant #1, personal communication, February 21, 2022).

4.1.4 Case summary

In 2021, Lendager Group changed its strategy for assuring collaboration across its VC by externalizing the steps in which secondary building materials were pre-processed and produced. By doing so the organization got streamlined leaving material mapping and consultancy and architectural design as the main in-house value drivers, however, control over parts of the VC was lost.

During the upstream VC steps, in which upcyclable materials are identified, and extracted the primary partners are demolishing companies. Early involvement is a key feature for LEG to ensure that materials are protected during the demolition phase by using selective demolition techniques and are not spoiled through incorrect handling. Pre-demotion material mapping is particularly promising in assessing the material potential for reuse and non-destructive quality control can be a game-changer in terms of improving upcycling rate from targeted UM.

When developing upcycled construction materials communication between ambitious circularity pioneers and technical specialists is of immense importance when balancing the aesthetics of the design with material performance through the use of technological best practices and product innovation.

In the downstream phases, which include project sales and construction, LEG engages in two different contexts: One-off project configurations in which they engage as a service provider for one specific project, or longer relationships in which they build trust, exchange experience, and explore organizational synergies over a portfolio of building projects.

4.2 Gamle Mursten

Gamle Mursten (GAM) is a brick recycler in operation since 2003. The core business of the company is to import secondary bricks from recycling stations and demolition sites, test their structural quality, and prepare them for reuse by cleaning them for mortar. They sell second-hand bricks and low-material brick slip modules either for exterior wall cladding in the building envelopes or interior wall decorations.

To restore the bricks they are separated depending on size, type, and quality, and any leftover mortar is removed. The cleansing technology is a patented combination of mechanical techniques including vibration and manual scraping (Rebrick, n.d.-a). In 2018, GAM developed methodology for performing quality assurance tests for reused bricks as the first ever building material recycler. As a result, GAMs products are CE-certified ensuring high functional quality. The department responsible of developing the testing methods and performing the material tests is the affiliated research branch GM Tech Aps, which was started to introduce consultancy and knowledge-based business model into the company:

> "With GM Tech and the entire laboratory function, we are trying to build raw material [secondary bricks] sourcing into the process by creating better and bigger deals with our customers" (GAM Informant #1, personal communication, February 18, 2022).

GM is experiencing high demand for reused bricks in an industry which is increasingly engaged in the sustainability agenda and material reuse. However, due to a limited production capacity the company is not growing as fast as they would like to. The company aims to double its production by the end of 2023 (GAM Informant #1, personal communication, February 18, 2022).

A key barrier for reusing bricks is the way they are treated during the demolition. The quality of the brick waste fraction highly depends on the method of demolition and how they are loaded and transported.

> "It is important for us to have an early dialogue with them [the demolition companies] so they know not to drive on top of the brick with heavy machinery. We try to have an initial dialogue so they know they are for reuse and not for road filling." (GAM Informant #1, personal communication, February 18, 2022).

Currently, bricks may be demolished using destructive methods, and moved at the demolition sites by grips or used as ground stabilizer during deconstruction. This should all be avoided to maintain the quality of the brick, yielding an important position for knowledge transfer and guidance in the pre-demolition phase. Oftentimes they are engaged post-demolition which lead to a smaller share of reusable bricks pr. truck load (GAM Informant #1, personal communication, February 18, 2022).

GM is going through a transformation in which new business models are added to the portfolio of value proposals. While the implementation is ongoing, the end goal is to operate three separate business models: Their original business model based on product sales, a secondary model based on service provision through Urban Mining Agreements (UMAs), and a tertiary model also based on service provision offering quality assessment tests for external parties.

4.2.1 Collaboration strategy

With the introduction of GM Tech and UMA, the company is in the process of rethinking their collaborative strategy. They are do so with the dual purpose of extending the organizational activity span across the VC to include the pre-demolition and construction phase, allowing them to apply their material expertise in the earlier stages of the VC, and to support long-term and stable relationships with it partners (GAM Informant #1, personal communication, March 18, 2022). In doing so, they have introduced a new business model offering an adjusted value proposition, an UMA, aiming at key customers who are engaged both in building demolition and construction. These include municipalities and private builders and construction developers.

An UMA consists of three aspects. When entering an UMA with GAM, the following services are provided:

- Knowledge partner on brick reuse: Offering consulting on optimal material treatment during demolition an construction to preserve the structural value of the bricks.
- Service-based business model: Offering an adjusted value proposition by offering a service-based business model instead of one based on ownership transfer. As such, the party entering the agreement retains ownership of the brick but pays for the service of testing and cleaning them.
- Material hotel: Offering an extended service including material storage. After remanufacturing, testing, and certifying the bricks they are then stored at the GAM facilities until they are needed by the customer.

The UMA is mainly offered to municipalities currently, but on the long-term this is expected to be expanded to include private builders and construction developers.

4.2.2 Collaborating partners

As for the downstream project collaboration, GAM participates as a construction material supplier. As such, their participation and involvement in the construction phase is mainly limited to assuring that the demanded materials are available at the time of need. Some consultancy as to what materials are appropriate and how to manage it properly can be part of the sales negation process, engaging as a knowledge partner, however due to the product simplicity and long industry history of using of bricks this part is rather limited.

GM has a history for participating in collaborative development programs. They were project coordinators on the EU-funded project REBRICK investigating possible technologies and potential market uptake of automated technology for brick reuse across a selection of European locations (EC CORDIS, 2013). Furthermore, they have participated in research projects with research institutes, however, lately they have only been involved in few projects due to time and human resource scarcity.

Regarding operational VC partners the main collaborating partners are suppliers of used bricks which can be demolition companies, waste management companies, construction development companies and private or public builders. Downstream collaborating partners different organizations taking part in the design and construction of buildings, in which the relationship are mainly based on market interaction. In the following section the main collaborating partners are mapped out.

4.2.3 Value chain mapping

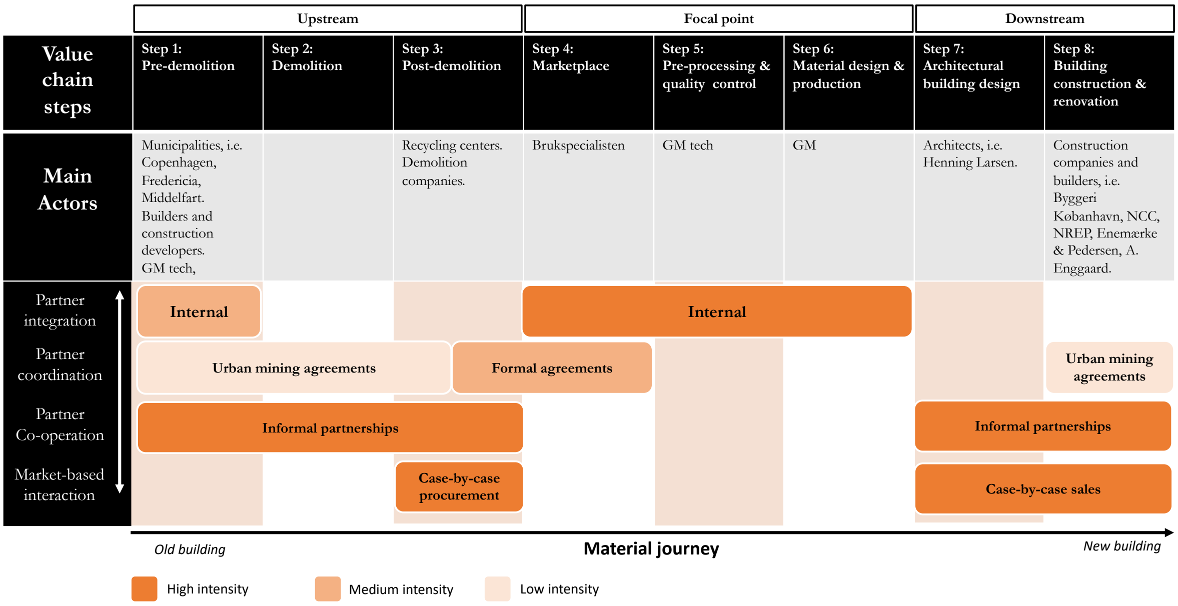

Fig 4.2.3 Value chain collaboration of Gamle Mursten divided in steps 1-8 and ranked according to the level of integration

Upstream

While the UMAs are part of new collaboration strategy, the vast majority of the input materials still comes from informal partnerships in the private demolition sector in the form of single project transactions or informal relationships with returning customers.

As such, material inflow is mainly managed on a case-by-case basis depending on project characteristics and circumstances. Resultingly, the upstream phases gets special attention from the GAM management as volatile material inflow is a main barrier for increasing sales. "We are constantly working on getting enough raw materials, so the more stable an agreement, the better" (GAM Informant #1, personal communication, February 18, 2022).

<u>Step 1: Pre-demolition</u>

Within the upstream VC steps, particularly step 1 is an important aspect in of the new collaboration strategy. Step 1 is the main area for proactive procurements, and where GAM has the biggest potential for influencing the demolition process and ultimate quality of the sourced materials. By engaging in longer and better partnerships, GAM will be able to enter the procurement negotiations already in the pre-demolition which may contributes to better criteria for demolition tendering and ultimately the implementation of value preserving demolition techniques.

Main actors at this stage are city administrations, including those of Copenhagen, Fredericia and Middelfart. Furthermore, partners of the private industry including builders and construction developers. Currently, city administrations are particularly promising partner for GAM as they are involved in many construction projects either through construction development of public buildings or as an supervising authority of private projects (GAM Informant #1, personal communication, February 18, 2022).

While the UMA strategy may change this in the future, there are no medium or long-term partnerships formal partnerships at this step of the VC. The main venue is informal relationships with returning customers. These relationships and subsequent transactions are managed on a case-by-case basis where suppliers (demolition companies or municipalities) reach out to GAM when they have a potential demolition case involving potentially reusable bricks. Most actors engaged at this step is returning customers who are familiar to GAM and their services, whereas unfamiliar actors often engage GAM later in the process (GAM Informant #1, personal communication, February 18, 2022).

The main activities for GAM include process consulting to increase the reusability of the bricks and performing pre-demolition material test, where a brick is extracted by GM Tech and tested at their facilities followed by negotiations about terms and conditions for the transaction. As such, these informal relationships are based on the terms of the market though mediated by an informal setting and some level mutual learning and development.

<u>Step 2: Demolition</u>

During the demolition GAM is engaged only through the development of value preserving demolition guidelines in step 1. However, as an earlier disclosed quote emphasize, the project manager stresses that the initial dialogue is important to preserve material value and maintain the reusability of the bricks. As such, the demolition process is a key point for supply chain risks which they aim to counteract with aligning earlier in the process (GAM Informant #1, personal communication, February 18, 2022, personal communication, March 18, 2022).

<u>Step 3: Post-demolition</u>

In the post-demolition phase, reactive sourcing strategies has previously by a main contributor for material inflow. Reactive sourcing strategies include case-by case management of inbound logistics from demolition sites and management of formal agreements with selected recycling stations in which GAM gets they masonry and brick waste fractions.

Regarding the inbound logistics, the inbound material transport ranges from 1 to 30 truckloads, each weighing approximately 30 metric tons, depending on the demolition project. Terms and conditions for the are negotiated on a case-by-case basis and managed through informal partnerships as described in step 1 or as completely market-based negotiations in the case of new customers. A strategic goal in at this step is to create incentive for entering an agreements and to make the collection of secondary bricks as convenient as possible, i.e. by offering to plan and pay for the logistics or by providing satellite drop-off spots in close proximity to the demolition site (GAM Informant #1, personal communication, February 18, 2022).

The formal partnerships with the recycling centers are landed through contacts within the City Administration: "There need to be a forward thinking person in the City Administration propose making a deal with Gamle Mursten," however, "it is very different how the communication starts" (GAM Informant #1, personal communication, February 18, 2022). Entering deals with GAM can be based on coincidence and goodwill amongst the potential partners.

> "It seems slightly coincidental, when it is possible and when it is not. It seems like it is largely depending on the individuals in the decisive positions. They are the ones who can make it happen if they have a vision to do so, also depending on the pressure they experience from elsewhere in the organization. It is also a question about some cities being quite elaborate in sustainability and allocating resources to implement sustainable solutions. Others talk about sustainability but are not at the stage of implementing it yet." (GAM Informant #1, personal communication, March 18, 2022)

Resultingly, a key determinant is the mindset of decision-making individuals and the engagement to circular transition of the waste management practices in the City Administration.

Focal point

While GAM is gradually internalizing step 1, the main their main area of operation is within step 4-6: Operating a marketplace for secondary bricks, conducting quality control of the bricks, and finally remanufacturing the bricks to a reusable state through a series of cleansing techniques. Activities with the focal points are entirely internal processes performed by GAM itself.

<u>Step 4: Marketplace</u>

The process of operating a marketplace for reusable bricks is a central aspect of the GAM business model. This is the part where upstream effort and downstream effort meet by linking actors with waste bricks with actors in need of bricks for construction.

As compared to the processes undertaken by LEG at step 4, GAM is a facilitator of transactions rather than a customers at external marketplaces. As such, GAM secures an inflow of raw material bricks as described in the upstream phases above, and sells them on to customers at the other end of the VC. Facilitating these markets is a manual task and is highly time and resources consuming. Because each transaction is negotiated manually transaction costs are high.

This role of facilitating a marketplace is taken further with a new task undertaken by GAM of importing secondary bricks from Germany and selling them to the Swedish construction material retailer Brukspecialisten, who is currently starting a similar business within brick recycling. Conversely, Brukspecialisten have facilitated a link to the Swedish market for GAM by selling their products in their web shop (GAM Informant #1, personal communication, February 18, 2022, personal communication, March 18, 2022).

<u>Steps 5-6: Material pre-processing, quality control, and production</u>

The facilitating role undertaken in step 4 is strengthened by GAM main value proposal in step 5 and 6 which is the act of quality assuring the bricks and enabling reuse by removing excess mortar. Development within these areas of the organization have gotten most attention during the past years, somewhat neglecting to engage systematically with the other steps. GAM have spent resources on consolidating business processes and further developing the knowledge base of the company with the introduction of GM Tech.

> "We haven't grown a lot, but we see the we are producing smarter and that our economy is better during the past three years. The laboratory, CE certifications and the entire knowledge base of the company have made it possible to extend our storage space and material delivery and build a dry-storage, making us better equipped for winter production. We have consolidated rather than grown. But we see that competitors are coming, so we need to stay alert" (GAM Informant #1, personal communication, February 18, 2022).

With the development of the quality assurance methods and UMA concept, GAM focused mainly on the knowledge work instead of production. In that period they lost a production facility in the outskirts of Copenhagen and decreased the staff significantly. Current issues within production includes low production capacity, challenges, with maintaining production staff. To remedy this they aim to double production capacity, however no immediate solution is identified to the staffing issue.

Downstream

Steps 7-8: Architectural design & actual construction

Main actors within the downstream VC steps first of all direct customers but also proxy customers have played an important role in the GAM sales. While the direct customers include construction developers, builders, and bricklayers who directly buy the materials of GAM, proxy stakeholders are architects, advisors and other stakeholders who can influences the direct customers to choose GAM bricks for their construction projects.

Within both categories they have a series of returning customers but it has not possible to make long-term formal agreements or partnerships as neither architects and builders want to limit their options in the building design stage. As a result customers often want case by case negotiation rather than binding agreements. "We experience that customers – i.e. NREP - come back after doing a project with us. It is like planting a seed which then catches on afterwards" (GAM Informant #1, personal communication, March 18, 2022). They furthermore see a snowballing effect where customers become proponents of GAM, leading to more project from that particular organization (architectural firms or building developers) but also external parties". However, the informant continues to highlight that: "these relationships are characterized as customer relationships rather than a formal partnership" (GAM Informant #1, personal communication, March 18, 2022).

But while formal agreements are appear not to be within reach in the downstream phases, GAM also argues that they may not be in the interest to pursue such agreements: "As things are right now, there is no reason for pursuing long term agreements downstream because the demand is so big. We only produce on order and never gets to the point where we can create a material stock." (GAM Informant #1, personal communication, March 18, 2022). As a result, GAM do not pursue long-term binding agreements to prevent not being able to deliver on them because of a volatile material inflow. Currently, they sell the bricks as soon as they are remanufactured so binding themselves on fixed agreements can be entails a level of risk. That said, the UMA may initiate a turning point in this area, by combining inbound and outbound material flows. Engaging in long term partnerships based on a the partners material input may secure both sales and raw materials.

Taking a look specifically at the proxy customers, the relationships with architects at step 7 in the VC have been of particular importance to GAM, as they can argue for the aesthetics of using secondary bricks, which in some cases can be the deciding factor for the customer to choose GAM bricks:

> "In the bigger projects it is usually the architects who starts it, because the like the materiality of the bricks – it gives a lot to the designs by using secondary bricks. That way, architects become the link to us and may result in our bricks being used in the actual project. In these cases, they contact us to get advice on what to put in the tender document to make sure which bricks will be used." (GAM Informant #1, personal communication, February 18, 2022).

Ultimately, the downstream VC steps are not something GAM considers as a strategic priority. Because of the high demand for bricks in general, but especially secondary bricks, product sales are considered as guaranteed through using conventional market-based sales venues.

4.2.4 Case summary

With the introduction of Urban Mining Agreements (UMAs) GAM pursues a business model that facilitates longer customer relationships and more continuity in the material inflow. UMAs are offering an a secondary business model based on a service-provision rather than ownership transfer through product sales. Furthermore, GAM aims to a larger extent to embed their knowledge work more in the industry by offering quality assurance tests as a tertiary business model, separate service for external parties exploring the reuse potential of their bricks.

In the past year GAM has not experienced the growth one would have expected from an otherwise growing market and an increased interest in their products across the industry. This is primarily due to internal factors such as a limited production capacity.

In the daily work collaboration with upstream suppliers are mainly ensured through informal relationships and case-by-case negotiations of transactions. These negotiations are mediated through social relations amongst GAM staff an 'CE enthusiasts' in the collaborating partners in suppliers and/or customers. As such, business success is highly dependent on informal relationships with individuals which may make business operations vulnerable to organizational changes in the partner organizations. Long term agreements are not common in the upstream stages besides the formal contracts with individual recycling stations to take their brick fractions.

5 A conceptual analysis

In the following sections, the cases will be unfolded applying a combination of analytical frameworks. In section 5.1, the adapted Leising et al. (2018) framework is presented and used to highlight six aspects that in the cases are decisive factors for their collaborative efforts, thereby answering RQ 2. In section 5.2, RQ 3 will be answered by applying theoretical perspective from transition management theory. This section will furthermore open the discussion about the relevance of collaboration in relation to industry transition and market creation.

5.1 Six aspects of supply chain collaboration

To expand the understanding of what aspect are influential to how the two case companies have organized their value chains (VCs), an analytical framework is presented. This framework is the result of an abductive data analysis, starting will the Leising et al. (2018) framework, including: Shared vision, actor learning, network dynamics, and business model innovation. However, as part of the analytical phases of the abductive methodology the framework has been adapted to further explore the new context of medium- and long-term collaboration. The adapted framework is proposed to better equip the framework for assessing long-term collaborative configurations, taking a business model perspective as opposed to the project-based perspective applied by the original Leising et al. framework.

The final framework is used to analyze how the strategies may help to achieve the elements highlighted by research to lead to successful medium- and long-term collaboration:

i) A shared vision for the future;
ii) facilitating actor learning across the value chain steps;
iii) strong network dynamics and value creation;
iv) the ability to operate innovative and inclusive business models;
v) pursuing automated action, and finally;
vi) choosing an appropriate level of integration.

Each of these aspects influences how well the collaboration scheme works and should be considered or purposefully leveraged when designing a collaborative strategy. In the following sections, these will be explored considering how they relate to the strategic decisions made by the case companies regarding collaboration schemes to ensure alignment across the VC. Using this framework, the section aims to answer research question 2:

> *RQ 2: What aspects are influential when developing and operating a collaborative strategy for urban mining?*
>
> > *SQ 2.1: How well does the conceptual framework developed by Leising et al. (2018) fit long-term collaborative supply chain strategies?*

5.1.1 A shared vision for the future

Leising et al., (2018) present visions for the future as consisting of three dimensions: transformative ideas on how the future could be, the use of explicit language and metaphors to describe the vision and discuss a potential transition toward it, and finally, that the vision is used in a way that is attractive to current or potential collaborating partners by facilitating motivation and inspiration.

Multiple informants expressed that there is a noticeable change happening in the industry, in which traditionally more conservative actors in the environment are increasingly acknowledging the importance of sustainability and material efficiency. This can be interpreted as a development in which they are acknowledging the transformative vision of pursuing a resource-efficient and sustainable construction industry (the first vision dimension), making them more supportive of proposals to apply UM as a material sourcing strategy.

A project manager at GAM explains:

> "We experience that the sustainability agenda and the circular management of construction materials are spreading. There are more finances available to implement sustainable practices. I think there are more politics involved and more goodwill to spend a little more to build sustainably" (GAM Informant #1, personal communication, February 18, 2022).

As a result, GAM increasingly sees large corporations get back to them to initiate longer-term collaborations to improve the circularity of their future buildings. This creates a good narrative for the corporation and it helps them perform better in terms of sustainability reporting providing an increased incentive and meeting the increasing expectations of the external stakeholder environment, ultimately supporting an incentive to »do good«. While the external narrative may be the primary driver for some companies, others display an internal drive for pursuing UM and circular construction methods. As such, a shared vision may be derived from the high-level goals of the CE.

This position is confirmed by LEG, highlighting while it may not be the case for every company in the industry, there is an ambitious club of industry front-runners who share the legitimate goal of pushing the industry toward more sustainable and resource-efficient practices. Most of LEGs VC partners are part of this club who share a recognition of the importance of circular practices and who aim to push the standards industry-wide, which creates a value-based interest community: "…in that sense, we are in the same boat, the front-runners of sustainable construction and demolition practices" (LEG Informant #1, personal communication, February 21, 2022).

During the past years, LEG has experienced that more industry actors are subscribing to these ideals, assembling under the flag of a circular transition of the construction industry:

> "A few years ago we experienced a great deal of resistance [in the established construction industry]. The conversations in the meeting were more difficult. But I feel that things have changed lately. There is a greater willingness to undertake some of the experiments that we are advising on. I think the conventional mechanism is taking a new form" (LEG Informant #1, personal communication, February 21, 2022).

Organizations operating within UM can align on the high-level goals of the CE, forming an overall guiding line in which the collaborative schemes and organizational activities should develop. While this may secure some broad-level alignment, alignment should also be pursued on a more detailed and specific level in terms of how the values of circular construction should be implemented in practice.

At the specific level, there is no doubt amongst the case companies that to enter successful partnerships with external parties it is necessary to adapt to their worldview and make the potential partner understand that engaging in circular activities such as UM is part of the solution in pursuing their transformative high-level goals. This is where the two other vision dimensions – language and metaphors and motivation and inspiration – play a key role.

In ensuring a shared vision for the future in the partnerships, companies can take a leadership role and become vision champions (Quist, 2007; Quist et al., 2011). A key role of a vision champion is to proactively develop a vision and share it amongst the collaborating partners. Part of this has to do with inter-organizational learning, which will be addressed more deeply in the following sections, however, in this context the main goal is to unlock a shared vision in the partnership by addressing any uncertainties in the potential partner organizations, provide guidance, and provide inspiration and motivation to change.

An example of the cases includes when GAM uses the common language of European standards and the CE-certification schemes to address the prevailing uncertainty regarding the structural strength of reused bricks when pursuing long-term partnerships and/or UMAs with City Administrations. Furthermore, vision championship is seen in both GAM and LEG when proactive efforts in the pre-demolition step of the VC help guide upstream actors to enable material reuse. Through these activities, they provide understanding and motivation amongst some of the most essential (but also traditionally most hesitant) actors of the construction VC to implement UM in practice.

Furthermore, the role of being a vision champion also entails addressing risks related to material quality and the financial consequences of implementing value preserving demolition techniques in the upstream steps or when building with secondary materials in the downstream steps. Knowledge-based tools such as life-cycle assessment (LCA) or life-cycle costing (LCC) can be instrumental in reaching this goal.

5.1.2 Actor learning

In these cases, actor learning and the possibility to create a system for capturing the experiences gained during operations were emphasized as a key incentive for engaging in long-term relationships with external industry actors or even internalizing supply chain steps.

For UM to become an effective sourcing strategy, upstream education systems are of immense importance to preserve the inherent value of the material throughout the supply chain steps. Networks facilitation actor learning can be a key tool for ensuring coordination across the supply chain and over time create synergies amongst the partners.

Leising et al. (2018) mention first-order learning and higher-order learning. First-order learning is the operational day-to-day aspects such as how to treat bricks properly during demolition to preserve their structural qualities and value. Higher-order learning is lessons that change the perspective on a more fundamental level, potentially leading to new ways of understanding the fundamental problem definitions, new norms, values, and convictions, and potentially also new goals of actors. (Leising et al., 2018)

In some first-order learning systems can be relatively simple, depending on simplicity of the learnings themselves. As such, while leanings on how to enable material reuse in the first place are important part of landing the initial agreement and initiate a partnership, it is the higher-order learnings that benefit most from engaging in prolonged partnerships.

The example from the GAM case of how demolition companies must treat the brick to enable reuse is an example of a first-order learning, which is easily communicated and also easily implemented once aware of it. However, to convey the information in due time, a point of contact need to be established already before the demolition. To facilitate a communicative system enabling first-order learning systems, informal networks can be enough if the content of the learning is simple.

However there are also higher levels of learning to achieve in the process of expanding their partnerships from episodic market-based interactions, which has a direct influence on their raw material suppliers: "The main share [of the material inflow] comes from private partners because we are still in the process of educating the city administrations" (GAM Informant #1, personal communication, February 21, 2022). It is essential that the industry actors who currently have direct access to the construction waste streams (which is mainly during the upstream phases) need to learn how their actions influence future reusability, but also what role they can play in pushing the standards beyond current norms.

LEG describes how the first project – be it a specific construction project, a material development project, or a sourcing agreement – serves as a pilot for a potential long-term partnership, testing how well the organizational values, visions, and workflows of each participant align. When a medium or long-term relationship you peel a layer of the onion, starting even closer to the core for the next project, allowing you to go even further (LEG Informant #1, personal communication, February 21, 2022). The more the actors are used to working together, the easier the communication and coordination become. The onion analogy can describe first order learnings, facilitating a constant improvement of operations creating synergies. However, besides contributing to operational efficiency, there also appear to be strategic upsides in prolonged collaborative schemes across the VC. An example of such strategic learnings can be seen in LEG's medium-term collaborative efforts with builders, which allows them to beyond the operational level, but also reassess their organizational goals related to sustainability and circularity, their general assessment criteria for initiating a construction project. That said, higher-order learning is not limited to reassessing strategic efforts, it is also concerned with influencing the norms and belief systems of individuals and organizations involved along the material journey. As established in the first section, there are big cultural barriers to implementing circular solutions based on UM principles. As a product designer, material manufacturer, or architect engaged with UM you can lead by example and show potential in the salvage materials thus providing first-hand experience to refute the established industry dogmas.

Actors in the downstream VC steps have the potential to play a key role in enabling UM by facilitating learning processes along the material journey from salvage material to a new building. Key activities here are facilitating first-order learning at the relevant steps to preserve material value, but also facilitating inter-organizational communication to identify and utilize embedded knowledge in the individual organizations along the VC to enable higher-order learning. That LEG highlights understanding what the upstream actors such as demolition companies need to improve their practices is a good example of actors late in the VC taking on this role.

But while companies such as GAM and LEG are in a special position as front-runners and knowledge hubs within UM and upcycling, LEG express an acknowledgment that successful collaboration depends on joint learning and that knowledge transfer goes both ways:

> "The most important thing is to understand what they [construction companies] need from us – be it specific information or requirements for material characteristics. […] In that way you can start a dialogue" (LEG Informant #1, personal communication, February 21, 2022).

5.1.3 Network dynamics and value creation

Collaboration schemes and partnerships are not just technical constructs in which partners collaborate to reach one or several goals, they also consist of an omnipresent social dimension that mediates how partners engage with each other to coordinate information and material flows (Berardi & de Brito, 2021). Resultingly, the social structure surrounding the collaboration is as crucial to a successful collaborative effort as agreeing on the division of labor and a shared vision. (Leising et al., 2018)

The technical structures facilitating BMUMs are mapped out in the supply chain maps of Section 0 and are best described as collaborative cycles in which secondary materials and financial and informational resources flow back and forth between the actors (Seuring & Müller, 2008). Reverse material cycles are complex and involve many actors across the sector. As such, a key skill to operate a successful business model based on these cycles is to utilize the social networks in a way that breaks down practical and inter-organizational barriers.

An example of such skills led to the realization of how LEG should interact with potential suppliers when conducting proactive sourcing of secondary materials. They acknowledge that sourcing materials are a social process in which a large network of potential suppliers is engaged. The informant emphasized that to be successful is important to consider how to engage them: Linked to the earlier statement on joint learning, it is important that LEG understands the social network in which their request for materials will be received during upstream sourcing. Often, the conventional demolition agents are not geared to handle ambiguous requests and vaguely stated performance requirements, instead, LEG acknowledges that to increase the chance of success in the material sourcing efforts they need to be specific in what requirements there are and what kind of materials they need. An example of sourcing steel plates for building enveloped is provided: "the plates must not be bent here, they need to be this size, can't exceed this price, and we need that many square meters" (LEG Informant #1, personal communication, February 21, 2022). This makes the task of identifying potentially reusable materials fit better to the social context of the demolition companies in which time resources are limited and material management is often determined by habits of the industry.

GM experienced that managing the social network within organizations and city administration could be a driver for business growth in both upstream and downstream partner management. First of all, having designated project leads in the organization is a strategy utilized by GAM to build relations with partners and create trust amongst the organizations: "It is good to have some continuity in who they [external contact persons] talk to. It makes them feel secure if they talk to the same person from the start and forthgoing" (GAM Informant #1, personal communication, February 21, 2022). They have experienced getting informal GAM promoters amongst returning customers within architects and city administrations.

The construction industry is an industry in which informal communication partnerships can potentially have a big impact on how projects evolve. Resultingly, network dynamics is an aspect that can be a key driver to counteract the cultural barriers for increased uptake of circular solutions in the construction, namely the power of habits in the industry and status quo preserving companies.

Besides the importance of navigating in social inter-organizational networks, also network value creation is a key aspect to effective collaborative schemes, which is highly important in designing a BM for shared value creation. VCs for UM is dependent of multiple actors aligning efforts to make it work. To do so it is important that value created during the chain of actors is shared to increase incentive for continuing the effort. It is vital for every actor involved in the partnership to experience an incentive to continue and develop the partnership further. Traditionally these incentives have been created by financial compensation, and everyone benefits from the collaboration (Senaratne et al., 2021). To ensure collaboration across the VC monetary flows generated in the material cycle cannot be absorbed by the one actor bringing it back on the market.

However, one thing is the financial compensation, but another is to achieve the organizational goals. As the external stakeholder pressure increase, sustainability goals will become an goal which is increasingly shared among actors. As such shared value include both monetary and non-monetary aspects.

5.1.4 Business model innovation and inclusion

In facilitating the transition toward a circular construction sector redesigning the conventional efforts through BM innovation (BMI) and inclusion of VC partners in designing such BM is considered essential (Bidmon & Knab, 2018; N. Bocken et al., 2013; Chang & Yujie, 2017).

While there is no theoretical classification of various types of BMUMs applied in the construction industry, two approaches were identified in the cases. Both aim to increase the market uptake of secondary construction materials and the wide use of UM principles in the construction industry. However, the approaches apply different foci which have a significant impact on how their business models are designed and what collaborative agreements they enter. The difference aligns with the classic distinction deriving from industrial theory between business models for scale and business models for scope (Chandler & Hikino, 2009).

GM operates a business model for increasing the scale at which UM is applied in the industry. They do so by offering standardized products with a wide appeal across conventional companies and industry front-runners. As such, they are aiming to increase the production of a single product type – bricks and brick slips – instead of widening the scope of their product portfolio. Following Chandler's economies of scale theory, the main goal of business models for scale is to decrease the production cost per product by spreading overhead and fixed costs on a larger product population (Nielsen & Lund, 2018). However, while this may be the case for many linear business models, the GAM case testifies that such scenarios are difficult to enact with secondary material sourcing. Within their current business model configuration, sourcing raw materials is a time-intensives task with high transaction costs pr. ton of inbound raw material as transactions are negotiated on a case-by-case basis.

To operate a business model of scale, supply chain stability and certainty of material delivery is a key concern. Once the production capacity of GAM, which is the main impediment currently, is increased material sourcing may become a highly pressing issue for them as demand is constantly increasing. This is a sign that engaging in collaborative agreements with larger upstream industry actors is a wise strategic decision to secure as many bricks as possible are reused.

LEG displays a radically different business model than GAM by largely abandoning the question of scale with the off-selling of LEG UP. With LEG UP still in the organization, two business models were in operation - a business model for scope and a business model for scale. However, they found that the scaling aspect was not the core business of the company which prohibited it from fully entering the market. Instead of spending its organizational resources on scaling the application of specific materials, it decided to focus on widening the scope of circular construction and construction materials based on UM:

> "I am not sure what it is, but we are always - sort of - in the deep because it is a new area. […] Because everything is so new, we need to be aware that it [systemic transition to circular practices] doesn't happen of its own accord, and we are aware that we should be part of pushing the boundaries of what is possible. We are observing that it is now possible to reuse some materials directly, and the method to do so will be copied by others […]. We shall always challenge what IS – sometimes we don't succeed, but that

> is the premise to be in the position we are in on the market" (LEG Informant #1, personal communication, February 21, 2022).

The above quote is a clear indication of business model experimentation as an organizational core principle of the company. This principle affects all aspects of operating their business model, from what type of product they chose to engage with, to how they engage with collaborating partners for product design and development and supply chain operation. As a consequence, LEG pursues flexibility in the supply chain partnerships as opposed to GAM which prioritizes supply chain stability and security. While the informal networks and case-by-case negotiations is an inhibiting factor for GAM to fulfill its organizational goal, it is a strength for LEG to fulfill theirs. In the two case companies, we see two drastically different organizational goals. We also see how this influences how they have chosen to approach collaborative schemes in their supply chains.

In developing BMUMs experience and competences from across the VC is important to include as the actor putting it back on the market. When developing secondary building materials, the quality and value of the end product is highly dependent of the quality of the input material. By engaging actors from across the VC in such processes can improve the end product by embedding knowledge from industry experts in the development. LEG acknowledge this in the development of their materials under the new organizational structure. Instead of developing the building materials and products inhouse, they engage in formal development projects with established material to utilize their product expertise (LEG Informant #1, personal communication, April 13, 2022). Such development project may have the dual effect of improving the end-product by embedding product specific knowledge in the development, but it may also be a way of engaging the development partner in the UM agenda. Looking further upstream in the VC, the demolishing companies can supply knowledge on demolition processes and obstacles in applying selective demolition strategies which may have an effect on the option in material design, development and use. Ultimately, developing and operating BMs in silos may limit the value created which emphasize the importance of inclusive approaches to strategic development of BMUMs.

5.1.5 Pursue automated action

To benefit from the collaborating practices over long timeframes, automated action is an important value driver. Collaborative schemes can support or counteract the implementation of automated action depending on the context in which the scheme is pursued. Automatic action builds on actor learning and aims at developing fixed operational structures for supply chain collaboration, benefitting from the repetition of well-functioning workstreams. To ensure automated action across the supply chain builds on effective communication amongst the collaborating partners and relative stability in the resources utilized and activities performed along the supply chain.

Automated action is highly related to the Transaction Cost theory, and measures to implement to pursue such workflows can be derived from this literature. Williamson (1979), one of the most prominent authors within this tradition, states how transaction costs should be key decision criteria for deciding to internalize organizational activities or not. Internalizing such activities can increase the level of automation, as efforts are easier coordinated across internal parties than across multiple organizations (Williamson, 1979). However, as Dyer (1997) argues, it also increases the organizational complexity, making its operation more rigid.

The present case studies indicate that engaging in collaborative schemes across the supply chain increase not only the asset specificity but also the potential influence the engaging organizations can have on otherwise external activities. As such, collaboration can increase the scope of potential activities amongst the firms.

Looking at the cases, GAM is a good example of an effort to decrease the transaction costs by integrating upstream partners more into their organizational structures through long-term agreements. When engaging in UMAs with city administrations or industry actors they embed a certain level of know-how in the upstream partners through actor learning, so they know how to treat the bricks to enable reuse and how to ensure engagement with GAM to make it happen. Reverse logistics become increasingly effortless as a framework agreement is in place. The only pending factor is the structural quality of the bricks assured by the CE-certification tests. With the current setup, there are options for automating this part of the business operations are limited. This may not only be the case for GAM, but also a relevant point in general regarding UM in the built environment, due to issues related to hazardous substances or varying structural qualities across products. As such, chances for implementing an operational structure based on costless interactions[3] are bound limited by the need the assure quality of the bricks as a prerequisite for the transaction to take place.

At LEG costless interactions are out of the question due to the diverse nature of the material input they are seeking. When interacting with material suppliers (i.e. demolition companies or secondary marketplaces) coordination is of high importance, as the sourcing process is also a learning process in which upstream actors gradually learn which criteria are important to enable reuse in the specific building design LEG has developed. These criteria are different from project to project depending on the building design, and resultingly need to be coordinated each for each sourcing effort. Processes are however put in place to minimize transaction costs from coordinating reuse criteria with external stakeholders. As earlier stated, the respondent empathized the importance of facilitating a good interface between the organizations by making »professional lists« stating the requirements for the given materials, mimicking the linear sourcing workflows. This has the dual purpose of making the criteria easily accessible for potential material suppliers and creating uniform workflows internally in LEG. With the constant change and project-based nature of the operational processes at LEG, a high level of flexibility amongst their material suppliers is preferable rather than automated action.

Ultimately, by formalizing the agreements between partner companies there is potential for streamlining the coordination between the organizations, thus increasing the potential automation in BMUMs. However, as exemplified in the cases, not all business models are suitable for a high level of automation in business operations. In BM for widening the scope of UM, which therefore is based on an exploratory material design process, informal partnerships with multiple organizations may be a better option than closer collaboration with fewer actors as the potential for decreasing transaction costs is limited due to high project diversity. Conversely, in BM for scale where the material input is more stable and the reuse criteria are uniform over time, engaging in closer collaborative schemes with potentially large secondary material suppliers may be the better option. As such, this factor primarily relates to the BM for scale, such as the one operationalized by GAM, due to a high level of repetition in the production processes, and a relative uniformity of the raw material needs. In business models for scale, automated action through highly integrated collaborative schemes has a high potential for supporting business objectives by decreasing transaction costs from engaging with upstream supply chain partners.

---

[3] Cost-less interactions refer to costless contracting, which is inter-organizational interactions that are fully automated, in which transaction flow effortlessly and relevant support systems are implemented to keep the processes running (Williamson, 1979).

5.1.6 Decide on an optimal level of integration

All the above aspects influence what level of integration is appropriate and should be taken into consideration when developing a collaboration strategy. Some of the aspects are something for the company to pursue to strengthen their partnerships (namely, a common vision for the future, actor learning across the supply chain, and automated action) and some are situational aspects for them to consider when weighing the upsides and downsides as relates to their particular business context (namely, the dynamics of the organizational network and how it related to the specific BM). To some extent, it is a matter of weighing the benefits and disadvantages of increasing the integration level. This thesis proposes that these five aspects together can provide a framework for deciding on a collaborative strategy suitable for the individual company.

A central benefit is to a larger extent being able to streamline activities of the value chain to maximize the value generated and align activities within the wider stakeholder environment (Khalfan et al., 2004). To achieve circular material management across the SC, much more information is necessary and the level of information detail needs to be higher. This emphasizes the importance of strong information transfer systems between actors which to some extent can be achieved by closer collaboration and increased coordination amongst actors. By integrating value chain functions objectives are more easily streamlined and incentives for sharing resources and information are strengthened due to the shared vision, high-level goals and benefits, and increased trust among actors (Barratt, 2004; Khalfan et al., 2004). Furthermore, collaboration can strengthen the competitive position of the engaged firms by minimizing the level of uncertainty for disruptions in the value and supply chain (Miozzo & Dewick, 2004).

However, there are also barriers to engaging in collaborative networks, and more collaboration is not necessarily good for a company. A company's ability to engage in effective collaborative networks with external partners depends on its collaborative capabilities (Barratt, 2004; Berardi & de Brito, 2021). Value chain integration naturally increases the operational scope of the company which can make processes more difficult and the organization structure more rigid and the company as such less agile in coping with a changing environment. Furthermore, relationship governance (the process of initiating, maintaining, operating, and terminating partnerships) can be time-consuming, which (especially in smaller companies) can be a significant barrier to engaging in systematic collaboration schemes (Berardi & de Brito, 2021). Relationship governance ensures organizational elements such as effective coordination amongst partner organizations, aligning expectations, sharing knowledge and benefits, but also social elements including the creation of strong relationships and mutual trust between actors (Berardi & de Brito, 2021). When weighing these aspects a perspective from resource dependency theory (RDT) can help decide on the collaboration strategy. RDT highlights the risk related to externalizing important steps in the business operations to external actors and thereby offers a relevant perspective on the matter of securing alignment in the supply chain through collaborative schemes with external parties. Engaging in collaborative schemes with external parties may decrease the transaction cost of securing supply chain alignment compared to a market-based approach, however, it also increases risk by outsourcing key strategic decision points that have a direct impact on company performance (Pfeffer & Salancik, 2003).

In the cases, it appears that in choosing the optimal level of integration, the company is facing a dilemma between gaining control and influence of upstream and downstream supply chain steps, expanding their area of activity, and remaining flexible in terms of being agile on the market. LEG elaborates:

> "I think collaboration is extremely important. We are experts in some things, but we do not know exactly what knowledge and competencies we need in the setups and processes we are operating in. With this uncertainty, we cannot hire the competencies" (LEG Informant #1, personal communication, February 21, 2022).

Engaging in collaborative schemes that are at the high end of the integration scale (partner integration and partner coordination) allows for taking a longer perspective which can decrease transaction costs while strengthening the systems for facilitating a shared vision, actor learning, network dynamics, and VC inclusion in innovation processes. However, in fields as new as UM, it can be key for an organization to stay agile which requires some flexibility in the supply chain. Thereby, LEG argues that the company should not be stretched too thin, and therefore it is also important to carefully consider which integration level is beneficial in the particular case.

5.2 Collaboration as dynamic transition capabilities

The above analysis argues that a collaborative scheme can support reaching organizational goals such as aligning efforts along the supply chain to enable the reuse of building materials. This section aims to expand the scope, arguing that inter-organizational collaboration has the potential to do more than that, depending on how it is used. As such this section will take a macro perspective and serve as a discussive analysis, building upon but also rising above the previous research questions to answer RQ 3:

> *RQ 3: How can supply chain collaboration influence industry transition toward large scale implementation of urban mining principles and reuse of building materials?*

Berardi & de Brito (2021) argue that circular initiatives are often implemented as isolated initiatives within a mostly linear context. Senaratne et al. (2021) echo, saying that a lack of involvement of key upstream industry actors such as demolition companies prevent further development of circular building practices. To depart from these tendencies and engage more holistically with CE, organizations are encouraged to increase collaboration across their SC and VC. This will increase synergies across the supply chain and is likely to increase value creation by developing better workflows and improved circular solutions. However, as outlined in Section 2, industry actors are often embedded in the established linear workstreams, which can be a significant barrier for pioneering companies attempting to implement BMUMs. These organizations depend on collaboration with industry actors which are not always immediately open to changing their ways. Getting these actors on board depends on the capabilities of the hub company to initiate and operate well-functioning alliances (Geigenmüller & Leischnig, 2017; Heimeriks, 2008; Leischnig & Geigenmüller, 2018). SC alliances can facilitate a point of contact that individual companies can use as a means of influencing the surrounding industry actors through the creation of innovation communities (Hansen & Schmitt, 2021). However, to create an innovation community from an initially reluctant SC partner, careful interaction between companies must be applied to aspire for change across the industry. Hansen & Schmitt (2021) propose a four-step plan for orchestrating a wider change toward circular practices by overcoming barriers at four levels: individual, organizational, value-chain, and institutional. While the individual and organizational barriers for CE are largely removed at the two case companies as both were founded with the very purpose of driving material reuse in the construction industry, this thesis project has mainly focused on the barriers to higher-level dissemination of BMUMs, in particular, the value and supply chain barriers for increasing the market uptake of UM and secondary building materials (for more on overcoming the individual and organizational barriers, see Hofmann & Jaeger-Erben (2020), Loorbach et al. (2009) and Roome & Louche (2016)). As sections 4 and 5 show, they are in the process of initiating change on a VC level as well by engaging with industry actors in formats varying from market-based interactions, informal networks, and formal partnerships, to fully integrated subsidiaries. Furthermore, as discussed in section 5, upstream and downstream alliance configurations create better circumstances for developing a shared vision and functional network structures, facilitating actor learning and coordinating workflows to automate them to an appropriate level.

Upstream alliances with building demolition companies, material management companies, etc. can help provide a more stable material input stream with a higher quality of secondary building materials. This may help scale up or scope out the material supply. Downstream alliances are more difficult to engage in, as some builders and building developers are reluctant to commit to long-term agreements regarding material sourcing. Nonetheless, by engaging more systematically with downstream VC actors, mutual learning processes which can influence the product development and ultimately the future demand for secondary building materials may be initiated. Some more-or-less significant barriers remain, including risk division and structuring the financial flows, which should be dealt with in the individual alliance initiation process, depending on the characteristics of the specific material, its risk profile, and the remanufacturing processes.

Ultimately, alliances that increase collaboration across the SC can become a tool for engaging in the industry as a circularity promoter, influencing the surrounding actors. However, while supply chain partnerships may show potential for breaking some of the barriers to large scale implementation of BMUMs, it is no silver bullet. As transition theory prescribes, societal transitions are dependent on multiple developments and dynamics in society to influence the future path (Frantzeskaki et al., 2012; Geels, 2011). As such, supply chain collaboration has the potential to be one of these developments to push for increased uptake of secondary construction materials, but it is still dependent on developments in other aspects such as legislation, further technological development and increased end-customer awareness.

Frantzeskaki et al. (2012) argue that sustainability transitions are open-ended processes which are cannot be fully governed using top-down approaches. Instead, they stress the importance of creating transition arenas in which co-creation, knowledge transfer, and mutual development are central. This thesis argues that supply chain collaboration can facilitate a transition arena in which front-running industry actors engage as circularity promoters utilizing their capabilities to create demand and supply for secondary materials. As such, this may aid the balancing act between the long-term need for a radical change of the building industry practices toward large scale implementation of resource-efficient practices and the short term need for compromise and small steps amongst the established regime of industry actors. Front-running industry actors can through alliances create a leverage point for engaging in transition management by engaging with the right stakeholders and stimulating commitment and innovation. Frantzeskaki et al. (2012) propose a transition management cycle that combined with the Leising et al.-framework may deliver a roadmap for how a company such as the two case companies of this thesis may engage with transition management to break down value and supply chain barriers.

The cycle that Frantzeskaki et al. (2012) present aims at governing transitions by combining activities at a strategic, tactical, operational, and reflexive level. This translates into four transition management phases (TMPs) each utilizing different transition management instruments. The phases and their connection to the aspects of SC collaboration are depicted in Table 4 and their reiterative nature is illustrated by the arrows forming a cyclical movement between the phases.

Table 4 Transition management phases and the associated supply chain collaboration aspects

Transition management phase (TMP) Frantzeskaki et al. (2012)	**Collaborative goal** Adapted Leising et al. (2018) framework	**Description**	**Level**
Strategic: Define problem statement	• Vision development	• Contextualize CE principles and set high-level goals. • Materiality and hotspot analysis - where is the problems related to circular construction typologies. • Identify the right materials, and potential material sources, etc.. • Overcome individual and organisational barriers (Hansen & Schmitt, 2021).	Hub-firm / Alliance
Tactical: Develop transition agenda and coalition configuration	• Vision diffusion • Build network dynamics • Utilize actor learning • Pursue optimal integration	• Chose partners and initiate alliance configuration and pursue optimal level of integration. • Utilize and build network dynamics in the industry, engage actors to break silos and initiate communication. • Facilitate actor learning in the initial BMs and SC configuration. • Overcome value chain barriers (Hansen & Schmitt, 2021).	Industry level
Operational: Conduct transition experiments	• Operate effective BMUMs for scale or scope • Pursue automated actions • Optimize integration level	• Develop functional operational processes with collaborating partner. Ensure good interfaces between companies and effective coordination between actors. • Ensure effective BMs that are equipped for increasing the scale or scope of urban mining in the industry and maximise levels of automation depending on the context. • Overcome organisational and value chain barriers (Hansen & Schmitt, 2021).	Alliance
Reflexive: Monitor results and evaluate	• Increase actor learning	• Monitor and evaluate partnerships and implement key learnings. • Reassess the strategic, tactical, and operational efforts of the BM and Alliance configuration. • Communicate results externally to influence the institutional barriers (Hansen & Schmitt, 2021).	Alliance

The transition management phases can in practice be undertaken with any given starting point, depending on the context, but it is of immense importance that the phases synergetic and are implemented through participatory processes (Frantzeskaki et al., 2012; Loorbach & Rotmans, 2010). In orchestrating these participatory processes, visionary industry actors can play a leading role by displaying transition leadership (Hansen & Schmitt, 2021) thereby supporting the transition toward the CE (Loorbach et al. 2009).

The two business model types identified in the case companies (as elaborated in section 5.1.4 on Business model innovation) can be utilized to take two different transition leadership roles: Qualitative industry leadership[4] and Quantitative industry leadership[5]. Which role to take on is decided on as part of the vision development in the Strategic TMP. This is a complex process of facing the trade-offs within circular construction such as those related to circular design, demolition vs. transformation, etc.. In the context of UM for material reuse, the latter is highly relevant as basing a BM on demolishing usable buildings hardly aligns with the principles of CE.

In the Tactical TMP, an alliance configuration is developed (or reconsidered) based on who can contribute to fulfilling the vision. This is the phase which informs the vision diffusion should is pursued, and networks are utilized and/or created to support inter-organizational communication to facilitate actor learning. This is crucial to ensure the alignment amongst the alliance actors and overcome value and supply chain barriers.

In the Operational TMP task and company, specific success criteria are coordinated to ensure a good interface between the organizations. This is important to operate the BMUMs effectively and automated action can be pursued to increase efficiency which increases competitiveness compared to virgin materials. Which type of organizational structure is appropriate here is highly different if a qualitative or quantitative transition leadership role is applied and should be tailored to the case. For qualitative transition leadership business model experimentation can be pursued, which requires more flexibility in the experimenting process to test the waters of new reuse solutions, oftentimes requiring loosely knit organizational structures, whereas quantitative transition leadership are better suited for fixed arrangements benefitting from economies of scale to push UM and CE principle to more industry actors. To relate it to the case companies LEG can be seen as a type of qualitative transition leader and GAM is a case of the quantitative approach.

In the Reflexive TMP inter-organizational, communication and actor learning are central tools for monitoring and evaluating the results of the BMUM and the processes that yielded them. This reflection should feed back to the other TMPs and inform the further development of the BMUM. Furthermore, to initiate societal transformation learnings should be disseminated beyond the alliance boundaries, institutional barriers addressed to the relevant authorities, etc..

Common for each TMP is that the transition leader plays an active role in orchestrating the processes and engaging the other companies. This includes engaging and persuading the right industry actors, facilitating networks and mutual learning processes. While taking on the transition of an entire industry is beyond the capacity of the individual company, this thesis argues that, though it is a large responsibility to on, facilitating industry transition is in the interest of the individual companies as it is part of a larger market creation within their core business area. As such, driving change and pioneering the field may be a differentiation criterion enabling business success in a future market with higher standards for environmental

[4] Qualitative industry leadership refers to the activity of orchestrating innovation communities to expand the scope of solution for reusing secondary building materials. This is highly connected to BMs for scope, as discussed earlier, and thereby also the business operations of Lendager Group (LEG).

[5] Quantitative industry leadership refers to the activity of orchestrating innovation communities for expanding the scale of solutions for UM. As such, this is connected to orchestrating the SC to increase the net-amount of secondary materials reused in the industry, decrease production cost, etc.. An important aspect of this exercise is to make the secondary materials competitive compared to conventional virgin building materials.

performance. The individual company may focus on market creation within their (niche) product(s) and through this process by association initiate a ripple effect equipping a wider industry uptake of secondary building material by breaking organizational barriers in their collaborating partners.

6 Discussion

The literature review provided evidence of the importance and potential of implementing principles of urban mining (UM) in the building industry. Large scale UM and reuse of secondary building materials can decrease the dependency on virgin materials significantly and reducing the adverse environmental effects of raw material extraction. However, a combination of barriers impedes the transition towards circular material management in the industry, creating a lock-in to linear construction practices in the mainstream industry. This results in the majority of building materials being downcycled, incinerated, or landfilled, instead of being remanufactured, upcycled, or reused directly as high-value building materials for new building projects. Increased collaboration between the industry actors is proposed as a tool that could potentially break some of these barriers, paving the way for an increased industry uptake of UM principles and secondary material reuse. Increased collaboration can facilitate better communication and more systematic networks for knowledge sharing. It can utilize resources and capacities of the external industry actor environment through inter-organizational agreements. It can facilitate trust amongst actors, and decrease opportunism and short-sighted decision-making. These are some of the aspects that may support the by-passing of the informational, practical, legal, structural, cultural, and cognitive barriers of the industry.

6.1 Catching momentum in a political movement

The industry literature reviewed in this work, painted a picture of an industry that was largely not engaging in circular construction. This research, however, saw that things are changing in the industry and that it is increasingly acknowledging the importance of the agenda. Most industry actors come across in this review (by first or second hand) are either already embracing some sort of circular activity or working on how to do it in the near future. This may be a sign of how quickly the agenda is moving or a sign of the case companies mainly engaging with a silo of front-runners. Most likely it is a combination. These initiatives, however, can still be considered small-scale and incremental improvements in the bigger picture. However, when looking ahead there is reason to believe that a change is luring in the Danish policy environment with the regulatory updates coming in 2023. With legislation demanding elaborate pre-demolition audits and selective demolition practices, awareness amongst the conventional industry actors is expected to grow. Resultingly, this may strengthen the current movement of increased interest in circular principles, engaging a broader segment of the private industry in circular material management. It can create a window of opportunity that can be exploited by private industry pioneers such as Lendager Group (LEG) and Gamle Mursten (GAM). Proactive industry engagement in the upstream phases of the value chain (VC) may allow them to embed their expert knowledge and facilitate mutual learning earlier in the process thereby influencing how these policy initiatives are received by the wider industry. Such proactive behavior may not only support industry transition but also facilitate market creation within an area in which they are front-runners. As such there are significant business opportunities related to taking the role of a transition leader within UM, orchestrating inter-organizational innovation communities for developing new and strengthening old concepts for UM, and reuse of secondary building materials.

However, by conducting in-depth case studies of pioneering companies within the secondary material design and production in the Danish building industry, we have learned that there may not always be a clear-cut collaboration strategy laid out even amongst the industry front-runners. Partnerships and alliances are often developed gradually in which incremental measures are implemented on an ad hoc basis depending on situational aspects. Resultingly, a company may have multiple collaborative schemes in operation at the same time each tailored to the partner, as opposed to one overarching collaboration strategy to lead the way. The case companies have engaged in different collaborative schemes to manage the obstacles related to small-scale suppliers and a limited supply. The companies have different goals, which influence what collaborative strategy best supports their objectives. The gradual development can be a sign of a reactive approach to inter-organizational collaboration, there may be a great deal of potential lost to coincidence and path dependencies related to past decisions with such an ad hoc organization. This research has pointed toward six mutually influential aspects which are essential for pioneers to achieve when orchestrating such innovation communities with external SC and VC partners: A shared vision for the future, actor learning, network dynamics, and value creation, business model innovation and inclusion, pursuit automated action, and an optimal integration level. These six aspects may provide some key points on how to engage in proactive transition management when setting up SC and VC partnerships. When managing relationships, partnerships, and alliances with the surrounding industry, a hub company may take the role of a transition leader initiating innovation communities by facilitating these six aspects.

This thesis argues that there may be untapped potential in purposefully engaging in collaborative alliances in which industry actors are committed to medium- and long-term collaboration. Disregarding the legal and formal aspects of how such arrangements are made, long-term collaboration help co-creation of ambitious visions and BM innovation showcasing effective operational processes which are over time strengthened through mutual learning and competence pooling and the creation of mutual trust through social community development. When engaging with conventional actors that are reluctant to implement UM principles, an ambitious hub firm can engage as a vision champion, leading the way through knowledge transfer and facilitating a mutual interest through the co-creation of BMs to generate network value for all the collaborating partners. The final contribution of the thesis is the development of the transition management roadmap for increasing the uptake of secondary building materials. By utilizing the six collaboration aspects proposed in this study according to the four transition management phases proposed by Frantzeskaki et al. (2012), a roadmap for creating a transition arena to bypass the industry barriers is formed.

6.2 A limited supply and holistic thinking

VC collaboration is no silver bullet for breaking the industry barriers, but it can be a tool to work in tandem with increased pressure from the external stakeholder environment. VC collaboration can initiate grass-root level commitment to UM, however, top-down policy initiatives should intensify the incentive to engage with such a tool.

Implementing BMUMs is inherently bound by obstacles that linear BMs (LBMs) are not regarding material sourcing, which influences the scalability of the BMs. Firstly, whereas LBMs to a greater extent can rely on a few big suppliers, BMUMs are bound to rely on small-scale suppliers of secondary building materials, i.e. from individual demolition sites and contractors. This is an obstacle in terms of transaction costs and economies of scale. Secondly, the BMUMs are bound by a limited supply of anthropogenic materials following the rate at which buildings are demolished. This results in a limited supply of input materials which can bring a corrupted incentive to increase demolition to ensure material supply. As such, there is a natural limit for scaling BMUMs. Both of these aspects are crucial to consider when implementing and assessing the potential for scalability of BMUMs, however, the main concern is currently rather the quality of the secondary material than the quantity. While the solution to both issues may be a large-scale implementation of selective demolition techniques, this should also serve as an incentive to build a business by combining BMs for scale and those of scope. Operating a one-dimensional BM utilizing a single waste stream has a natural limit for expansion, whereas BMs for expanding the scope of UM principles in practice are more adaptable to the accessible waste streams. Heesbeen & Prieto (2020) argues that it is crucial to take a holistic approach when implementing CBMs in general and in the building and construction sector. This study has found that the statement holds regard to the BMUMs in the building industry. UM is primarily a strategy to achieve smart material input through innovative material development and smart output through innovative demolition techniques and waste management procedures. However, the most circular building is the one that has already been built and which is used over and over again in its original state. To honor this statement, a holistic approach should be taken to UM, considering the principles of adaptable and long-lasting buildings when designing BMUMs and not cannibalizing on-site and as-built reuse of building materials, components, and load-bearing structures.

6.3 Future studies

Abductive inference is to participate in the constant development of theoretical frameworks based on empirical observations. Resultingly, the findings from this research, and particularly the frameworks developed in the research process is part of such a movement toward a gradual improvement of theory. As Tavory & Timmermans, the main theorists behind abductive qualitative research, argues: "Theorizing is joining a conversation" (2014, p. 265). As such, this theory is not meant to be an ultimate explanation of SC collaboration, but a step in the wider movement to understand its role by contributing to a body of literature on the subject.

The contribution of this thesis is two-fold: a theory alteration of the Leising et al. (2018) framework to fit the new context and a theory-driven roadmap with action for how to implement the adapted framework in practice to engage in grass-root industry transition leadership. Testing the frameworks in other industries with the potential for implementing principles of UM and material reuse would be relevant. While the finding from this study is targeted the context and VC of the building industry (with its unique industry characteristics, transition barriers, etc.), they may also be relevant in other industries with reasonably similar characteristics (long product life cycles, organized systems for disassembly, and material reuse or recycling). This could be electronics, heavy machinery, vehicles, etc.. Testing the framework in the context of these industries could assess the transferability of the findings from this study.

Furthermore, the research process has exposed areas that could benefit from being explored further in future research. Literature on BMUMs was largely unavailable, and no central typology has been developed. This thesis has identified two distinct types of BMUMs based on a sample of two. It is safe to assume that more BM types are present in the industry. While it was not within the scope of this paper, it is clear that more research could benefit from exploring this further. In a grounded theory study, exploring a larger sample could delineate typologies and develop archetypical BMs within UM. By data saturation, the full picture can be drawn.

Inter-personal dynamics within SC partnerships for UM could further develop the theory of transition leadership. It would be relevant to test the proposed transition management framework in the context of organizations engaging in inter-organizational collaboration by doing in-depth case studies covering a long time frame to follow how the alliances develop and how the internal dynamics influence mutual learning processes, and vision development, etc.. A central bank of literature on this topic is that of collaborative capability building, which this study has only used in passing. Diving deeper into this field may provide more insight into the operationalization of the collaboration framework and the transition management chart developed in this project and the hypothesis that industry front-runners can engage purposefully as transition leaders through collaborative SC alliances.

The present study has primarily focused on relationships formed with material suppliers and service providers in the upstream VC steps. These industry actors are important to align for product development and scalable business models. In future studies, more emphasis could be brought to the potential of the collaboration schemes in the downstream phases, aiming as increasing product sales. This is a key concern for business model scalability which was largely assumed in this study. It is therefore suggested to further explore how the design of BMUMs and downstream collaboration schemes could increase demand for secondary building materials.

7 Conclusion

A growing interest in urban mining (UM) and circular economy (CE) is spreading in the Danish building industry. However, most initiatives for reusing secondary building materials are still at a pilot project level and have yet to make a significant decrease of the aggregate industry footprint. This thesis has taken an explorative approach to investigate the role of supply chain (SC) collaboration in operating business models for UM (BMUMs) and initiating change by doing in-depth case studies of two pioneering companies in the danish building industry. An abductive research approach was taken, initially adopting established theoretical frameworks while letting findings from the empirical data adapt it to a new setting. From this rather limited sample a series of indications and hypotheses can be taken which may inform the design of future research within the area.

The first research question (RQ 1) aimed to describe how selected case companies organized their SCs to enable UM and reuse of secondary building materials. In answering this, two radically different approaches to interorganizational alignment were identified by conducting a SC mapping exercise. This indicates that the SC collaboration scheme is dependent on the product characteristics and the particular BM configuration. This in itself would be no surprise to the established literature on SC management. However, the value-added from conducting the research is the detailed descriptions of how pioneering companies have organized themselves to disable the barriers connected to reverse material cycles and UM.

Answering SQ 1.1, on the role of inter-organizational collaboration, the research found that collaboration is highly important to ensure material input which is the foundation of their BMs. The research also found that ensuring inter-organizational collaboration was a learning-by-doing effort in the companies. While the literature on strategic alliances describes it as a clear strategic matter, the collaboration strategies in the case companies appear to have emerged in a more problem-oriented manner. It is more a matter of bounded rationality than rational choice, as networks, partners, and alliances emerge in a fluid development rather than a desktop exercise in which actors are strategizing to find the optimal level of integration, etc.. As such, decisions are made based on gut feelings and tacit knowledge of industry dynamics.

This leads to SQ 1.2 on what collaborative strategies are employed by the case companies. Whereas the activities of one company show evidence of internalizing processes to a higher degree by engaging in formal agreements with upstream suppliers and downstream customers, the other appears to externalize VC steps to increase organizational flexibility. However, when analyzing the collaborative strategy of an organization, one may be able to identify the overall direction of the company, but the individual efforts observed in the organization may point in different directions. This insinuates that there might not be as clear-cut a collaboration strategy formulated in the company as the initial literature review assumed.

In answering the second research question (RQ 2), on which aspects are influential when developing and operating a collaborative strategy for UM, this study applied an abductive approach, initially using the framework of Leising et al. (2018) suggesting that collaboration depends on the four aspects: Visions for the future, Actor Learning, Network dynamics, and Business model innovation. This framework informed the initial interview questions used during data collection, however, the topic was further explored during data collection to accommodate the new settings in which the framework was applied, going from project-based collaboration to medium or long-term BM collaboration. This resulted in an adapted framework proposing six aspects that are influential where to the success of medium or long-term partnerships: A shared vision for the future, Actor Learning, Network dynamics and value creation, Business model innovation and inclusion, Automated action, and Optimal integration.

While the original four aspects are included, some are adapted slightly and two additional aspects were added to accommodate the slightly different context.

SQ 2.1 addresses the Leising et al. (2018) framework directly, asking how well it fits long-term collaborative SC strategies. Based on the conclusions from RQ 2, the study concludes that while the aspects from the original framework were all relevant in the new context, they did not paint the full picture. Based on the two case studies an adapted framework was produced and used for the conceptual analysis.

Finally, the third research question (RQ 3) addressed how SC collaboration can influence industry transition toward large-scale implementation of UM principles and reuse of building materials. In answering this, transition leadership theory was applied, arguing that by engaging in SC alliances, circular design pioneers could take the role of transition leaders by engaging purposefully with SC collaboration. It furthermore proposes a framework for how to engage in these partnerships to create innovation communities and transition arenas, based on the transition management phases of Frantzeskaki et al. (2012). By combining these four phases with the SC collaboration framework from RQ 2, a roadmap for engaging as a transition leader within UM and material reuse by orchestrating medium- or long-term SC alliances in the built environment is suggested.

These findings shows that orchestrating industry transition is not only a task for policy makers, but pioneering industry actors can also initiate a grass-root level commitment across industry actors to enable a transition toward material reuse in the built environment. By pioneering companies to take the role of transition leaders, inter-organizational innovation communities can be initiated, engaging more private resources and capabilities in the explorative development of solutions for UM and reuse of secondary building materials. This call for a dual change of mind-set in the industry and academia: Industry actors are encouraged to a larger extent participate proactively in the industry transition, academics and policy makers are encouraged to a larger extent to see industry actors as part of the solution to increase the market uptake of UM solutions in the industry.

This research have exclusively been studying companies who already have designed their business model based on the principles of UM, however, the aspect of implementing BMUMs in the first place is understudied. For companies based on linier BMs to rearrange their processes to implement UM and solutions based on secondary building materials, an overview of ways to do so could enable targeted change processes. Resultingly, base research on UM in the built environment is suggested for future research. Furthermore, personal attributes in orchestrating SC partnerships could be further explored by investigating internal politics and dynamics across partnerships. Lastly, studies to test the relevance of the frameworks developed in this study in similar industries is proposed, to assess the potential of SC partnerships in these industries.

Bibliography

Acharya, D., Boyd, R., & Finch, O. (2018). *FROM PRINCIPLES TO PRACTICES: FIRST STEPS TOWARDS A CIRCULAR BUILT ENVIRONMENT*. Arup & EMF. https://www.arup.com/perspectives/publications/research/section/first-steps-towards-a-circular-built-environment

Acharya, D., Boyd, R., & Finch, O. (2020). *FROM PRINCIPLES TO PRACTICES: REALISING THE VALUE OF CIRCULAR ECONOMY IN REAL ESTATE*. Arup & EMF. https://www.arup.com/perspectives/publications/research/section/realising-the-value-of-circular-economy-in-real-estate

Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Waste and Resource Management*, *170*(WR1), 10. https://doi.org/10.1680/jwarm.16.00011

Ajayabi, A., Chen, H.-M., Zhou, K., Hopkinson, P., Wang, Y., & Lam, D. (2019). *REBUILD: Regenerative Buildings and Construction systems for a Circular Economy*. 9. https://doi.org/10.1088/1755-1315/225/1/012015

Aldebei, F., & Dombi, M. (2021). Mining the Built Environment: Telling the Story of Urban Mining. *Buildings*, *11*(9), 388. https://doi.org/10.3390/buildings11090388

Antwi-Afari, P., Ng, S. T., & Hossain, Md. U. (2021). A review of the circularity gap in the construction industry through scientometric analysis. *Journal of Cleaner Production*, *298*, 126870. https://doi.org/10.1016/j.jclepro.2021.126870

Arora, M., Raspall, F., Cheah, L., & Silva, A. (2020). Buildings and the circular economy: Estimating urban mining, recovery and reuse potential of building components. *Resources, Conservation and Recycling*, *154*, 104581. https://doi.org/10.1016/j.resconrec.2019.104581

Arora, R., Paterok, K., Banerjee, A., & Saluja, M. S. (2017). Potential and relevance of urban mining in the context of sustainable cities. *IIMB Management Review*, *29*(3), 210–224. https://doi.org/10.1016/j.iimb.2017.06.001

ARUP. (2016). *Circular economy in the built environment*. https://www.arup.com/perspectives/publications/research/section/circular-economy-in-the-built-environment

Barratt, M. (2004). Understanding the Meaning of Collaboration in the Supply Chain. *Supply Chain Management*, *9*(1), 30–42. https://doi.org/10.1108/13598540410517566

Benachio, G. L. F., Freitas, M. do C. D., & Tavares, S. F. (2020). Circular economy in the construction industry: A systematic literature review | Request PDF. *Journal of Cleaner Production*, *260*. https://doi.org/10.1016/j.jclepro.2020.121046

Berardi, P. C., & de Brito, R. P. (2021). Supply chain collaboration for a circular economy—From transition to continuous improvement. *Journal of Cleaner Production*, *328*(129511). https://doi.org/10.1016/j.jclepro.2021.129511

Bidmon, C. M., & Knab, S. F. (2018). The three roles of business models in societal transitions: New linkages between business model and transition research. *Journal of Cleaner Production*, *178*, 903–916. https://doi.org/10.1016/j.jclepro.2017.12.198

Bocken, N. M. P., Pauw, I. de, Bakker, C., & Grinten, B. van der. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, 14. https://doi.org/10.1080/21681015.2016.1172124

Bocken, N., Short, S., Rana, P., & Evans, S. (2013). A value mapping tool for sustainable business modelling. *Corporate Governance (Bingley)*, *13*(5), 482–497. Scopus. https://doi.org/10.1108/CG-06-2013-0078

Böckin, D., Willskytt, S., Tillman, A., & Söderman, M. L. (2016). *What makes solutions within the manufacturing industry resource efficient?* 19. https://publications.lib.chalmers.se/records/fulltext/245232/local_245232.pdf

Bolig & Planstyrrelsen. (n.d.). *Den frivillige bæredygtighedsklasse*. Retrieved March 8, 2022, from https://baeredygtighedsklasse.dk/

Bourguignon, D. (2016). *Closing the Loop: New Circular Economy Package*. European Parliamentary Research Service. www.europarl.europa.eu/RegData/ etudes/BRIE/2016/573899/EPRS_BRI(2016)573899_EN.pdf.

Breuer, H., Fichter, K., Lüdeke Freund, F., & Tiemann, I. (2018). Sustainability-oriented business model development: Principles, criteria and tools. *International Journal of Entrepreneurial Venturing*, *10*(2), 256. https://doi.org/10.1504/IJEV.2018.10013801

BUILD. (n.d.). *BUILD - Institut for Byggeri, By og Miljø*. Retrieved February 14, 2022, from https://build.dk/

Byggeri København. (2022). *Håndbog i Cirkulær Økonomi [Handbook in Circular Economy]*. https://byk.kk.dk/for-leverandoerer/cirkulaer-oekonomi

Castell-Rüdenhausen, M. zu, Wahlström, M., Astrup, T. F., Jensen, C., Oberender, A., Johansson, P., & Waerner, E. R. (2021). Policies as Drivers for Circular Economy in the Construction Sector in the Nordics. *Sustainability*, *13*(16), 9350. https://doi.org/10.3390/su13169350

Chandler, A. D., & Hikino, T. (2009). *Scale and Scope: The Dynamics of Industrial Capitalism*. Harvard University Press.

Chang, R., & Yujie, L. (2017). Facilitating Systemic Changes Towards Green Buildings: Developing Conceptual Frameworks of Socio-Technical Transitions. *Energy Procedia*, *143*, 301–306.

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, *43*, 354–363. https://doi.org/10.1016/j.lrp.2009.07.010

Çimen, Ö. (2021). Construction and built environment in circular economy: A comprehensive literature review. *Journal of Cleaner Production*, 30. https://doi.org/10.1016/j.jclepro.2021.127180

CIRCuIT. (Forthcoming). *Pre-demolition audits for urban mining*.

Creswell, J. W., & Creswell, J. D. (2018a). Chapter 1: The selection of a reserach approach. In *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications, Ltd.

Creswell, J. W., & Creswell, J. D. (2018b). Chapter 9: Qualitative research. In *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications, Ltd.

Debacker, W., Manshoven, S., Peters, M., Ribeiro, A., & Weerdt, Y. D. (2017, June 21). *Circular economy and design for change within the built environment: Preparing the transition*. International HISER Conference on Advances in Recycling and Management of Construction and Demolition Waste, Delft University of Technology, Delft, The Netherlands. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7<535::AID-SMJ885>3.0.CO;2-Z

Ding, G. K. C. (2014). 3 - Life cycle assessment (LCA) of sustainable building materials: An overview. In F. Pacheco-Torgal, L. F. Cabeza, J. Labrincha, & A. de Magalhães (Eds.), *Eco-efficient Construction and Building Materials* (pp. 38–62). Woodhead Publishing. https://doi.org/10.1533/9780857097729.1.38

DS. (n.d.). *Dansk Standard—Danmarks standardiseringsorganisation*. Retrieved February 14, 2022, from https://www.ds.dk/da

Dyer, J. (1997). Effective Interfirm Collaboration: How Firms Minimize Transaction Costs and Maximize Transaction Value. *Strategic Management Journal*, *18*(7), 535–556.

Eberhardt, L. C. M., Birkved, M., & Birgisdottir, H. (2020). Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management*, 1–21. https://doi.org/10.1080/17452007.2020.1781588

EC CORDIS. (2013, September 16). *"New old bricks" for the construction industry*. https://cordis.europa.eu/article/id/36066-new-old-bricks-for-the-construction-industry

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges on JSTOR. *The Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.2307/20159839

EMF. (n.d.). *Climate and a circular economy | Ellen MacArthur Foundation*. Retrieved February 11, 2022, from https://ellenmacarthurfoundation.org/topics/climate/overview

EMF. (2015). *Towards a circular economy: Business rationale for an accelerated transition*. Ellen MacArthur Foundation. https://ellenmacarthurfoundation.org/towards-a-circular-economy-business-rationale-for-an-accelerated-transition

European Commission. (2018). *REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on the implementation of EU waste legislation, including the early warning report for Member States at risk of missing the 2020 preparation for re-use/recycling target on municipal waste* (COM(2018) 656 final). https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1537873850842&uri=COM:2018:656:FIN#footnote18

Frantzeskaki, N., Loorbach, D., & Meadowcroft, J. (2012). Governing societal transitions to sustainability. *International Journal of Sustainable Development*, *15*(1). https://doi.org/10.1504/IJSD.2012.044032

Frederiksen, N., & Johansen, P. (Eds.). (2022). *Erfaringer og fakta om strategiske partnerskaber [Experiences and facts about strategic partnerships]* (1st ed.). Institut for Byggeri, By og Miljø, Aalborg Universitet.

Fröberg, M., Mendez, E. T., & Larsson, J. H. (2018). *Life Cycle Analysis a study of the climate impact of a single-family building from a life cycle perspective* [Uppsala Universitet]. https://www.diva-portal.org/smash/get/diva2:1228922/FULLTEXT01.pdf

GAM Informant #1. (2022, February 18). *Interview #1, Gamle Mursten* [Personal communication].

GAM Informant #1. (2022, March 18). *Interview #2, Gamle Mursten* [Personal communication].

Gamle Mursten. (2014). *GAMLE MURSTEN VINDER NY BÆREDYGTIGHEDSPRIS [Gamle Mursten to win another sustainability prize]*. http://gamlemursten.dk/nyheder/2014/gamle-mursten-vinder-ny-baeredygtighedspris/

Gamle Mursten. (2017). *Gamle Mursten kåret som Gazelle 2017 [Old bricks honored as Gazelle 2017]*. http://gamlemursten.dk/nyheder/2017/gamle-mursten-kaaret-som-gazelle-2017/

Gamle Mursten. (2018). *Nu kan gamle mursten CE-mærkes*. http://gamlemursten.dk/nyheder/2018/nu-kan-gamle-mursten-ce-maerkes/

Gamle Mursten. (2021a). *BYGNINGSKOMPONENTPRISEN 2021 GIK TIL GAMLE MURSTENS DIREKTØR, CLAUS JUUL NIELSEN [The construction component prize 2021 goes to Gamle Murstens director, Claus Juul Nielsen]*. http://gamlemursten.dk/nyheder/2021/bygningskomponentprisen-2021-gik-til-gamle-murstens-direktoer-claus-juul-nielsen/

Gamle Mursten. (2021b). *GM TECH APS - RESSOURCEKORTLÆGNING OG TEST AF GAMLE MURSTEN [GM TECH APS - Resource mapping and test of bricks]*. http://gamlemursten.dk/nyheder/2021/gm-tech-aps-ressourcekortlaegning-og-test-af-gamle-mursten/

Gamle Mursten. (2021c). *KUN MURSTEN (OG KALKSANDSTEN OG SKALLER OG...) HOS GAMLE MURSTEN [Only bricks (and chalkstone and slips and...) at Gamle Mursten]*. http://gamlemursten.dk/nyheder/2021/kun-mursten-og-kalksandsten-og-skaller-og-hos-gamle-mursten/

Gamle Mursten. (nda). *Forside [Front page]*. http://gamlemursten.dk/

Gamle Mursten. (ndb). *Om Gamle Mursten [About Gamle Mursten]*. OM GAMLE MURSTEN. http://gamlemursten.dk/om-gamle-mursten/

GBC DK. (2022). 600 medlemmer med et højt ambitionsniveau for fremtidens bygge- og ejendomsbranche. *Green Building Council Denmark*. https://dk-gbc.dk/nyhed/600-medlemmer-med-et-hoejt-ambitionsniveau-for-fremtidens-bygge--og-ejendomsbranche-

Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. *Environmental Innovation and Societal Transitions*, *1*(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

Geigenmüller, A., & Leischnig, A. (2017). Chapter 3: A configurational perspective on alliance management capabilities. In T. K. Das (Ed.), *Managing Alliance Portfolios and Networks* (pp. 71–90). Information Age Publishing.

Geissdoerfer, M., Morioka, S. N., Carvalho, M. M. de, & Evans, S. (2018). Business models and supply chains for the circular economy—ScienceDirect. *Journal of Cleaner Production*, *190*, 712–721. https://doi.org/10.1016/j.jclepro.2018.04.159

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, *143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Gorgolewski, M. (2019). The architecture of reuse. *IOP Conference Series: Earth and Environmental Science*, *225*, 012030. https://doi.org/10.1088/1755-1315/225/1/012030

Gustafson, F. (2019). *Embarking upon circular construction* [Lund University]. https://lup.lub.lu.se/student-papers/search/publication/8996520

Hansen, E. G., & Schmitt, J. C. (2021). Orchestrating cradle-to-cradle innovation across the value chain: Overcoming barriers through innovation communities, collaboration mechanisms, and intermediation. *Journal of Industrial Ecology*, *25*(3), 627–647. https://doi.org/10.1111/jiec.13081

Hart, J., Adams, K., Giesekam, J., Tingley, D. D., & Pomponi, F. (2019). Barriers and drivers in a circular economy: The case of the built environment. *Procedia CIRP*, *80*, 619–624. https://doi.org/10.1016/j.procir.2018.12.015

Heesbeen, C., & Prieto, A. (2020). Archetypical CBMs in Construction and a Translation to Industrialized Manufactur. *Sustainability*, *12*(4), 1572. https://doi.org/10.3390/su12041572

Heimeriks, K. H. (2008). *Developing Alliance Capabilities*. Palgrave Macmillan UK. https://doi.org/10.1057/9780230594043

Hill-Hansen, D. L. C. (2021). *A collaboration tool for circular innovation settings.* [Aalborg University]. https://projekter.aau.dk/projekter/en/studentthesis/a-collaboration-tool-for-circular-innovation-settings(2c2a6a93-2288-4523-8cf8-cef688f1a63a).html

Hofmann, F., & Jaeger‐Erben, M. (2020). Organizational transition management of circular business model innovations. *Business Strategy and the Environment*, *29*(6), 2770–2788. https://doi.org/10.1002/bse.2542

Huang, L., Krigsvoll, G., Johansen, F., Liu, Y., & Zhang, X. (2018). Sustainable construction and socio-technical transitions in London's mega-projects. *Renewable and Sustainable Energy Reviews*, *81*, 1906–1916.

Jakon. (n.d.). *DSP PLUS – Jakon*. Retrieved April 6, 2022, from https://jakon.dk/referencerprojekter/dsp-plus/

Jones, P., & Comfort, D. (2018). The construction industry and the circular economy. *International Journal of Management Cases*, *20 (1)*, 4–15.

Khalfan, M., McDermott, P., & Cooper, R. (2004). Integrating the supply chain within construction industry. *Association of Researchers in Construction Management*, *2*, 897–904. https://www.researchgate.net/publication/228982042_Integrating_the_supply_chain_within_construction_industry

Lange, T., Beckett, T., & Oberender, A. (2022). *Status: Sådan står det til med cirkulært byggeri i Danmark [Status: How it is going with circular construction in Denmark]* (Greenpaper #01). VCØB Community. https://vcob.dk/vcob/saadan-goer-du/green-papers/faa-status-paa-cirkulaer-oekonomi-i-byggeriet/

LEG Informant #1. (2022, February 21). *Interview #1, Lendager Group* [Personal communication].

LEG Informant #1. (2022, April 13). *Interview #2, Lendager Group* [Personal communication].

Leischnig, A., & Geigenmüller, A. (2018). When does alliance proactiveness matter to market performance? A comparative case analysis. *Industrial Marketing Management*, *74*, 79–88. https://doi.org/10.1016/j.indmarman.2017.09.025

Leising, E., Quista, J., & Bocken, N. (2018). Circular Economy in the building sector: Three cases and a collaboration tool. *Journal of Cleaner Production*, *Volume 176*, 976–989. https://doi.org/10.1016/j.jclepro.2017.12.010

Lendager Group. (n.d.). *Om—Lendager Group*. Retrieved February 11, 2022, from https://lendager.com/om-os/

Lendager Group. (2021). *MIES VAN DER ROHE — Lendager Group*. https://lendager.com/nyheder/mies-van-der-rohe/

Lendager UP. (n.d.). Lendager Group. Retrieved April 25, 2022, from https://lendager.com/upcycle/

Lewandowski, M. (2016). Designing the Business Models for Circular Economy—Towards the Conceptual Framework. *Sustainability 2016, 8*(1), 43.

Lomite, H., & Kare, S. (2009). *Impact of Construction Material on Environment*. University College of Borås.

Loorbach, D., & Rotmans, J. (2010). The practice of transition management: Exemples and lessons from four distinct cases. *Futures: The Journal of Policy, Planning and Futures Studies*, *42*(3), 237–246. https://doi.org/10.1016/j.futures.2009.11.009

Loorbach, D., van Bakel, J. C., Whiteman, G., & Rotmans, J. (2009). Business strategies for transitions towards sustainable systems. *Business Strategy and the Environment*, n/a-n/a. https://doi.org/10.1002/bse.645

Marres, N., & Weltevrede, E. (2013). Scraping the Social? *Journal of Cultural Economy*, *6*(3), 313–335. https://doi.org/10.1080/17530350.2013.772070

Marsh, R. (2017). Building lifespan: Effect on the environmental impact of building components in a Danish perspective. *Architectural Engineering and Design Management*, *13*(2), 80–100. https://doi.org/10.1080/17452007.2016.1205471

Matrai, I. (2019). *Multi-stakeholder collaboration in the building sector for building material reuse projects: Case-studies in Denmark* [Lund University]. http://lup.lub.lu.se/student-papers/record/8991854

McDermott, P., & Khalfan, M. (2012). *Achieving supply chain integration within construction industry*. *6*(2), 11. https://doi.org/10.5130/AJCEB.v6i2.2983

Miljøministeriet. (2021a). *Bæredygtigt byggeri [Sustainable construction]*. https://mim.dk/media/222891/faktaark_byggeri_dadocx.pdf

Miljøministeriet. (2021b). *Handlingsplan for cirkulær økonomi: National plan for forebyggelse og håndtering af affald 2020-2032 [Action Plan for Circular Economy: National Plan for prevention and management of waste 2020-2032]*. Miljøministeriet. https://mim.dk/media/224184/handlingsplan-for-cirkulaer-oekonomi.pdf

Miozzo, M., & Dewick, P. (2004). Networks and innovation in European construction: Benefits from inter-organisational cooperation in a fragmented industry. *International Journal of Technology Management*, *27*(1). https://doi.org/10.1504/IJTM.2004.003882

Munaro, M. R., Tavares, S. F., & Bragança, L. (2021). Circular Business Models: Current State and Framework to Achieve Sustainable Buildings. *Journal of Construction Engineering Management*, 14.

Ness, D. A., & Xing, K. (2017). Toward a Resource-Efficient Built Environment: A Literature Review and Conceptual Model. *Journal of Industrial Ecology*, *21*(3), 572–592. https://doi.org/10.1111/jiec.12586

Nielsen, C., & Lund, M. (2018). The Concept of Business Model Scalability. *Journal of Business Models*, *6*(1), 1–18. https://doi.org/10.2139/ssrn.2575962

Nußholz, J. (2017). Circular Business Models: Defining a Concept and Framing an Emerging Research Field. *Sustainability*, *9*(10), 1810. https://doi.org/10.3390/su9101810

Nußholz, J. (2018). A circular business model mapping tool for creating value from prolonged product lifetime and closed material loops. *Journal of Cleaner Production*, 10.

Nußholz, J. L. K., & Milios, L. (2017). *Applying circular economy principles to building materials: Front-running companies' business model innovation in the value chain for buildings*. SustEconConference, Berlin, Germany. https://www.researchgate.net/publication/320831772_Applying_circular_economy_principles_to_building_materials_Front-running_companies%27_business_model_innovation_in_the_value_chain_for_buildings

Nußholz, J., & Milios, L. (2017). *Applying circular economy principles to building materials: Front-running companies' business model innovation in the value chain for buildings*. 12.

Nußholz, J., Rasmussen, F. N., & Leonidas, M. (2019). *Circular building materials: Carbon saving potential and the role of business model innovation and public policy*. *141*, 308–316.

Nußholz, J., Rasmussen, F. N., Whalen, K., & Plepys, A. (2019). A circular business model for material reuse in buildings: Implications on sustainable value creation. *Journal of Cleaner Production*, *Virtual Special Issue: Urban Mining*. https://doi.org/10.1016/j.jclepro.2019.118546

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers* (1st ed.). Hoboken: John Wiley & Sons. https://eds.s.ebscohost.com/eds/detail/detail?vid=4&sid=89abb2f4-63a6-4650-b0f3-8487cd4ceb6f%40redis&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3d%3d#AN=lub.5640569&db=cat07147a

Peirce, C. S. (1978). *Scientific metaphysics* (C. Hartshorne & P. Weiss, Eds.; 4. print). Belknap Press of Harvard Univ. Press.

Pfeffer, J., & Salancik, G. R. (2003). *The external control of organizations: A resource dependence perspective*. Stanford Business Books.

Preisler, M. (2021). *Danish world first: A circular and sustainable building—Nordic Labour Journal*. http://www.nordiclabourjournal.org/i-fokus/in-focus-2021/theme-the-green-transition/article.2021-04-27.7673248389

Quist, J. (2007). *Backcasting for a Sustainable Future: The Impact After 10 Years*. Eburon Uitgeverij B.V.

Quist, J., Thissen, W., & Vergragt, P. J. (2011). The impact and spin-off of participatory backcasting: From vision to niche. *Technological Forecasting and Social Change*, *78*(5), 883–897. https://doi.org/10.1016/j.techfore.2011.01.011

Realdania. (n.d.). *Cirkulært byggeri*. Retrieved May 7, 2022, from https://realdania.dk/tema/cirkulaert-byggeri

Realdania. (2020, June 2). *Realdania støtter afprøvning af den frivillige bæredygtighedsklasse*. https://realdania.dk/nyheder/2020/05/den-frivillige-baeredygtighedsklasse

Rebrick. (n.d.-a). *Rebrick: Technology*. Retrieved February 15, 2022, from http://www.gamlemursten.eu/technology/

Rebrick. (n.d.-b). *Rebrick: What we do*. Retrieved February 15, 2022, from http://www.gamlemursten.eu/what-we-do/

Rohracher, H. (2001). Managing the Technological Transition to Sustainable Construction of Buildings: A Socio-Technical Perspective. *Technology Analysis & Strategic Management*, *13*(1), 137–150. https://doi.org/10.1080/09537320120040491

Roome, N., & Louche, C. (2016a). Journeying Toward Business Models for Sustainability: A Conceptual Model Found Inside the Black Box of Organisational Transformation. *Organization & Environment*, *Vol. 29(1)*, 11–35.

Roome, N., & Louche, C. (2016b). Journeying Toward Business Models for Sustainability: A Conceptual Model Found Inside the Black Box of Organisational Transformation. *Organization & Environment*, *29*(1), 11–35. https://doi.org/10.1177/1086026615595084

Senaratne, S., Perera, S., Almeida, L., & Abhishek, K. (2021). *Promoting stakeholder collaboration in adopting circular economy principles for sustainable construction | Western Sydney University ResearchDirect. Proceedings of the 9th World Construction Symposium, 9-10 July 2021, Colombo, Sri Lanka*, 471–482. https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A60584

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699–1710. https://doi.org/10.1016/j.jclepro.2008.04.020

State of Green. (2016). *Circular economy: Denmark as a circular economy solution hub* [White Paper].

Superti, V., Houmani, C., & Binder, C. R. (2021). A systemic framework to categorize Circular Economy interventions: An application to the construction and demolition sector. *Resources, Conservation and Recycling*, *173*, 105711. https://doi.org/10.1016/j.resconrec.2021.105711

Tavory, I., & Timmermans, S. (2014). *Abductive analysis: Theorizing qualitative research*. The University of Chicago Press.

Teknologisk Institut. (2021). *Temaark: Cirkulær økonomi i byggeriet [Theme: Circular economy within construction]*. https://realdania.dk/publikationer/faglige-publikationer/temaark---cirkulaer-oekonomi-i-byggeriet

Thelen, D., Thomaes, T., Acoleyen, M. van, Huurman, W., Brunschot, C. van, Edgerton, B., & Kubbinga, B. (2018). *Scaling the Circular Built Environment: Pathways for business and government*. Arcadis, WBCSD, and Circle Economy. https://www.wbcsd.org/Archive/Factor-10/Resources/pathways-for-business-and-government

TRUST. (n.d.). *ByK med TRUST*. Retrieved April 6, 2022, from http://www.bykmedtrust.dk/

United Nations Environment Programme. (2017). *Towards a zero-emission, efficient, and resilient buildings and construction sector- Global Status Report 2017* (UNEP 188).

Vandkunsten. (n.d.). *Transformation af Konstabelskolen*. Retrieved May 7, 2022, from https://vandkunsten.com/projects/konstabelskolen

VCØB. (n.d.). *Hvilke byggematerialer kan du genbruge, genanvende eller materialenyttiggøre på anden vis? [Which building materials can you reuse, recycle or otherwise make useful?]*. Videnscenter for Cirkulær Økonomi i Byggeriet. Retrieved February 14, 2022, from https://vcob.dk/media/1599/hvilke_gamle_byggematerialer_kan_genanvendes.pdf

VCØB, N. krav til nedrivning i løbet af 2023-V. for C. Ø. i B.-. (2022, January 4). *Nye krav til nedrivning i løbet af 2023*. Nye krav til nedrivning i løbet af 2023 - Videncenter for Cirkulær Økonomi i Byggeriet - VCØB. https://vcob.dk/vcob/aktuelt/nyheder-2022/nye-krav-til-nedrivning-i-loebet-af-2023/

Vila-Henninger, L., Dupuy, C., Van Ingelgom, V., Caprioli, M., Teuber, F., Pennetreau, D., Bussi, M., & Gall, C. (2022). Abductive Coding: Theory Building and Qualitative (Re)Analysis. *Sociological Methods & Research*, 004912412110675. https://doi.org/10.1177/00491241211067508

wbcsd. (2021). *The business case for circular buildings: Exploring the economic, environmental and social value*. World Business Council for Sustainable Development. https://www.wbcsd.org/Programs/Cities-and-Mobility/Sustainable-Cities/Transforming-the-Built-Environment/Resources/The-business-case-for-circular-buildings-Exploring-the-economic-environmental-and-social-value

Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *The Journal of Law and Economics*, *22*(2), 233–261. https://doi.org/10.1086/466942

World Architecture Community. (n.d.). *Copenhagen named UNESCO-UIA World Capital of Architecture for 2023*. World Architecture Community. Retrieved May 7, 2022, from https://worldarchitecture.org/article-links/evggm/copenhagen-named-unescouia-world-capital-of-architecture-for-2023.html

Yin, R. K. (2018). *Case study research and applications: Design and methods* (Sixth edition). SAGE.

Zanni, S., Simion, I. M., Gavriles, M., & Bonolia, A. (2018). Life Cycle Assessment Applied to Circular Designed Construction Materials. *Procedia CIRP*, *69*, 154–159. https://doi.org/10.1016/j.procir.2017.11.040

Želinský, Dominik. (2019). From Deduction to Abduction: Constructing a Coding Frame for Communist Secret Police Documents. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *20*(3), Art. 22. https://doi.org/10.17169/fqs-20.3.3377.

Appendix

Appendix I - Business models for circular construction

Below, the Heesbeen & Prieto (2020) framework for CBM in the built environment are presented in a table format followed by a brief presentation of each.

Table 5 Circular construction strategies adapted from Heesbeen & Prieto (2020)

Circular construction	**Definition**	**Examples**
Smart Input	A reactive use of secondary and renewable raw materials and inter-organizational synergy in the form of industrial symbioses, efficient and reduced material use and mass customization.	• Industrial symbiosis • Use secondary construction material • Dematerialization in building and product design
Smart Output	Facilitating cascaded re-use of components and materials.	• Design for disassembly • Urban mining • (E)BAMB
Practice stewardship	Manufacturing building products and taking producer responsibility of using and retrieving secondary and renewable raw materials.	• DBMR contracting • Sharing schemes
Adaptable buildings	Facilitating the basis and compatible products for a flexibly used building.	• Flexible building operation • Modular design
Never-ending buildings	Increasing a time-less quality and durability of materials and products in order to obtain a building that continues to appeal to users without making physical changes to the building.	• Simple design • Design for repair

Smart input refers to the use of sustainable construction materials in the form of secondary or renewable materials. It is concerned with minimizing the building footprint by ensuring a net-decrease of energy and material use in the construction phase. Examples are industrial symbiosis utilizing by-products and material reuse and recycling of secondary materials in the material production.

The **smart output strategy** aims at minimizing the construction and demolition waste by ensuring cascaded re-use of components and materials. CBMs for smart output includes design strategies enabling selective demolition, material separation and value preserving deconstruction techniques as well as techniques utilizing the residual value of the built-in materials. Examples of smart output strategies are design for disassembly, urban mining, and (existing) buildings as material banks ((E)BAMB).

The **stewardship model** refers to business models where a focal actor pro-actively takes responsibility for across the life-cycle of the building, thus abandoning the conventional product orientation of the building management. In this way the recovery of secondary materials and sound choices made with a life cycle perspective can be ensured. Examples include Extended Producer Responsibility of construction materials and Design Built Maintain Remove (DBMR) contracts. This strategy also includes efforts to intensify resource loops by engaging in sharing schemes.

The **adaptable building** strategy aims at extending the use-phase of structures and components by the use of adaptable building designs, giving technical, functional, and spatial flexibility to change building characteristics as needed. Examples include building design for repair and upgradability and modular building design.

The **never-ending building** strategy aim at designing durable buildings adapt for whole-structure reuse. They design for durability, longevity, and easy repair and facilitates user satisfaction over long time-horizons by offering time-less quality. Examples are simple design and the strategy aligns with product-life extension and classic long-life model to slow resource loops in regular CBM typologies.

Appendix II - Final coding table

Code	**Origin of code**
Alliance management capabilities	Schreiner (2009), Geigenmüller & Leischnig (2017).
• Partner identification	Schreiner (2009), Geigenmüller & Leischnig (2017).
• Partnership initiation	Schreiner (2009), Geigenmüller & Leischnig (2017).
• Partnership maintenance	Schreiner (2009), Geigenmüller & Leischnig (2017).
• Partnership termination	Schreiner (2009), Geigenmüller & Leischnig (2017).
Collaboration practices	Empirical foundation
• Development programs	Emerged
• Downstream	Emerged
• Engagement period	Emerged
• Logistics	Emerged
• Upstream	Emerged
• Early dialogue	Emerged
Collaborative strategy	Empirical foundation
• Deciding factors	Emerged
• Control vs flexibility trade-off	Emerged
• Doing good	Emerged
• Economic incentives	Emerged
• PR	Emerged
• Formal structures	Emerged
• Risk management	Emerged
• Levels of integration	Emerged, Pfeffer & Salancik (2003)
Effective collaboration for circularity	Leising et al. (2018)
• Actor learning	Leising et al. (2018)
• Business Model Innovation	Leising et al. (2018)
• Collaborative culture	Barratt (2004)
• Network dynamics	Leising et al. (2018)
• Visions for the future	Leising et al. (2018), Quist (2007)
• Automated action	Dyer (1998), Williamson (1979)
Industry transition	Geels (2002, 2011), Geels & Schot (2007)
• Circularity promotion and promoters	Schmitt & Hansen (2020)
• Industry culture	Bidmon & Knab (2018)
• Transition leadership	Frantzeskaki et al. (2012)
• Scale-up bottlenecks	Emerged
• Transition arenas	Frantzeskaki et al. (2012)
Organization	Empirical foundation
• Company goals	Emerged
• Operations	Emerged
• Service provision	Emerged

Appendix III - Non-disclosure agreement (in Danish)

INFORMERET SAMTYKKEERKLÆRING

Hensigten med denne erklæring er at sikre samtykke til brug af data indsamlet i forbindelse med case studiet af din organisation samt at informere om hhv. informantens og forskerens rettigheder under forskningsprojektet. Indiker venligst samtykke (med x) i nedenstående tabel efter præference og underskriv forneden:

	Projektet og den rolle min organisation spiller i det er tilfredsstillende introduceret og jeg har haft mulighed for at stille uddybende spørgsmål efter ønske.
	Jeg er bevidst om, at jeg kan afblæse min deltagelse i projektet på et hvilket som helst tidspunkt uden at uddybe hvorfor.
	Jeg giver tilladelse til at interviews jeg deltager i må blive optaget, transskriberet og analyseret samt at uddrag kan blive udgivet i skreven og oversat form i rapporten.
	Jeg giver tilladelse til at blive identificeret ved navn i rapporten.
	Jeg giver tilladelse til at blive identificeret ved arbejdsfunktion og titel i rapporten.
	Jeg giver tilladelse til at min organisation nævnes ved navn i rapporten samt efterfølgende oplæg afholdt i forbindelse med specialet.
	Jeg giver tilladelse til at lydoptagelser af interview jeg deltager i bliver opbevaret sikkert på instituttets server maksimalt 10 år efter projektets afslutning.
	Jeg giver tilladelse til at ovenstående også gælder såfremt rapporten bliver tilpasset og omskrevet til en eller flere artikler udgivet i videnskabelige tidsskrifter.

Note: Deltagelse i dette projekt er frivillig. Som repræsentant for din organisation behøver du ikke at besvare alle spørgsmål der måtte komme i løbet af interviewsne og det står dig frit for at tilbagetrække udsagn under og efter interviews (frem til den 20. maj 2022). Rapporten bliver udgivet ved The International Institute for Industrial Environmental Economics, Lund Universitet, og bliver dermed offentlig tilgængelig. Citater og parafraseret indhold fra interviewsne bliver som led i afrapporteringen oversat til engelsk, samlet og sendt til godkendelse inden offentliggørelse af rapporten.

Du bedes underskrive for at give et informeret samtykke:

	Informant	**Forsker**
Navn		Mathias Peitersen
Titel		Kandidatstuderende
Organisation		IIIEE, Lunds Universitet
Underskrift		
Dato		

I tilfælde af tvivl eller spørgsmål er du til hver en tid velkommen til at henvende dig til:
Mathias Peitersen,
MSc in Environmental Management & Policy (Student), International Institute for Industrial Environmental Economics, Lunds Universitet.
Telefon: +45 29930865Mail: ma5161pe-s@student.lu.se eller peitersen94@gmail.com

Appendix IV – Search Strings for Literature Review

The follwoing search strings were used:

- Urban mining business
- Urban mining supply chain
- Urban min* buil*
- Circular economy collabora*
- Circular economy construc* OR buil*
- Circular construction (business OR CBM)
- Circular (construct* OR buil*) (Denmark OR Dansih)
- Circular business model (construc* OR buil*)
- Buil* material reuse
- Collaboration chain (construct* OR build*)
- Collaboration (circular OR re*)
- (Circular OR selective) (strateg* OR material manag*) demolition
- Circular Business Model (construct* OR Build*)
- (Supply OR Value) chain integration
- building material bank chain)
- Sustainable (construction OR buildings) Denmark