URBAN MINING HUB BUSINESS MODELS

ENABLING THE MATCHING OF SUPPLY AND DEMAND OF REUSABLE CONSTRUCTION COMPONENTS

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MSc Thesis in Urban Environmental Management
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Those who initiate change

will have a better opportunity to

manage the change that is inevitable

William Pollard

Summary

Reuse of construction components offers actors in the construction and real estate sectors a means to reduce the carbon and environmental footprint of their activities. To enable the reuse of deconstructed components, various urban mining hubs (hereafter UMH) have emerged in major cities across Northwestern Europe. These hubs source and deliver, that is, they match the supply of reusable components from deconstruction sites with demand in other projects and on construction sites. The novelty of the phenomenon manifests as the lack of research on the UMHs in general. To understand how UMHs enable the matching of supply and demand, an improved understanding of their business models (BM) is needed. Since reuse of construction components is attempted to be established as a more common practice in Helsinki region, the objective of this thesis was to investigate what kind of an UMH BM, that enables efficient matching of supply and demand of construction components, can be created for Helsinki region.

As the analytical framework, the study employed mainly the economic layer of the Triple Layered Business Model Canvas (TLBMC), with some elements from the environmental and social layers, together with four value dimensions (value proposition, value creation, value delivery, and value capture). Two qualitative methods were used. Firstly, a descriptive embedded multiple-case study with literal replication was conducted, with six UMHs from major cities in Northwestern Europe. Secondary data were collected from multiple sources, on the basis of which primary data were obtained through semi-structured interviews with representatives of the selected UMHs. A cross-case synthesis was undertaken to identify similarities and differences in how UMH BMs enable the matching of supply and demand for reusable components. Building on these insights, an action research (AR) approach was then applied to co-create an UMH BM suited to the Helsinki region. Representatives of key stakeholders from the region were invited to participate. The economic layer of the TLBMC was used as a framework and tool to collect input from participants. In addition, two semi-structured interviews with key regional actors were conducted to examine the barriers and enablers of the UMH BM implementation in the Helsinki region.

The cross-case synthesis results indicate two key value chain configurations for matching supply and demand of reusable construction components. Half of the cases rely on a streamlined value chain, while the other half employ a warehouse-based value chain. The former is underpinned by established customer relationships with manufacturers, retailers, developers, and architects, whereas the latter involves non-established relationships primarily with small construction contractors, other small firms, and households. The co-created UMH BM for the Helsinki region shows similarities with both value-chain types. Findings on barriers and enablers, in turn, reveal a difference between the perspectives of two actor groups. Namely, the private operator highlighted factors on which the UMH operations are dependent on, while city representatives prioritized creating enabling conditions for implementation as well as the intrinsic factors of the UMH BM. The resulting UMH BM for the Helsinki region builds on the results of these three analyses. Efficient matching of supply and demand is ensured through a webstore featuring a digital catalogue of available components and through established customer relationships with commercial organizations to secure continuous demand and predictability.

This thesis builds on and contributes to research on UMH BMs, the TLBMC, value dimensions, circular BM innovation, and the literature on barriers and enablers of construction component reuse. The findings provide recommendations for UMH operators on the strategic organization of UMH BMs. They further offer guidance for actors in construction and real estate, municipalities, and policymakers on how to participate in, benefit from, and support UMH operations. Future research should further investigate how existing UMHs match supply and demand of reusable construction components and the factors that influence their ability to capture value.

Tiivistelmä

Rakennusosien uudelleenkäyttö tarjoaa rakennus- ja kiinteistöalan toimijoille keinon vähentää toimintojensa hiili- ja ympäristöjalanjälkeä. Purettuja rakennusosien uudelleenkäytön mahdollistamiseksi useisiin Luoteis-Euroopan suurkaupunkeihin on syntynyt erilaisia urban mining hubeja (yleisesti hyväksytyn suomennoksen puuttuessa tiivitelmässä käytetään englannin kielistä termiä urban mining hub, UMH). Ne hankkivat ja toimittavat eli yhteensovittavat uudelleenkäytettävien rakennusosien tarjontaa ja kysyntää purkukohteista seuraaviin hankkeisiin työmaille. Ilmiön uutuus ilmenee sen tutkimuksen vähäisyytenä. Jotta ymmärrettäisiin, miten UMH:it mahdollistavat kysynnän ja tarjonnan yhteensovittamisen, tarvitaan parempaa käsitystä niiden liiketoimintamalleista. Rakennusosien uudelleenkäyttöä pyritään käytäntönä vakiinnuttamaan Helsingin seudulla, ja tämän työn tavoitteena oli selvittää, millainen UMH-liiketoimintamalli mahdollistaisi rakennusosien kysynnän ja tarjonnan tehokkaan yhteensovittamisen alueella.

Tutkielman analyyttisenä viitekehyksenä käytettiin pääasiassa kolmikerroksisen Business Model Canvasin (Triple Layered Business Model Canvas, TLBMC) taloudellista kerrosta, yhdessä neljän arvodimension (arvolupaus, arvonluonti, arvontoimitus ja arvonansainta) kanssa. Tutkimuksessa käytettiin kahta laadullista menetelmää. Ensin toteutettiin kuvaileva upotettu monitapaustutkimus kirjaimellisella replikaatiolla, johon valittiin kuusi UMH:ia Luoteis-Euroopan suurkaupungeista. Useista lähteistä kerättiin toissijaista aineistoa, jonka pohjalta hankittiin ensisijaista dataa puolistrukturoiduilla haastatteluilla valittujen UMH:ien edustajilta. Tapausvertailusynteesissä tunnistettiin samankaltaisuuksia ja eroja siinä, miten UMH-liiketoimintamallit mahdollistavat uudelleenkäytettävien rakennusosien kysynnän ja tarjonnan yhteensovittamisen. Näihin havaintoihin pohjautuen hyödynnettiin toimintatutkimumenetelmää Helsingin seudulle sopivan UMH-liiketoimintamallin yhteiskehittämiseksi. Yhteiskehittämistilaisuuteen kutsuttiin keskeisten sidosryhmien edustajia Helsingin seudulta. TLBMC:n taloudellista kerrosta sovellettiin viitekehyksenä ja työkaluna osallistujien näkemysten keräämiseksi. Lisäksi alueen keskeisten toimijoiden kanssa suoritettiin kaksi puolistrukturoitua haastattelua UMH-liiketoimintamallin käyttöönoton esteiden ja mahdollistajien selvittämiseksi.

Tapausvertailusynteesin tulokset osoittavat kaksi keskeistä arvoketjua uudelleenkäytettävien rakennusosien kysynnän ja tarjonnan yhteensovittamiseksi. Puolet tapauksista nojaa virtaviivaistettuun arvoketjuun, ja puolet hyödyntää erityisesti varastoihin tukeutuvaa arvoketjua. Ensimmäisen toimintamallin perustana on vakiintuneet asiakassuhteet valmistajien, jälleenmyyjien, rakennuttajien ja arkkitehtien kanssa. Jälkimmäisessä suhteet ovat vakiintumattomia ja asiakaskunta muodostuu pääasiassa pienistä rakennusurakoitsijoista, muista pienistä yrityksistä ja kotitalouksista. Helsingin seudulle yhteiskehitetty UMH-liiketoimintamalli osoittaa samankaltaisuuksia molempien arvoketjutyyppien kanssa. Esteitä ja mahdollistajia koskevat havainnot puolestaan paljastavat eron kahden toimijaryhmän näkökulmissa: yksityinen operaattori korosti tekijöitä, joista UMH-toiminta on riippuvaista, kun taas kaupungin edustajat asettivat etusijalle käyttöönottoa tukevien edellytysten luomisen sekä UMH-liiketoimintamallin sisäiset tekijät. Helsingin seudun UMH-liiketoimintamalli rakentuu näiden kolmen analyysin tuloksille. Uudelleenkäytettävien rakennusosien kysynnän ja tarjonnan tehokas yhteensovittaminen varmistetaan verkkokaupalla, joka sisältää saatavilla olevien osien digitaalisen luettelon, sekä vakiintuneilla kaupallisten organisaatioiden asiakassuhteilla, jotka takaavat jatkuvan kysynnän ja ennustettavuuden.

Tämä tutkielma hyödyntää ja täydentää UMH:eihin kohdistuvaa tutkimusta, erityisesti niiden liiketoimintamallien näkökulmasta. Tutkielma täydentää TLBMC:ta, ja erityisesti sen taloudellista kerrosta, arvodimensioita, kiertotalouden liiketoimintamalli-innovaatioita sekä rakennusosien uudelleenkäytön esteitä ja mahdollistajia käsittelevää kirjallisuutta. Tulokset antavat suosituksia UMH-operaattoreille UMH-liiketoimintamallien strategiseen organisointiin. Rakennus- ja kiinteistöalan toimijoille, kunnille ja päätöksentekijöille työ puolestaan tarjoaa suosituksia siitä, miten osallistua UMH-toimintaan, hyötyä siitä ja tukea sitä. Jatkossa tuotettavan tutkimuksen tulisi syventää ymmärrystä olemassa olevien UMH:ien keinoista yhteensovittaa uudelleenkäytettävien rakennusosien kysyntää ja tarjontaa sekä niistä tekijöistä, jotka vaikuttavat niiden kykyyn ansaita arvoa.

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AR	Action research
B2B	Business-to-business
BM	Business model
BMC	Business model canvas
BMI	Business model innovation
CBM	Circular business model
CBMI	Circular business model innovation
CCH	Circular construction hub
CE	Circular economy
CECP	Circular Economy Cluster Program
GHG	Greenhouse gas
RQ	Research question
SRQ	Sub-research question
TLBMC	Triple layered business model canvas
UMH	Urban mining hub

1 INTRODUCTION

1.1 Background, key concepts and research gaps

Reuse of components and materials offers companies a vehicle to attain significant reductions of their carbon and environmental footprints (Nußholz et al., 2019). Particularly relevant it is to companies in construction and real estate sectors (Aarikka-Stenroos et al., 2021), which, as industries, generate 35 % of greenhouse gas emissions (GHG), over 30 % of the EU's total environmental footprint and consume one third of all materials (European Environment Agency, 2024). While a large proportion of the buildings' lifecycle impacts (Cabeza et al., 2014) and the consumed natural resources are embedded in construction components, the components and buildings these constitute are, however, systematically demolished prior to the end of their designed service lives, as is the case in Finland (Räsänen & Lahdensivu, 2023). Thus, several decades of service life is often left for the components at the demolition stage (Räsänen & Lahdensivu, 2023).

In order to prolong the component lifecycles, material *reuse* is promoted as one of the circular economy (CE) strategies to maintain use and economic value as high as possible (Riuttala, 2022). It can be defined as an "operation by which products or product components that are not waste, are reused with the same use for which they were designed." (European Parliament and Council, 2018). Regarding construction components, reuse is concerned with reintroducing products and materials back into construction process and from there into the built environment, with no or trivial processing (Thormark, 2000; Sassi, 2008; Sassi, 2009; Cooper & Allwood, 2012; Iacovidou & Purnell, 2016; Çetin et al., 2021). It can take place in the same or a different location, while the product's function may remain or change (De Wolf et al., 2020). In the context of this thesis, construction components and elements are considered to encompass structural elements (e.g., foundations, beams, columns, slabs and load-bearing walls), non-structural elements (e.g., façade and roof elements such as doors, windows and roofings), internal space elements (e.g., internal dividers, space surfaces, internal fixtures), services elements (e.g., electrical and air conditioning elements) (Finne et al., 2010), furniture (e.g., lightning elements, office desks) (Brand, 1994) and secondary raw materials (e.g., wood, glass, metals, i.e., materials that are recycled and incorporated in new products) (Köhrer, 2024) (see Table 1 on the categorization of components).

Material and building component reuse have been promoted in the field of urban mining for several years (Nußholz et al., 2020). It regards the urban built environment as a mine of secondary building materials (Baccini & Brunner, 2012) that become available from construction and demolition (Koutamanis et al., 2018; Simon & Holm, 2018). Spurred by the increased understanding and utilization of urban mining, various concepts and definitions of circular building hubs (Van Uden, 2025) or circular construction hubs (CCH) (Tsui et al., 2023) have emerged. These are proposed particularly in Dutch grey literature (Tsui et al., 2023), municipal and provincial documents (Van Uden, 2025), master theses (Isselman, 2023; Karamanou, 2019; Köhrer, 2024; Nieuwhoff, 2022) and in the form of pilot projects (Tsui et al., 2023). Various definitions exist for CCHs (Tsui et al., 2023). Common to them is a physical location where construction and demolition waste, most notably reusable construction components, are exchanged between companies and organizations (Tsui et al., 2023; Van Uden, 2025). It further serves as a location where components are inspected, prepared, repaired, refurbished, remanufactured, temporarily stored and redistributed for subsequent reuse (Tsui et al., 2023; Van Uden, 2025). The urban mining perspective argues that such physical hubs are crucial for matching the supply and demand of reusable construction components. This lies on the often long temporal gap between deconstruction of the components and their reinstallation in a subsequent building (Tsui et al., 2023). Thus, CCHs serve to increase the changes of reuse (Tsui et al., 2023).

Tsui et al. (2023) take a spatial perspective on CCHs and categorize existing hubs in four categories based on a case study on The Netherlands. These are craft centres, industry hubs, local material banks and urban mining hubs. This thesis focusses specifically on *urban mining hubs* (UMH) for two key reasons. Firstly, UMHs focus on collecting and redistributing bulkier components, namely building elements, products, greenery and infrastructure from residential, governmental and office properties, with a service area of 30-50 kilometres (Tsui et al., 2023). In comparison to other CCHs, UMHs focus on the reuse of construction components of large volumes (Tsui et al., 2023) and oftentimes high environmental impacts. Secondly, the impetus for this thesis came from the Circular Economy Cluster Program (CECP) of the City of Helsinki. The CECP seeks to gain an improved understanding of what kind of a CCH could be designed for Helsinki region. As the hub should possess the capacity to serve the region (CECP, personal communication, 12.10.2023) and handle large volumes of bulky components, such as pallets of bricks, wood elements and glulam beams (CECP, personal communication, 17.10.2023), UMH satisfies the criteria.

A variety of UMHs have emerged within the past decade (e.g., New Horizon, Ombygg, Rebygg, Urban Mining Hub Berlin). For a private company to operate such component reuse business, it must, above all, be economically viable (Nußholz & Whalen, 2019; Nußholz et al., 2020). This, in turn, requires a *business model* (BM) that has the capacity to commercialize reusable construction components (Nußholz et al., 2020) and related services. A BM can be understood as "a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm." (Osterwalder et al., 2005, p.10). A BM further describes the value a company offers to its customer segments, as well as the architecture of the firm and its partner network for creating and delivering this value to generate profitable revenue streams (Osterwalder et al., 2005). Reuse BMs in construction industry have received limited attention in the extant literature (Bestul & Gruis, 2024; Buchard & Christensen, 2023; Nußholz et al., 2020; Nußholz & Milios, 2017; Nußholz & Whalen, 2019), with a few grey literature publications on UMH BMs (Ahlen, 2021; Sandberg & Hultegård, 2021). Isselman (2023), Köhrer (2024) and Van Uden et al (2025), in turn, focus on practices of UMHs, thereby covering parts of the UMH BMs, yet not attempting to illustrate the entire BMs of the studied UMHs. Simultaneously, there is an increasing interest in and need for knowledge on how organizations that fit the description of an UMH, holistically enable the matching of supply and demand of reusable construction components through their BMs.

Traditionally in the BM research, value has been considered as economic value, that is captured by companies and purchased by customers (Massa & Tucci, 2013). In order to expand this narrow view, Nußholz et al. (2020) applied the triple bottom line approach to study building component reuse literature. In so doing, they expand the concept of value to include environmental and social values as well (Nußholz et al., 2020). Despite the central role that these two value dimensions have in the construction component reuse business, systematic approaches to their analysis are lacking. The theoretical framework of *triple layered business model canvas* (TLBMC) (Joyce et al., 2015) offers one such approach. It has been deployed in the context of circular BM literature, to ensure the analysis of the three sustainability dimensions and holistic value creation (e.g., Daou et al., 2020; García-Muina et al., 2020; Zilia et al., 2021). However, it has not been applied to reuse BMs, which poses a significant knowledge gap in the emerging research stream.

Research on how UMH BMs enable matching supply and demand of reusable construction components is essential to strategically enhance those existing. In order to further support those to be initiated, it is essential to grasp how these BMs can be implemented. Thus, understanding of the enablers and barriers of the UMH BM implementation needs to be created. Plenty of literature exists on the barriers and enablers of reuse of construction components (Fufa et al., 2023; Gerhardsson et al., 2020; Huuhka & Hakanen, 2015; Knoth et al, 2022; Kummen et al., 2023; Rakhshan et al., 2020). However, academic and grey literature specific to the implementation of reuse BMs is lacking due to the novelty of the issue.

As the type of BM is determined, to some extent, by the context in which it locates in and its implementation is a context-dependent endeavor, they are studied in the geographic and institutional context of Helsinki region. This further results from this thesis being commissioned by the CECP of the City of Helsinki.

1.2 Research objective and research questions

The overarching objective of this thesis is to *create an urban mining hub business model, that enables efficient matching of supply and demand of reusable construction components in Helsinki region.* This aim is addressed by the following exploratory research question (hereafter RQ):

What kind of an urban mining hub business model enables effective matching of supply and demand of reusable construction components in Helsinki region?

The research aims to contribute to creating novel understanding of UMH BMs by developing theory through empirical evidence on six existing UMH BMs from various Northwestern European cities. Based on these findings, an UMH BM is co-created for the Helsinki region, with various regional stakeholders. Lastly, insights from interviews with two relevant regional actors contribute to knowledge on the implementation of an UMH BM in the region. Thus, besides contributing to theory development in the Finnish, and specifically in context of Helsinki region, the research provides two key types of practical inputs for the actors in the field. Firstly, a potential UMH BM that incorporates insights from key actors regarding the operation of an UMH. Secondly, the barriers and enablers of an UMH BM implementation are presented, thereby providing important insights for regional actors to facilitate the implementation of the created UMH BM and beyond. In order to answer the presented main RQ, three sub-research questions (SRQ) are formulated in alignment with the existing knowledge gaps. By answering these, the study provides additional theoretical and practical contributions.

The first SRQ addresses the research gap in the intersection of UMH and BM research, as this presents a previously non-explored field of literature. Since operational UMHs have emerged over the past decade, empirical evidence can be collected to contribute to the understanding of how their individual BM elements and the BMs as a whole, enable matching the supply and demand of reusable construction components. In order to analyze how the UMH BMs enable this, this thesis utilizes TLBMC (Joyce et al., 2015), and most notably, its economic layer (Osterwalder & Pigneur, 2010) as theoretical approaches. In so doing, this study provides an enhanced understanding of the UMHs and their operations from the BM perspective. Practical contributions are provided by offering insights into how UMH BMs are arranged elsewhere in Northwestern European cities. Thereby, the results can provide guidance on what aspects to consider in developing a BM for the local context. Furthermore, as the initial impetus for the research on UMH BMs came from the representatives of the CECP of the City of Helsinki, the study caters directly to the needs of those working to advance CE practices and processes in construction and real estate industries in the Helsinki region. To provide understanding of UMH BMs, the first, descriptive SRQ investigates:

SRQ1: How do the existing urban mining hub business models enable matching supply and demand of reusable construction components in the selected Northwestern European cities?

The second SRQ builds on the first in that the empirical findings of the former serve as the basis on which the Helsinki region specific UMH BM is co-created. Hence, the SRQ addresses the research gap on what kind of a private UMH BM can serve the construction and real estate industry actors in Helsinki region. Specifically, empirical evidence is provided on what kind of a value proposition should the UMH BM possess and how it should create, deliver and capture value to enable the matching of supply and demand of construction components in the region. In order to create a BM that responds to the needs of the regional stakeholders, these need to be integrated in the process of co-creation, to collectively develop a model that takes account of multiple relevant perspectives, knowledge and needs. Thus, this research draws on the economic layer of the TLBMC as a tool to create the UMH BM for Helsinki region in a collaborative manner.

The findings have direct and indirect practical implications as, firstly, an UMH BM is required to match the supply and demand of reusable construction components and thereby enable the reuse of construction components in the first place. By proposing a privately owned UMH BM that has been created in collaboration with the regional industry actors, this study seeks to serve potential customers' and partners' needs, and to attract and commit them to the UMH. The private ownership seeks to contribute to its operational continuity through changing governments and thus, fluctuating funding. As a result, the thesis offers a potential model for the actors to either further develop, to learn from or integrate selected elements to their own BMs. Secondly, the scope of the UMH BM is on Helsinki region, which is the fastest growing in Finland regarding its population, building stock and construction activities. The density of construction and demolition sites and projects offer an ideal playing field and pose the most supply and demand for reuse of construction components. Accordingly, the potential for carbon and environmental footprint reductions as well as for the creation of economic savings and new jobs, are significant in the region. Lastly, the study seeks to offer an initial impetus for further explorations. In order to provide understanding of the potential UMH BM, the second, exploratory SRQ asks the following:

SRQ2: *What kind of a business model can be created for an urban mining hub in Helsinki region, from the perspective of regional stakeholders?*

The third SRQ addresses the research gap on the barriers and enablers of the UMH BM implementation in Helsinki region. Both academic and grey literature lack an in-depth understanding of these factors not only in the Finnish context but in general. Hence, research is needed to gain an enhanced understanding of the impediments and enablers of the UMH BM implementation. By capitalizing on these findings, a variety of stakeholders can support its implementation. This gives raise to the societal relevance of the findings. In order to explore the barriers and enablers, third, descriptive SRQ is formulated as follows:

SRQ3: *What are the barriers and enablers of the urban mining hub business model implementation in Helsinki region?*

1.3 Research outline

This thesis is organized in six chapters. The first chapter placed the topic of the thesis in its scientific and societal context and gave an overview of the relevant literature in the field. Definitions of key concepts and research gaps were given. It concluded by introducing the research objective and research questions and presented the theoretical and practical relevance of the study. The second chapter provides the theoretical foundation of the study by further elaborating on the key concepts and the theoretical framework. The third chapter presents the applied methodology, whereas the fourth chapter gives the analysis. Here, the chapter is arranged into subsections according to the posed SRQs. Chapter 5 presents the discussion, whereby the SRQs are answered and discussed against the existing literature. The thesis concludes by providing an answer to the main RQ and highlights its theoretical contributions and practical implications. The research quality is evaluated against the criteria presented under methodology. Finally, the limitations of this thesis are discussed and recommendations offered for future research.

2 THEORETICAL AND ANALYTICAL FRAMEWORKS

This chapter outlines the theoretical framework of the research. Firstly, the phenomenon of reuse of construction components is introduced with a literature review provided on barriers and enablers of construction component reuse in the context of Nordic countries. Subsequently, the phenomenon of UMHs is presented Thirdly, the theoretical frameworks of BM and the TLBMC are presented. The chapter concludes by connecting the two fields and discussing the importance of circular BM innovation for enabling construction component reuse.

2.1 Reuse of construction components

Building component reuse in construction industry has been promoted as one of the CE strategies to prolong component lifecycles by maintaining use and economic values as high as possible (Riuttala, 2022). It has been advocated for by a variety of actors, from academics (Bertino et al., 2021), to consultancies (Ellen MacArthur Foundation, Circle Economy, Metabolic) and public organizations (European Commission, n.d.; Ministry of the Environment, n.d.). Adapted from Condotta and Zatta (2021) and de Wolf et al. (2020), reuse of construction components is defined in the context of this thesis as recovering building products or components in their formal and physical integrity from demolition activities and used again in the same or another building and in the same or another function. Depending on their qualities and "second life" purpose, refurbishing and/or remanufacturing can be a prerequisite for their reuse.

Table 1. Categorization of construction components applied in this thesis.

Category	***Explanation***	***Life expectancy***	***Examples of components***
Structural elements (Brand, 1994)	Foundations Load-bearing elements	30-300 years	Beams Columns Load-bearing walls
Non-structural elements (Devin & Fanning, 2019)	All components that are non-load bearing but attached to the primary structural system		Façade elements Doors Windows
Services elements (Finne et al., 2010)	Plumbing elements Air conditioning elements Electrical elements Data transfer elements Mechanical elements	7-15 years (Brand, 1994)	Air conditioner Radiator
Internal space elements (Brand, 1994)	Interior layout of the building, including Walls Floors Ceilings Doors Internal fixtures	3-30 years	Tiles Glass partition element Vinyl floor Kitchen cabinets
Furniture (Brand, 1994)	Furniture and other items that can easily change place in a building	Changes from daily to monthly	Lightning elements Office desks and chairs
Secondary raw materials (European Union, 2025)	Materials that are recovered from waste or end-of-life products through recycling		Wood Glass Metals

Source: Adapted from Brand (1994), with additional inputs from Devin & Fanning (2019), European Union (2025), Finne et al. (2010).

The building components can be categorized by building layers, as introduced by Duffy (1989) in his theory of layers of building, that was further developed and expanded by Brand (1994). Brand (1994) presents five types of layers specific to a building, with the sixth layer considering its geographical setting, the site. The five building specific layers involve structure (i.e., structural elements), skin (i.e., the exterior surfaces), services (i.e., functioning systems integrated in the building), space plan (i.e., the interior layout) and stuff (i.e., furniture), each involving a different service life expectancy. Building on Brand (1994), this thesis applies the above presented categorization as its starting point to study the reuse of construction components (illustrated in Table 1).

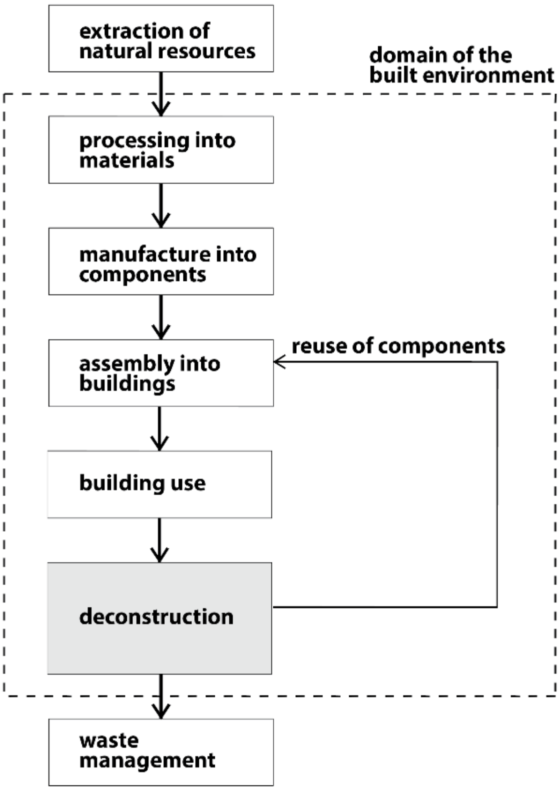

Figure 1. Dominant life cycle of the built environment with component reuse scenario highlighted. Adapted from Crowther (2001).

The theory of building layers helps to identify layers with different service lives, to determine which components and materials obsolescence and when their deconstruction can take place (Crowther, 2001). In a building's life cycle, deconstruction, considered as "the reverse of construction" (Pun & Liu, 2006, p. 196), takes place at the end of the building or its component life cycle, resulting to their subsequent installation to same or another building. Deconstruction involves the objective to reuse materials and whole elements (Hobbs & Hurley, 2001). Figure 1 presents the process flowchart of reuse of construction components in the building life cycle. This model is commonly used to present the life cycle impacts of a building and is referred to as 'cradle to grave' (Crowther, 2001).

Jayasinghe et al. (2018) conceptualize the component reuse process, that takes place between deconstruction and assembly, as post end-of-life of building (PEoLB) operations. The authors define these as "operations and processors initiated for regeneration of materials and products at the end-of-life-of-building [that] result into value added products which will be available in the secondary markets for construction industry" (Jayasinghe et al., 2018). They found the process, synthesized in Figure 2, on the principles of reverse logistics (RL) and closed loop supply chain. Both of these represent procedures that deal with returning materials and components to the construction stage of a new project (Hosseini et al., 2015). RL contributes to the concept with its central operations such as deconstructing, collecting, testing and treating the components (Jayasinghe et al., 2018). Closed loop supply chain, in turn, proposes a systematic approach maximizing the value of products over their life cycle by utilizing RL approaches (Govindan et al., 2015). Together RL and closed loop supply chain compose a process that presents the reusable building components' pathway from buildings at their end-of-life to regeneration operations in between, subsequently resulting in products that are made available to the secondary construction product markets and ultimately assembled into buildings (Jayasinghe et al., 2018).

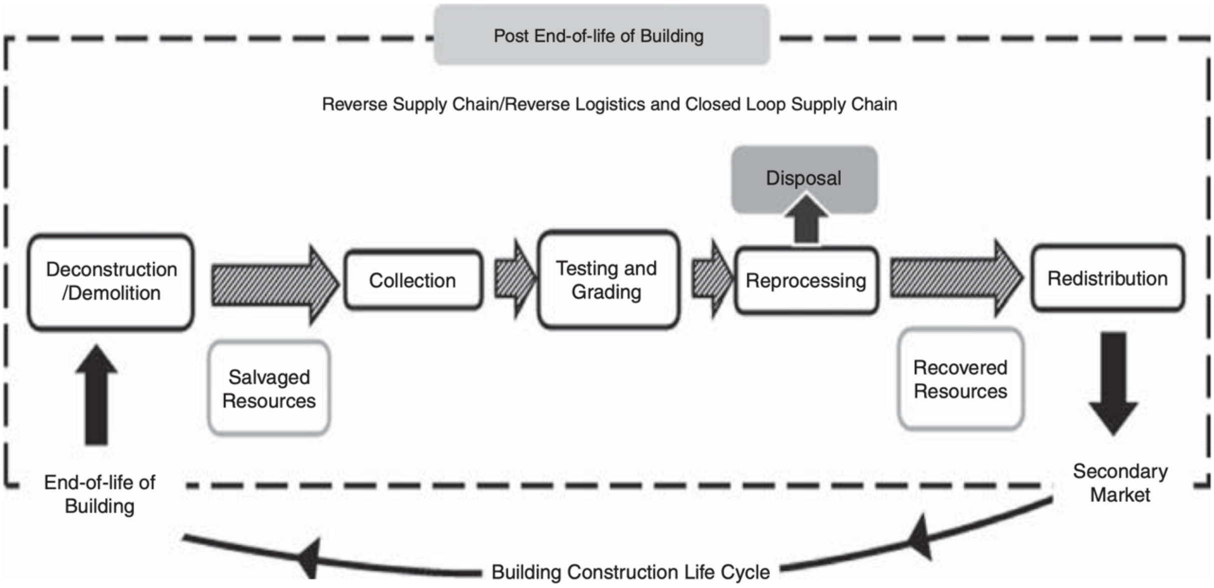

Figure 2. PEoLB concept and its operations (Jayasinghe et al., 2018).

The reuse of construction components has been identified to produce a range of environmental, economic and social benefits that reuse of construction components can offer to stakeholders. By reusing building parts, changes in land use, environmental damage, as well as loss of habitat and biodiversity can be reduced due to lesser resource extraction (Tukker & Jansen, 2006). On average, 40% CO_2 emission reductions across different housing types can be achieved, when reusing building materials in construction, in comparison to the business-as-usual scenario with no reuse (Bosch et al., 2023). Economic benefits are generated, for example, by offering lower prices for customers, increased material performance (Riuttala et al., 2024) and cost-efficiency (Nußholz & Whalen, 2019) as well as avoided waste management costs (Akinade et al., 2015). Furthermore, new business models and revenue source can be developed (Hosseini et al., 2015; Ness et al., 2015; Iacovidou & Purnell, 2016, Riuttala et al., 2024). Social benefits arise, most notably, from the jobs that emerge from the labour-intensive nature of reuse (Gorgolewski, 2008; Gorgolewski & Morettin, 2009; McQuibban et al., 2021; Willeghems & Bachus, 2018). Vocational training and specialization are required (Old et al., 2022), with opportunities to offer these to marginalized groups with low levels of education (McQuibban et al., 2021). Furthermore, by reusing buildings or components of historic value, these parts can be preserved when giving them a life elsewhere (Bertino et al., 2021). Additionally, lower prices increase product accessibility for low-income households (da Rocha & Sattler, 2009; Schenkel et al., 2015).

2.2 Barriers and enablers of reuse of construction components in the Nordic context

The increasing interest in the reuse of construction components has spurred a range of academic literature (e.g., Hobbs & Adams, 2017; Park & Tucker, 2017; Rakhshan et al., 2020), industry papers (e.g., Deloitte, 2017) and master theses (e.g., Chaba & Mridha, 2022; Frändberg & Nyqvist, 2021; Gremmen, R., 2018; Isselman, 2023; Köhrer, 2024; Trabulsi & Sofipour, 2020) on the barriers and enablers or drivers of construction component reuse. Relevant academic publications in the Nordic context were reviewed to create an understanding of the factors that impede and enable reuse of construction components. The scope was limited to the Nordic region, firstly, for the similar economic, political, regulatory and socio-cultural environments across the included countries. Secondly, the thesis' focus is lied on the barriers and enablers of an UMH BM implementation in the Finnish capital region, for which this theoretical exploration provides a foundation. The identified factors are categorized based on the framework of Knoth et al. (2022) as this was considered to comprehensively represent and capture the quintessence of the identified factors. Some terms describing the categories were modified to better suit the identified factors.

2.2.1 Barriers

Regarding barriers, factors related to *culture and know-how*, reuse infrastructure and the business framework were stated most often in the reviewed literature. Regarding the former category, the impeding factors that were stated most often can be summarized as conservative way of thinking and attitudes that prevail in the industry (Gerhardsson et al., 2020; Hradil, 2014; Huuhka & Hakanen, 2015; Knoth et al., 2022; Kummen et al., 2023). These involve reluctance to change habits and conventional ways of working (Kummen et al., 2023) that result in slow adoption of new concepts and practices (Hradil, 2014). Additionally, lack of knowledge of reuse of construction components was observed to be a barrier (Ericsson et al., 2024; Fufa et al., 2023; Gerhardsson et al., 2020; Hradil, 2014; Huuhka & Hakanen, 2015; Knoth et al, 2022; Kummen et al., 2023; Nordby, 2019). This involves lack of awareness of the possibility to reuse in the first place (Hradil, 2014; Huuhka & Hakanen, 2015), lack of information about the used construction products (Nordby, 2019), their availability (Hradil, 2014), as well as environmental (Hradil, 2014; Huuhka & Hakanen, 2015) and other benefits of reuse (Gerhardsson et al., 2020). Lastly, lack of practical skills (Ericsson et al., 2024) and knowledge of how to process the materials was observed (Kummen et al., 2023).

Regarding *reuse infrastructure*, two main types of barriers to reuse of construction components were observed in the literature. These are, firstly, additional costs of reuse (Fufa et al., 2023; Hradil, 2014; Huuhka & Hakanen, 2015; Knoth et al, 2022; Nordby, 2019; Sandberg, 2022) that is perceived to result from the various time-intensive tasks that reuse necessitates. Such are the intact deconstruction of the components, design and engineering solutions for their implementation (Nordby, 2019), deconstruction planning, coordination and testing (Hradil, 2014). Secondly, lack of testing framework, methods, infrastructure and warranties were identified as barriers (Fufa et al., 2023; Gerhardsson et al., 2020; Hradil 2014; Huuhka & Hakanen, 2015; Knoth et al, 2022; Nordby, 2019; Sandberg et al., 2022). Their absence is a particularly significant issue at the face of uncertain or inadequate quality of built-in construction components (Ericsson et al., 2024; Gerhardsson et al., 2020; Huuhka & Hakanen, 2015; Kummen et al., 2023). Further constraining factor stated in the literature is the temporal dimension of reuse (Fufa et al., 2023; Gerhardsson et al., 2020; Huuhka & Hakanen, 2015; Knoth et al, 2022; Nordby, 2019), with construction projects often short in time (Gerhardsson et al., 2020) while reuse is considered as time consuming (Fufa et al., 2023) and activities of supply and demand as difficult to match temporally (Huuhka & Hakanen, 2015).

The main type of *business*-related impediment can be summarized as the lack of market (Ericsson et al., 2024; Fufa et al., 2023; Gerhardsson et al., 2020; Hradil, 2014; Huuhka & Hakanen, 2015; Knoth et al., 2022; Kummen et al., 2023; Nordby, 2019; Sandberg, 2022). This includes both, the limited supply and demand of reusable construction components (Fufa et al., 2023; Gerhardsson et al., 2020; Huuhka & Hakanen, 2015; Kummen et al., 2023) and inadequate market infrastructure (Ericsson et al., 2024; Gerhardsson et al., 2020; Knoth et al, 2022; Kummen et al., 2023; Nordby, 2019; Sanberg, 2022). A risk identified to relate to both factors is the parallel development of several different platforms that are not designed to communicate with each other. Such development fragments the market as it hinders open access, communication and cooperation across projects (Kummen et al., 2023). Further challenges to reuse are posed by the lack of financial incentives (Ericsson et al., 2024; Hradil, 2014; Knoth et al., 2022; Kummen et al., 2023), lack of reuse experts (Knoth et al., 2022) and actors offering services such as design, deconstruction (Hradil, 2014), storage and refurbishment (Gerhardsson et al., 2020).

Obstacles related to *policy and regulation* were observed to be the lack of supporting regulation (Ericsson et al., 2024; Fufa et al., 2023; Hradil 2014; Knoth et al, 2022; Sandberg et al., 2022) and insufficient technical documentation (Fufa et al., 2023; Knoth et al, 2022; Nordby, 2019; Sandberg et al., 2022).

2.2.2 Enablers

Factors related to reuse infrastructure, policies and regulations and business were regarded most often as enablers in the reviewed literature. A significant number of studies recognized the importance of establishing *reuse infrastructure* (Fufa et al., 2023; Hradil, 2014; Knoth et al., 2022, Kummen et al., 2023; Nordby, 2019; Sandberg et al., 2022). Particularly digital and physical marketplaces (Fufa et al., 2023; Hradil, 2014; Kummen et al., 2023; Nordby, 2019; Sandberg et al., 2022) are needed to match the supply and demand of reusable construction components (Sandberg et al., 2022). The physical marketplaces can involve interim storage that serves to bridge the temporal gap between deconstruction and purchase or reinstalling the components (Knoth et al, 2022; Kummen et al., 2023; Sandberg, 2022). Papers on the Norwegian context propose a national, open access platform (Kummen et al., 2023) that is linked to local physical warehouses (Nordby, 2019). The national online marketplace could be established on a public-private cooperation, with public authorities providing support for the establishment and operation of the online marketplace (Nordby, 2019). Additionally, proper testing infrastructure is necessary (Fufa et al., 2023; Knoth et al., 2022; McNamee et al., 2023; Nordby, 2019; Sandberg et al., 2022). Nordby (2019) proposes a public-private cooperation with construction industry actors to establish organizational units for the quality control, documentation and certification of materials. The services should be supported with incentive schemes to make them affordable and targeted at small enterprises, in order to enhance competitiveness of local reuse operators (Nordby, 2019).

The proposed *policy and regulatory* tools include, most notably, reuse-friendly laws, regulations and stricter requirements for reuse (Ericsson et al., 2024; Fufa et al., 2023; Knoth et al, 2022; Nordby, 2019). For the Norwegian context, Nordby (2019) proposes the requirement to submit a waste plan upon application for demolition to ensure early marketing of available materials. Further proposed measures are protection status for construction components, as well as extended manufacturer responsibility to provide material passports and takeback arrangements for products. Other potential policy tools are the requirement to long-term and standardized documentation of reusable products (Fufa et al., 2023; Gerhardsson et al., 2020; Knoth et al, 2022; McNamee et al., 2023), which is particularly important for products with specific requirements attached, such as fire safety classes (McNamee et al., 2023). Setting ambitious and clear reuse requirements in public (and private) procurement (Fufa et al., 2023; Gerhardsson et al., 2020; Knoth et al, 2022) and concrete targets in an early project planning phase (Ericsson et al., 2024; Gerhardsson et al., 2020; Knoth et al, 2022; Sandberg et al., 2022) ensure procurement and planning that support reuse.

Knowledge is considered as a central enabling element of reuse (Ericsson et al., 2024; Fufa et al., 2023; Knoth et al, 2022; Sandberg et al, 2022). Specifically, two types of knowledge were highlighted, namely, practical knowledge (Fufa et al., 2023) and measurable benefits of reuse (Sandberg et al, 2022). Both types can be obtained, firstly, through pilot projects that serve as important sources of information and examples (Fufa et al., 2023; Knoth et al, 2022; Nordby, 2019; Sandberg et al., 2022) and secondly, through disseminating experiences and project results via collaboration (Fufa et al., 2023), in networks (Sandberg et al., 2022), guidelines and courses (Nordby, 2019). Furthermore, cooperation and communication were highlighted as important enablers of reuse projects (Fufa et al., 2023; Knoth, 2022; Nordby, 2019; Sandberg, 2022). This lies on the immature market which forces several actors to be involved in and collaborate closely in the value chain to find reusable construction components and solutions for their reuse (Fufa et al. 2023; Sandberg et al., 2022).

The *business*-related enablers are funding schemes (Fufa et al., 2023; Knoth et al, 2022; Nordby, 2019; Sandberg et al., 2022) and financial incentives (Ericsson et al., 2024; Fufa et al., 2023; Knoth et al, 2022; Nordby, 2019; Sandberg, 2022) such as VAT exemptions on reusable construction components (Nordby, 2019). Moreover, particularly for large commercial players, competition (Fufa et al., 2023) and reputational benefits (Sandberg et al., 2022) gained through reuse of construction components were identified as driving factors.

2.3 Urban mining hubs

The reuse of construction components and materials is closely related to urban mining (Tsui et al., 2023), that denotes the reuse of anthropogenic materials incorporated in buildings, infrastructure and other human-made structures (Baccini & Brunner, 2023; Brunner, 2011). To this end, urban mining involves activities, most notably, mapping the location of material stocks and flows in cities or countries and thereby estimating the availability of secondary resources within the given geographical area (Tsui et al., 2024). Subsequently, when the buildings and infrastructure come to the end of their lifecycles, the stocks of resources become available for reuse (Brunner, 2011; Cossu & Williams, 2015). Initially, attention was paid to metals (Brunner, 2011; Cossu & Williams, 2015), for their high prices and demand (Koutamanis et al., 2018) as well as concrete, for its environmental impact (Mostert et al., 2020) and amount of supply (Stephan & Athanassiadis, 2018). Increasingly, other construction materials gain attention as the object of urban mining (Arora et al., 2021). This results from the large amount of materials buildings encompass and the availability of cadastre data, the governmental recording of real estate properties, that allows the estimation of types and amounts of materials in the first place (Tsui et al., 2023).

The growing understanding of urban mining and reuse of construction components has stimulated various circular hub concepts (Tsui et al., 2023) and their implementation. To describe the variety of circular hubs, the authors use circular building hub (Van Uden et al., 2024) or circular construction hub (CCH) (Tsui et al., 2023) as umbrella terms. The hubs can vary in their spatial scale (from neighborhood level to countrywide), target groups (from citizens to governmental organizations) and ownership (from private to public and third sector organizations) (Tsui et al., 2023). The extant literature identifies five main types of CCHs (of which those that focus on material reuse are presented in Figure 3). These are the industrial clusters, focused on recycling of specific material flows (e.g., concrete or soil masses) among specialized companies, virgin material hubs that possess a purely logistical function, craft centers that conduct primarily business-to-consumer sales of reusable products (Tsui et al., 2023; Van Uden, 2024). Tsui et al. (2023) further differentiate between urban mining hubs (UMH) and local material banks that both focus on connecting the supply and demand of reusable materials. This is done by collecting, storing, processing and redistributing the components (Tsui et al., 2023). The urban mining perspective argues that such physical hubs are essential, since they increase the chances that components are matched in the otherwise so narrow timeframe between the operator receiving the information about potential components and the start of demolition (Tsui et al., 2023).

The UMHs and local material banks differ in three main ways. Firstly, they target different material flows and thus necessitate warehouses of different sizes. While UMHs focus on redistributing bulky components, namely building elements, products, greenery and infrastructure from residential, governmental and office properties, the materials banks target smaller residue flows. Accordingly, the UMHs require land up to 10 hectares for the bulky, fragile and difficult-to-stack materials, whereas 1-2 ha suffice to material banks. Secondly, their customer segments differ in that UMHs target building product resellers and construction companies as potential customers, whereas material banks cater to the demand posed by small scale private housing renovations and public organizations. Thirdly, their operations' geographic radius differs as UMHs have a service area of 30-50 kilometers, implying that they serve clients within their own cities. Material banks, in turn, operate more locally with a geographic radius of 10-20 kilometers. (Tsui et al., 2023).

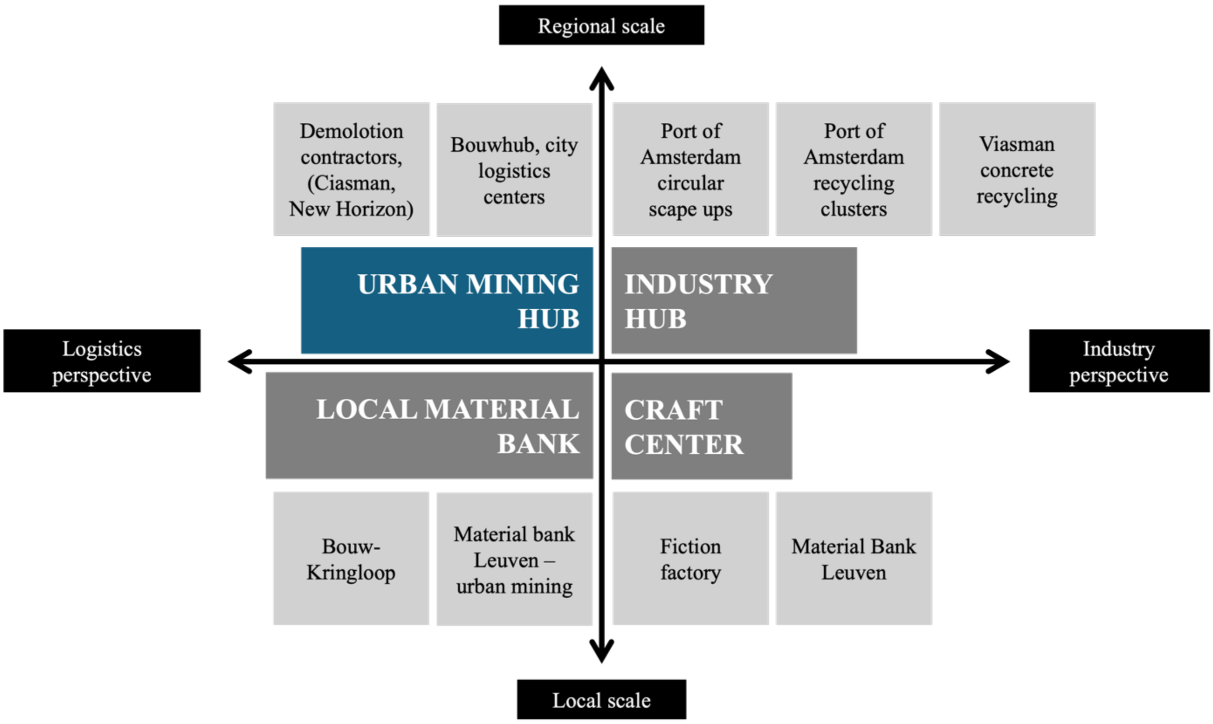

Figure 3. Diagram highlighting UMH as one of the circular construction hub categories. Adapted from Tsui et al. (2023).

This thesis focusses on UMHs as these target large residue flows and address construction components of highest environmental and carbon impacts. These considerations are central to the overarching objective of this study, which is to reduce these impacts with a BM that enables efficient matching of supply and demand of reusable construction components. In line with the empirical evidence provided by Tsui et al. (2023) UMHs are defined in the context of this thesis as *focal points that possess the physical and digital infrastructure to collect and redistribute bulky and non-bulky construction components in large volumes. Components sourced from residential and office buildings are prioritized due to their often-standardized materials and solutions. The components can be temporarily stored, when necessary, at a warehouse, and require some or no treatment, such as refurbishment. Temporary storage can be arranged at vacant plots or demolition sites, while fixed warehouses can be established at existing ports, business parks or industrial estates. The UMHs serve customers such as building product resellers and construction companies within large cities and regions.*

2.4 Business models

A commonly used definition of a BM is that it "describes the rationale of how an organization creates, delivers and captures value" (Osterwalder & Pigneur, 2010, p.14). In a more comprehensive manner, BM can be understood as "a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams." (Osterwalder et al., 2005, p.10). Value plays a central role in most BM definitions (Richardson, 2005). Whereby value itself is generally defined as value for customers (i.e., use value) and value for company (i.e., financial profit and exchange value) (Lüdeke-Freund et al., 2019). Value proposition, value creation and delivery, and value capture elements are typically the most recognized (Osterwalder & Pigneur, 2010; Richardson, 2005) in the context of a BM, with some authors including value network as well in the definition (Geissdoerfer et al., 2018).

Value proposition is deemed to describe the kind of value the company offers and to whom it is offered (Richardson, 2005). It further involves the strategic positioning or approach of the company that makes it stand out from other companies with similar value propositions (Richardson, 2005). Value creation and value delivery are often considered as building blocks of value chain (Chesbrough & Rosenbloom, 2002). It involves a variety of activities, resources, suppliers, partners, channels and customer relationships the company utilizes to create and deliver their offering to customers (Richardson, 2005; Osterwalder & Pigneur, 2010). Lastly, the value capture depicts how the company generates revenue and profit (Richardson, 2005) and how it covers its costs that incur from value chain (Osterwalder & Pigneur, 2010). Overall, the company's value chain should be designed to serve both, its value proposition and value capture (Richardson, 2005). Table 2 and Figure 4 connect the discussed value dimensions to BM elements.

Table 2. Connecting value dimensions and BM elements.

Value dimension		***Corresponding question***	***Business model elements***
Value proposition		*What value is provided and to whom?*	• Product/service offer and value proposition • Customer segment
Value chain	Value creation	*How is value created?*	• Resources • Partners • Activities
	Value delivery	*How is value delivered?*	• Customer relationships • Channels
Value capture		*How does the company generate revenue, profit, and cover its costs?*	• Costs • Revenues

Note. Adapted from Osterwalder and Pigneur (2010), Demil & Lecoq (2010) and Nußholz & Milios (2017).

Osterwalder and Pigneur (2010) offer a visual representation of the elements and structure of a BM (as illustrated in Figure 5). With the business model canvas (BMC), the authors make an attempt to provide a simple and intuitively understandable model to analyse, evaluate, describe, discuss and compare existing BMs and their environments. Furthermore, the BMC can be used to innovate and design new BMs and reconfigurate existing ones. Due to these qualities, it has gained popularity as a strategic management tool amongst practitioners. It involves nine BM elements: customer segments, value propositions, channels, customer relationships, revenue streams, resources, activities, partners and costs. The elements on the left side (activities, resources and partners) describe the value creation mechanisms, on the right side (customer relationships and channels) the value delivery vehicles, and at the bottom, the means of value capture (costs and revenues), with value proposition and customer segments describing the overall value proposition. (Osterwalder & Pigneur, 2010)

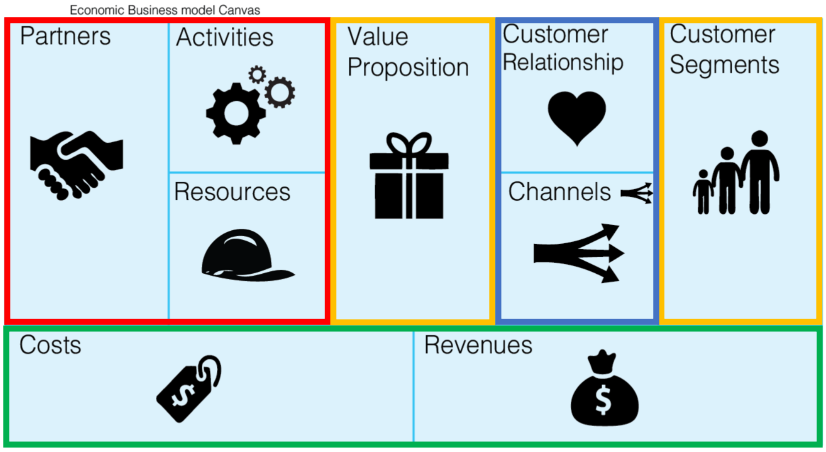

Figure 4. Economic Business Model Canvas. The economic BM elements highlighted in yellow illustrate value proposition, the red ones represent value creation, while those in blue represent value delivery. The green BM elements illustrate a company's value capture capacity. Adapted from Joyce & Paquin (2016).

Osterwalder and Pigneur (2010) describe the elements as follows:

- The *Customer Segments* -element describes the different groups of people or organizations that a company aims to reach and serve with its value proposition.
- *Value Proposition* involves the services and products that create value for a defined customer segment. The strategy to win customers is integrated in the value proposition, for example in that the offering solves a customer's entire problem or satisfies a need (Richardson, 2005).
- *Channels* include communication, distribution and sales that together create an interface between a company and its customers and serve as the vehicle to deliver the value proposition to customers.
- *Customer Relationships* imply the type of relationships a company establishes with defined customer segments. These can range from personal to automated.
- *Resources* encompass the most important, physical, financial, intellectual, or human, assets required to make a BM operational. The type of BM dictates the needed resources. Overall, these allow the company to create and offer a value Proposition, enter markets, maintain relationships with the different customer groups and earn income.
- Similarly, *Activities* are required for these aspects, and they vary depending on the type of BM. In essence, they describe the actions and pursuits of the company central to operate successfully and make its BM work. These can be divided into three major groups: production, problem solving or providing a platform or a network.
- *Partners* describe the type of organizations a company has as its partners and the type of partnerships it establishes with these. For example, in order optimize the use of resources and activities, a company can establish alliances with organizations that it does not compete with. Another type of partnership is the buyer-supplier relationships that is established to assure reliable supplies.
- *Costs* describe the most important costs that arise from value creation and delivery (i.e., from value chain).
- *Revenues* -element represents the cash a company generates from each customer segment. In order to arrive at profits, costs must be subtracted from revenues. A BM can capitalize on two different types of revenue streams: (1) transaction revenues that result from one-time payment, and (2) recurring revenues.

2.5 Triple layered business model canvas

The BMC has received criticism for its narrow focus on financial value (Upward, 2013; Coes, 2014). With the increasing awareness of environmental and social issues, authors are turning to the triple bottom line approach that incorporates and measures these three types of value (Elkington, 1997), in order to develop sustainable BM concepts (e.g., Dewulf, 2010; Evans et al., 2017; Lüdeke-Freund, 2010; Upward & Jones, 2014). One such concept is the triple layered business model canvas (TLBMC), created by Joyce et al. (2015) from the need for a systematic approach to integrate the triple bottom line in BM innovation. The TLBMC builds on the original economic BMC and adds two new layers, the environmental and social. Thereby, it presents the three pillars of sustainability as three separate yet interconnected layers. Coherence across the layers is ensured by projecting the elements and structure of the original BMC on the two others, in line with the layer's theme (see Figure 5). (Joyce et al., 2015)

The environmental layer takes the life cycle assessment (LCA) as its approach to systemically incorporate and measure the environmental impacts associated with all stages of the product or service at the heart of a BM. By applying the LCA as a lens to analyzing and developing a BM, the decisionmakers can consider the essential environmental impacts of the product or service across its life cycle stages and subsequently make conscious decisions to improve the environmental sustainability of the BM (Joyce et al., 2015). Thus, Joyce et al. (2015) include the service lifecycle stages as the elements of the environmental layer: materials, supplies and outsourcing, production, distribution, use phase, end-of-life, together with the functional value, as well as the environmental impacts and benefits (Figure 6).

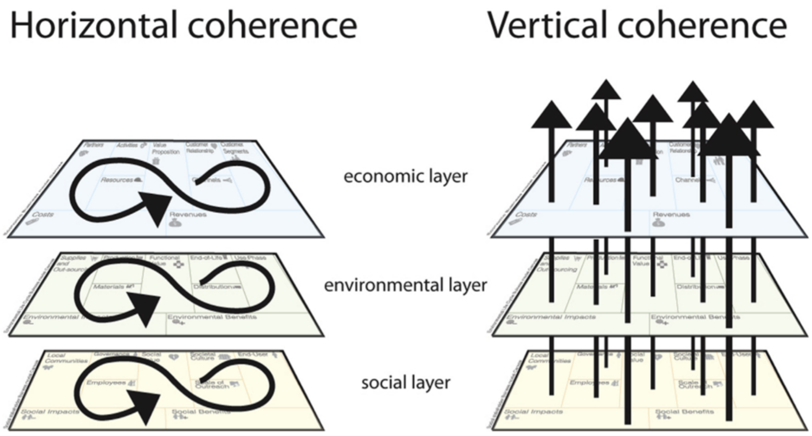

Figure 5. The TLBM canvas creates two new dynamics: horizontal and vertical coherence (Joyce & Paquin, 2016).

Joyce et al. (2015) describe the elements as follows:

- Placed at the middle of the canvas, *Functional Value* represents the functional unit of an LCA. The functional unit can be defined as the "quantitative description of the function or service for which the assessment is performed, and the basis of determining the reference flow of product that scales the data collection in the next LCA phase, the inventory analysis." (Hauschild, 2018, p.61). Thus, the functional value can be described in terms of area, energy, mass, product unit, volume, economic or nutritional value (Arzoumanidis et al., 2019), depending on the product or service in question.
- *Materials* describe the bio-physical stocks deployed by the organization to create and deliver value. While service providers do not necessarily hand over their materials to their clients, they do consume and use consumables such as water, gas and assets such as computers and warehouses.
- *Production* involves undertaking actions with the assets, such as running the IT infrastructure or heating and maintaining warehouses.

- *Supplies and Outsourcing* involve all material resources and production activities that are not regarded as part of the core business. An example of an outsourced resource is energy that is required for in-house processes and often acquired from local utility companies.
- *Distribution* takes place when the product or service – i.e., the value proposition – is ready to be delivered. Transportation comprehends the type of transportation, the distance and the weight or volume to be transported as well as packaging.
- *Use Phase* begins when the client partakes in the value proposition. It involves client using the services or products offered by the company, maintenance and repair.
- *End-of-Life* (EOL) begins when the client chooses to end the consumption of the product or service. For products, the company can offer EOL treatment "options such as remanufacturing, repurposing, recycling, disassembly, incineration or disposal." (Joyce et al., 2015, p.15).
- *Environmental Impacts* can be measured and monitored with various indicators such global warming potential, eutrophication, virgin resource consumption and produced waste.
- *Environmental Benefits*, in turn, represent the positive environmental contributions of the BM as measured with the same environmental impact indicators. Since few human actions result in positive improvements on the environment, the authors emphasize these as relative savings or reductions.

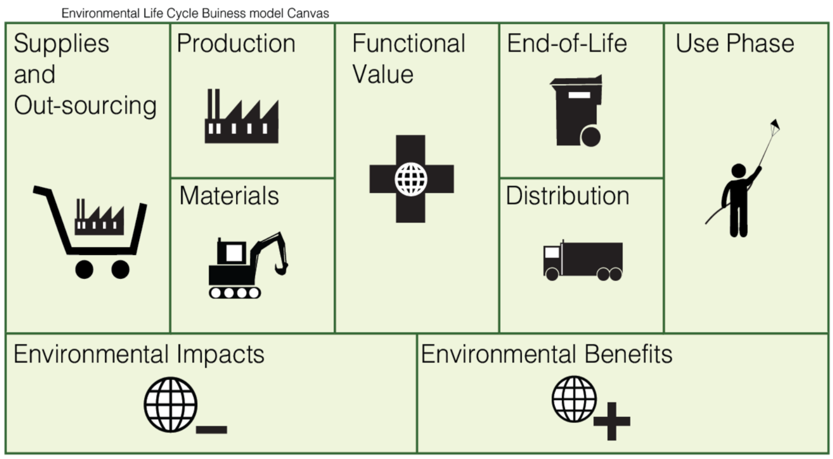

Figure 6. Environmental Life Cycle Business Model Canvas (Joyce & Paquin, 2016).

The social layer of the TLBMC is founded on a stakeholder approach that is an organizational management theory initiated by Feeman and Reed (1983) and further developed by Freeman (1984). Its priority is the maximization of the interests of all its stakeholders such as employees, community, customers, shareholders and suppliers (Freeman, 1984). Besides the variety of stakeholders, Joyce et al. (2015) integrate social impact indicators to the layer to analyze and measure the social sustainability. The included elements are employees, end-user, and local communities, governance, scale of outreach, social value, societal culture, social impacts and benefits (see Figure 7). The authors advice to consider the layer as more flexible in comparison to the other two, due to diversity of the stakeholder groups relevant and related to each organization.

- The authors define *Social Value* as representative of "how an organization has a purpose to provide a benefit for its stakeholders." (Joyce et al., 2015, p.19). Social value describes how the company contributes to making the world a better place.
- The *Employees* element involves human resource strategies and programs such as working conditions, social packages and initiatives for employees' personal growth in the given organization. These contribute to offering a positive and healthy environment for the workers.

- *Governance* captures the organization's structure, type of hierarchy and leadership approach that are aligned to accomplish its mission.
- The company locates in and has relationship with a *Community*, making it one of the stakeholders to be considered. This element further involves the suppliers and their communities.
- The *Societal Culture* captures the influence of an organization on society. It can involve promoting positive values such as diversity and integrity or negative ones such as inequality or irresponsibility.
- *Scale of Outreach* represents the depth of relationships the organization forms with its stakeholders. This depth can be observed in two main dimensions: time and space, but also in terms of psychological attachment or breaking ethical or cultural barriers.
- *End-User* consumes the value proposition and is not always the same person as the customer. The element describes "how the value proposition addresses the needs of the end-user and contributes to their quality of life." (Joyce et al., 2015, p. 20).
- *Social Impacts* are not easily identifiable or quantifiable. These can be determined by choosing or creating an indicator, depending on the given issue, e.g., fair competition, community engagement, and health and safety (Benoît-Norris et al., 2011).
- *Social Benefits* describe the improvements to the stakeholders' quality of life provided by the company, for example in terms of emotional state or perceived well-being.

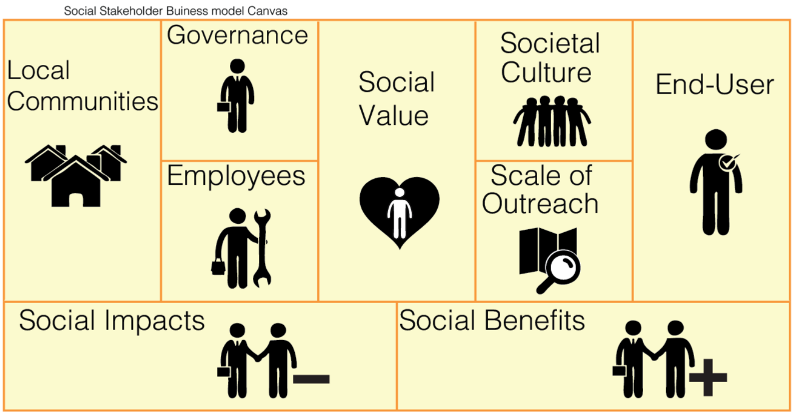

Figure 7. Social Stakeholder Business Model Canvas. (Joyce & Paquin, 2016).

2.6 Circular business model innovation for construction component reuse

The potential of material and construction component reuse to reduce buildings' embedded emissions has gained attention from actors in construction and real estate industry and beyond (Nußholz et al., 2020). Increasing number of products and services are being innovated in the European context to enable the reuse of construction components, and commercialized in new BMs (e.g., a:gain, Gamle Mursten, Madaster, New Horizon, Spolia Design, zupply) (Nußholz et al., 2020). Besides serving as a means to establish new BMs, BM innovation (BMI) involves modifying elements of an existing BM (Massa & Tucci, 2013; Zott & Amit, 2010), while lining up the "company's logic of doing business with reusing materials" (Nußholz & Whalen, 2019, p.2). Many authors stress the importance of BMI to business success (Chesbrough, 2010; Zott et al., 2011) with BMI and redesign considered as central to generate long term sustainable value (Stubbs & Cocklin, 2008; Lüdeke-Freund, 2010; Schaltegger et al., 2012).

While the conventional BM innovation (BMI) is defined as "designed, novel, nontrivial changes to the key elements of a firm's business model and/or the architecture linking these elements" (Foss & Saebi, 2018, p.201) circular BMI roots on the acknowledgement of resource deficit (Ritala et al., 2023). Thus, it seeks maximizing resource efficiency and effectiveness, while "ultimately closing energy and resource flows by changing the way economic value and the interpretation of products are approached" (Pieroni et al., 2019, p.201). In other words, CBMI plays a central role in fundamentally changing the way business is done to move beyond the dominating sustainability approaches that focus on productivity, efficiency and 'greening' the supply chain (Bakker et al., 2014) to the application of the circular economy (CE) principles and practices as guidelines in business model design (Pieroni et al., 2019).

CBMIs necessitate collaboration, coordination and communication within the complex networks of independent yet interdependent stakeholders (Antikainen & Valkokari, 2016). By offering a simple, flexible (Bigliardi & Filippelli, 2021), collaborative and visual way to define the composition of a BM (Pieroni et al., 2019), the BMC approach can be applied to CBMI (Bigliardi & Filippelli, 2021).

3 METHODOLOGY

In order to ensure that another researcher is able to conduct the study in a similar manner and attain similar results, this chapter presents the research methodology and its rationale on as detailed level as possible. It begins by introducing the context of the study, research design, and criteria used for case selection. Lastly, the methods of data collection and data analysis are presented.

3.1 Context: Helsinki region

For the past 30 years, large Finnish cities have kept growing in terms of population, while small rural municipalities have continued to decline (Huuhka & Lahdensivu, 2016). The national trend of urbanization follows closely the global megatrend (Ympäristöhallinnon verkkopalvelu, 2024). Helsinki Metropolitan area, or Helsinki region, covers 68% of the nation's population growth, including immigration (comparing 2021 to 2022) (Tilastokeskus, 2023). In 2025, 79% of the population in the region lived in the four cities – Espoo, Helsinki, Kauniainen (Kauniainen, n.d.) and Vantaa – that form the capital region (Helsingin Seudun Suunnat, 2025) (see Figure 8). While the region's current population is 1,61 million inhabitants, it is expected to grow up to 1,88 million by 2040 (STT, 2024). The growing population necessitates expanding building stock. Between 2015 and 2022, new building construction in the capital region ranged between 51 850 000 m^2 (in 2015) and 59 109 000 m^2 (in 2022), with an average of 55 397 000 m^2 completed living area produced per year. Residential construction holds the top position in Helsinki region with 63 % of all surface area constructed annually on average since 2015. Office construction comes as the second, with 7 % of all constructed surface area (Helsingin seudun avoimet tilastotietokannat, n.d).

The urban densification and land-use change rely largely on replacement of buildings (Thomsen & van der Flier, 2011). This involves demolition, of which the rate in Finland is among the highest in Europe (Thomsen & van der Flier, 2011), despite the housing stock being among the youngest (Hassler, 2009). By conducting a statistical and geographical study on demolished buildings between 2000 and 2012 in Finland, Huuhka and Lahdensivu (2016) found that the amount of demolition, the size of the community, its demographic development and construction activity are strongly interconnected. Namely, the "larger the city, the more it has gained population during the 2000's, the more has been built and the more has been demolished." (Huuhka & Lahdensivu, 2016, p.89). In 2023, over 6 700 buildings were demolished in Finland, many of them locating in Helsinki region or other growth centers (Samila & Tähtinen, 2024). The average lifespan of a demolished building is 50 years (Huuhka 2016; Huuhka & Lahdensivu, 2016), while office and industrial buildings reach less than 40 years on average (Huuhka & Lahdensivu, 2016; Ylitalo, 2021). While these buildings are

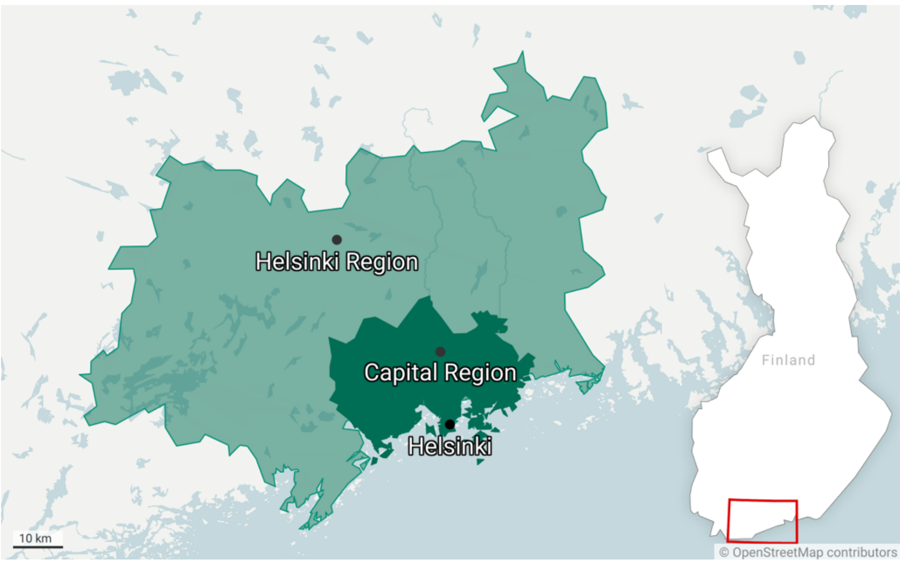

Figure 8. Illustration of the location of Helsinki region.

very rarely in such a poor condition that renovation is not worthwhile (Ylitalo, 2021), demolition is nevertheless often seen as the only alternative (Huuhka et al., 2021). Particularly in the inner cities demolition is seen as a means to release space for new, larger buildings (Huuhka & Lahdensivu, 2016; Huuhka & Kolkwitz, 2021). By demolishing buildings prior to the end of their designed service lives, several decades of lifespan is often left for the components at the demolition stage (Räsänen & Lahdensivu, 2023). Against the outlined background, Helsinki region offers countrywide the most potential and highest demand for studying the potential UMH BM to be created for enabling efficient matching of supply and demand of reusable construction components.

3.2 Research design

3.2.1 Descriptive embedded multiple case study

In line with the objective of the first SRQ, which is to investigate the novel phenomenon of UMH BMs, the first part of the study was conducted as a descriptive, embedded multiple-case study. Six UMH BMs were selected for the within-case analysis, as the aim was to study the BMs that the existing UMHs have adopted to enable matching supply and demand of reusable construction components. The BM elements (as presented in sections 2.4 and 2.5), in turn, served as the embedded units of analysis to be investigated (see section 3.5 for elaboration) (see Figure 9). Subsequently, a cross-case synthesis was conducted with the objective to induce information about how the different BM elements function as an entity to create, deliver and capture value. Thus, the case study was conducted from an inductive perspective. Furthermore, case study was the most suitable method as the boundaries between the UMH BMs and their spatial contexts are not clearly evident and multiple sources of data were used with the researcher

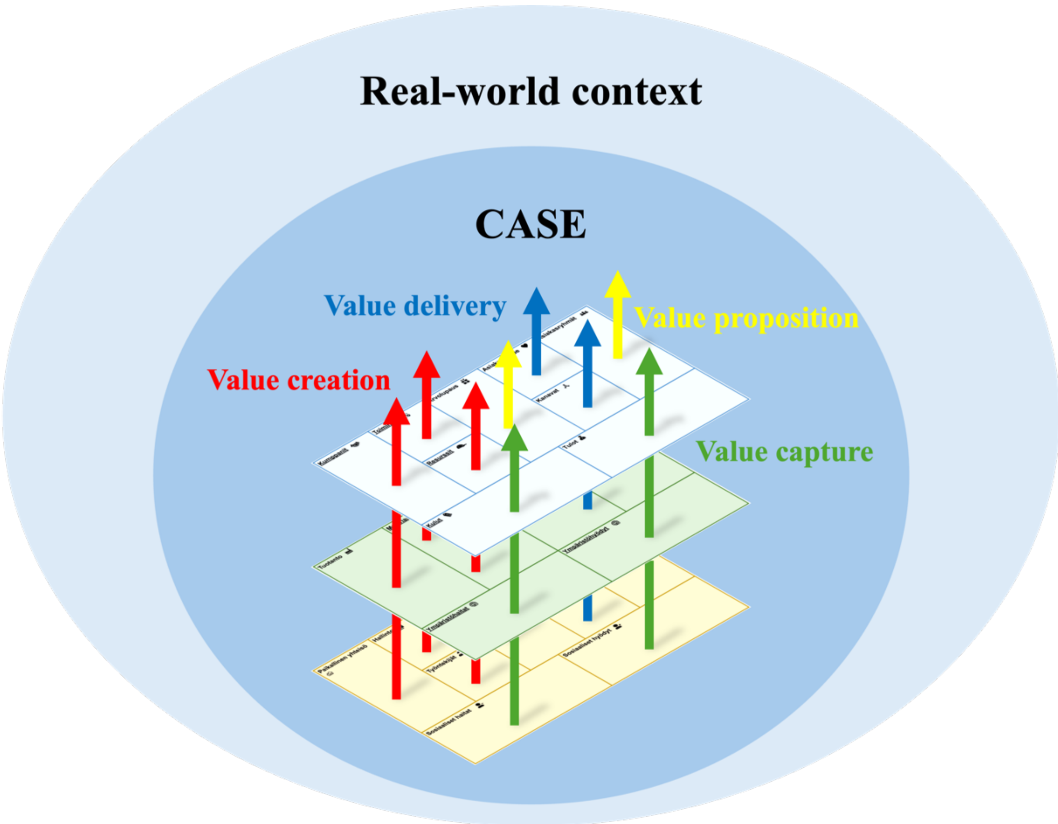

Figure 9. Illustration of the embedded multiple case study research design. The yellow arrows represent value proposition, while those in red refer to value creation. Blue arrows indicate value delivery and those in green value capture. Adapted from Joyce & Paquin (2016).

having no control over events. Lastly, the research design could be derived from the SRQ 1 as it deals with 'how' of the phenomenon (specifically, how the existing UMH BMs enable the reuse of construction components) and describe it in the phenomenon's real-world context. This is typical to descriptive case studies. (Yin, 2018)

This thesis adopted multiple case study approach for its capacity to produce reliable theory extension that is internally robust, accurate and coherent (Halkias et al., 2023). Through comparison and contrast of differences between the UMH BMs, the method allows making an original contribution to the emerging theoretical framework (Halkias et al., 2023). More specifically, the strength of multiple case study lies in its replication logic. In the context of this thesis, literal replication logic was applied to study cases that were selected for yielding similar results (Yin, 2018). This provides understanding of the main mechanisms that the UMHs deploy to enable matching supply and demand of reusable construction components (Yin, 2018).

3.2.2 Action research

The second, exploratory SRQ was studied by utilizing action research (AR) – a method that integrates both action and research (Coghlan & Shani, 2019). In the literature, it has been termed as an umbrella for its function as a gatherer of a variety of research approaches under one design (Dick et al., 2015). Within this study, co-creation with relevant stakeholders was used as an AR method. AR facilitates the twofold aim of, firstly, answering the exploratory question of what kind of an UMH BM should be developed for Helsinki region, and secondly, producing scientific knowledge through the documentation and analysis of the process outcome (Coghlan & Shani, 2019). Due to its focus on solving problems in practice, as well as on building on the past, taking place "in the present with a view to shaping the future" (Coghlan & Shani, 2019, p.4), AR was well-suited to be deployed on the co-creation of an UMH BM. Furthermore, the exploratory process supported the co-creation of knowledge needed for the generation of the BM (Arqyris et al., 1985; Denis & Lehoux, 2009; Coghlan & Shani, 2019).

3.3 Case selection

In order to select cases for the multiple case study, two sets of criteria were deployed to determine which cases are included or excluded. The first set of criteria arises from the definition of UMHs, presented in section 2.3 on UMHs. Accordingly, the selected cases must fulfil the following criteria:

1. They are focal points that possess physical and digital infrastructure.
2. They collect and redistribute construction components.
3. They focus on bulky and non-bulky construction components sourced from residential and office buildings, due to their often-standardized components and solutions.
4. They are capable of handling large volumes of components and materials.
5. They can temporarily store components.
6. Temporary storage can be arranged at vacant plots or demolition sites, while fixed warehouses can be established at existing ports, business parks or industrial estates.
7. Customers are, for example, building product resellers and construction contractors in large cities and regions.

The second set of criteria, presented in Table 3, were developed to further specify the kind of cases to be selected or excluded. The criteria are created to support answering the SRQ 1 and subsequently, the main RQ.

Table 3. Case selection criteria and justification.

Criteria	*Justification*
1 The cases locate in Northwestern Europe	As the main objective of this thesis is to develop an UMH BM for the *Helsinki region*, cases from similar socio-cultural and legislative contexts are selected for the multiple case study. Thus, the United Kingdom and Ireland were left out. No cases that suit the developed criteria were found in Iceland at the time of case selection during early winter 2024. The selected cases locate in capital regions and other large cities in Northwestern Europe. This allows transferring and application of the learnings from the multiple case study to the context of Helsinki region.
2 The cases are private companies	As the UMH that is to be established in Helsinki region is likely to be private, the organizations to be studied need to be privately owned and run. Private ownership can provide independence and continuity in the face of Finnish municipalities' cost-cutting agendas that pose uncertainty to funding. Similar internal conditions enable using the selected cases as input for the establishment of a novel UMH BM for the region.
3 The cases offer a variety of components	UMHs that provide a variety of construction components that are in-demand, were preferred over those that are specialized in specific types of products. Since the UMH in Helsinki region is likely to facilitate the reuse of several types of materials, the cases should provide input on how such UMHs handle the variety. The focus on variety results from the novelty of the reuse of construction components and very limited number of existing, specialized reuse actors.
4 The cases are established and effective actors in their ecosystems	In order to gain an understanding of how the UMHs that are seemingly effective at enabling the matching of supply and demand of reusable construction components operate, those considered as well-established in terms of their position in their respective ecosystems were preferred over those that were considered as less established. Due to the limited resources available for this study, the cases were, however, not examined in-depth prior to conducting the single case studies. Thus, there was no certainty of their actual position.

Based on the two sets of criteria, six cases were selected. While most of the cases were selected from different countries (one case per country), two cases are Netherlands-based, since reuse of construction components is a well-established practice there (Tsui et al., 2023). One UMH, located in Sweden, was approached by multiple means and persons, yet no response was obtained. The selected cases are

- Case A, Germany,
- Case B, the Netherlands,
- Case C, the Netherlands,
- Case D, Norway,
- Case E, Denmark,
- Case F, Belgium.

The studied cases were anonymized due to the provided sensitive information on their BMs.

3.4 Data collection

In accordance with the case study research design, the study "relies on multiple sources of evidence, with data needing to converge in a triangulating fashion." (Yin, 2018, p. 46). Three types of data collection methods are used to answer the main RQ. Both primary and secondary data are utilized. Figure 10 presents the methods of data collection and analysis that are utilized to answer each SRQ. It further shows how the results of the multiple case study, analyzed with qualitative content analysis, serve as input for the co-creation.

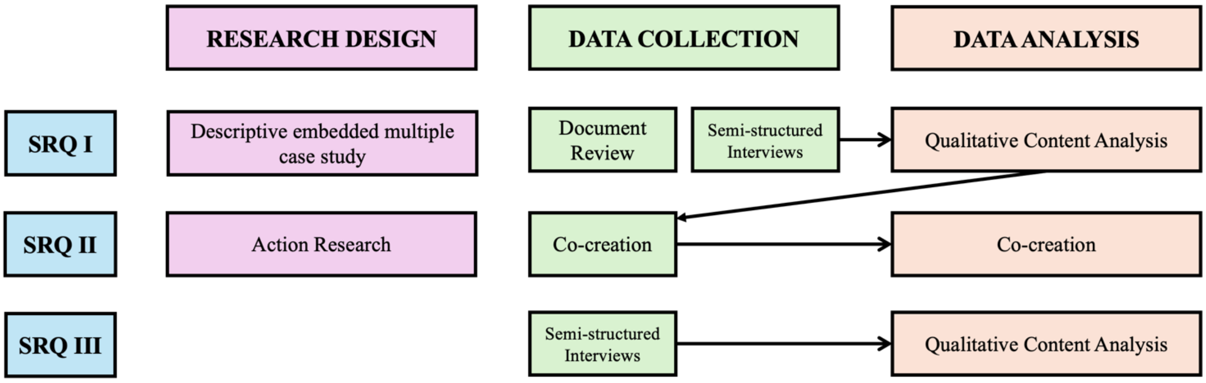

Figure 10. Illustration of the interlinkage between research design, methods of data collection and analysis.

3.4.1 Document review

A document review was conducted to identify information that is available on the cases selected for the multiple case study. Primarily grey literature, such as master's theses, interviews, newspaper articles and websites were found on the cases (the literature is listed in a separate appendix). The literature was sought with several keywords, both in English and native languages, using words that were observed to be used in the specific context. The texts that were found in native languages were translated into English using ChatGPT. The AI language model was used for its high accuracy and authenticity in provided translations as compared to other translation tools. Subsequently, the selected information and their references were transferred to a Microsoft Word document and categorized according to the three layers of TLBMC and the nine elements of each layer. An initial analysis was conducted on the extracted data to identify missing information that should be derived through the following interviews.

3.4.2 Semi-structured interviews

Two sets of interviews were conducted, one for answering the SRQ 1 and the other for answering the SRQ 3. In order to ensure a sufficient amount and quality of data for the SRQ 1, the information gained from document review was completed with six semi-structured interviews. The data for SRQ 3 was collected solely from semi-structured interviews. The method allows addressing a number of predetermined questions and topics (Berg, 2009), while providing flexibility to ask follow-up questions and move beyond the standardized ones (Berg, 2009; Bryman, 2012). In so doing, it enables structuring the interviews according to the theoretical framework, while simultaneously diving deeper into a topic that is deemed as particularly relevant for the investigated cases (Kumar, 2018). Thereby semi-structured interviews can provide more detailed and nuanced information (Shearer, 2021).

In order to answer the SRQ 1, one interview on each case was conducted with those responsible for managing the operations at the selected UMHs. The interviewees were found through personal contacts of a CECP representative and by emailing the organizations' managers considered as most suitable for the role. They are listed in the separate Appendix. In order to ensure consistency across the interviews, a general interview protocol (Appendix B) was drafted, providing a common basis for all interviews. The protocol consists of three parts, namely, introducing questions, main interview questions and final remarks. It begins with a brief introduction of the researcher, the research and interview objectives, followed by ensuring that the interviewee agrees with recording the interview. A letter of consent was sent to each respondent to be filled out in advance. A couple of introducing questions were posed to open the interview. The second section involved the actual interview questions that were adapted for each case based on the information retrieved from the document analysis. The section was divided into four parts, each addressing one of the four value dimensions. So doing, the interviews aimed to acquire information about what kind of value propositions each case possesses and how they create, deliver and capture value, thereby matching the supply and demand of reusable construction components. The questions for the economic layer were adapted from the original BMC, that proposes 2-6 questions per each element (Osterwalder & Pigneur, 2010). These partly overlap, thus some of those similar were either deleted or modified in a manner that distinguishes them. The authors of the TLBMC do not present similar guiding questions. Therefore, questions were created in line with the characterizations of the environmental and social elements, as presented by the creators of TLBMC (Joyce & Paquin, 2016). As the time limit for each interview was set to 45 minutes, questions related to the economic layer were prioritized over those on environmental and social layers. This lies on its perceived relevance for the private sector perspective, as well as the uncertainty considering and interest in, for example, the UMHs ability to capture economic value. The questions were formed in a manner that avoids steering the respondents in any specific direction. The third part of the protocol involved closing remarks and clarification of the next steps.

The interviews were limited to 45 minutes and communicated to the potential interviewees in the sent email invitation to increase the likelihood of positive response. With two of the interviewees the interviews took significantly longer (54 mins to 65 mins) as they gave more detailed information and expressed the willingness to continue over the limited timeframe. One of the interviewees was interviewed twice, as the opportunity came up to interview the expert on two occasions. Thus, questions that were left unanswered during the first interview, were asked during the second interview. Since the interviewees located in different countries, the interviews were conducted as a video meeting on Teams, with one exception taking place on phone. The Teams' transcription tool was used to transcribe the interviews, while the interview conducted on phone was transcribed with an AI based transcription tool WhisperAI. Subsequently, the transcriptions were scrutinised to ensure they match the audio recording.

In order to answer the SRQ 3, two semi-structured interviews were conducted with relevant regional actors, one representing the public sector perspective and another the private sector (the separate Appendix lists the interviewees). Both actors were presented the same three questions on barriers, enablers and the role of public actors in enabling the UMH BM implementation (Appendix G presents the questions). The two actors were selected for their comprehensive overview of the field and experience on projects where reuse of construction components has been undertaken. The two perspectives were further selected for their complementary roles in the industry and in realizing reuse of construction components in particular. While the interview with two public sector representatives took place via a Teams meeting, the private sector representative's responses were received with an email. The interview on Teams took 40 minutes, it was transcribed with the Teams' tool and inspected for validity. As the interviews were conducted in Finnish, they were subsequently translated in English with ChatGPT.

3.4.3 Co-creation

As the second method of primary data collection, a co-creation workshop with eight industry related stakeholders, was conducted to answer the SRQ 2. In general, co-creation refers to two distinct processes, those of design and business value creation, both of which are "characterized by facilitated participation in orchestrated multi-stakeholder engagements" (Jones, 2018, p. 3). In the context of this thesis, it is considered as a design approach, defined as "the collaborative, generative creative participation of individuals in design-led workshops and group practices." (Jones, 2018, p.10). It originates from the practices of creative problem solving and structured brainstorming sessions and has developed individually within each of the fields in which it is applied – business, design, and systems engineering (Guntveit et al., 2020). Co-creation involves a broad range of participatory methodologies, such as facilitation, creative organizing, generative co-design and dialogics, to be deployed among different stakeholder populations (Jones, 2018). It is deemed as a suitable method of data collection and analysis, as it offers an effective means to extract and integrate several industry stakeholders' knowledge and perspectives (Kjørstad et al., 2019; Guntveit et al., 2020) into an UMH BM. It is pivotal for business success that the key stakeholders' ideas, needs and solutions are captured in the BM development, to ensure that the UMH corresponds to those. Consequently, this mitigates the UMH's execution uncertainty as it increases the likelihood that it will be used by the industry actors (Jones, 2018).

3.4.3.1 Design of the co-creation workshop

The starting point for the design of the co-creation workshop is the economic layer of the TLBMC, namely, the BMC (as presented in section 2.3). The BMC was used as a tool to capture knowledge, ideas and insights shared by the stakeholders, thereby innovating a new BM for the regional UMH (Osterwalder & Pigneur, 2010). It is particularly useful to be used among groups, due to its hands-on nature that facilitates increased understanding, designing, analysis and discussion (Hope, 2018). Furthermore, it is widely known among the business development and management experts and hence, potentially familiar to some of the co-creation participants. Due to the limited time available for the workshop, the economic layer was given priority for its importance in the context of a private, commercial organization. Moreover, the current public interest considers mainly economic aspects, providing a justification for the focus. Prior to the workshop, the participants received the workshop agenda and schedule as well as a link to a YouTube video explaining the idea of the economic BMC.

The co-creation workshop was arranged as a one-off session of 210 minutes with two breaks in between. The event took place at a venue of the City of Helsinki, provided by the CECP. It offered a "neutral" ground for the multi-stakeholder workshop (Jones, 2018) and served to motivate action, assist collaboration, as well as offered equipment required to complete the work (Nicolini et al., 2012). In order to ensure as professional facilitation as possible, in the face of the limited facilitation experience of the author, the co-creation event was carefully planned under the supervision of the thesis and CECP supervisors. While the author served as the main facilitator, some support was received from the CECP representatives.

The workshop was structured in three main phases. It begun by the author sharing selected insights derived from the analysis of the economic BMC on the selected UMH BMs. The results were presented on the level of the BM elements, instead of that of the value dimensions, as stakeholder input was sought on the element level. Only the subsequent analysis conducted by the author took place on the level of the value dimensions. Results on selected elements (activities, resources, suppliers and costs) were presented, as these were discovered to be similar across the UMHs involved in the multiple case study. Thus, it was assumed that the stakeholder responses would approximate the identified factors regardless of whether they learned about it in advance or not. Results on the other elements were not presented as the participants' original knowledge and ideas were more relevant regarding them.

In the second step, the participants were asked to formulate answers to questions that each BM element posed. The questions are presented in Appendix D. The stakeholders were guided to answer them from their own industry perspectives, whether as manufacturers, subcontractors, public clients or demolition contractors, in relation to the potential UMH BM in Helsinki region. They were asked to put forward ideas and information on what they as partners, customers or representatives of other roles, would need from or want the UMH to offer or how it should operate in relation to them. For answering questions, the participants were offered post-its and pencils. The questions were developed to support the participants in the generation of knowledge and ideas. Similar to the case study interview questions, they were adapted from those posed by the original BMC (Osterwalder and Pigneur, 2010). The questions were iterated and revised following a review by the CECP representatives, to ensure they are easily understandable, concise, and consistent. The element on customer relationship was excluded in an agreement with the CECP representatives as it was considered as not as relevant as the others and to increase focus on the others.

In the third phase, the participants were asked to present their ideas and knowledge. By focusing on one element at a time, the shared insights were discussed and new ideas emerged (Lee et al., 2018). The participants placed the post-its on a printed A1-sized BMC that was photographed for the subsequent analysis (see separate Appendix).

3.4.3.2 Stakeholder selection for co-creation

Stakeholders to be invited for the co-creation were identified and selected in an iterative, three-step process. Stakeholders are considered as actors that have, or claim, ownership, rights, or interests in a decision-making process (Brugha and Varvasovsky, 2000), which in this case is the co-creation of an UMH BM for the Helsinki region. These actors are also those on which a significant portion of project risks, viability and support that needs to be obtained for the project, depend (Smith, 2000). The stakeholder identification begun by composing criteria for participant selection. Here, the results of the analysis on the semi-structured interviews as well as the purpose of the co-creation session served as the guidelines. The criteria are presented in the Table 4.

Table 4. Criteria for the initial selection of the co-creation participants.

Criteria	*Justification*
1. Construction and real estate industry actors	Analysis on the interviews conducted for the multiple case study indicated eight types of construction and real estate industry actors as most relevant for the UMH operations. These are UMH operators, demolition contractors, cities and municipalities, manufacturers, property owners, real estate developers, construction companies and architects. As many of these stakeholders as possible, should be present at the co-creation workshop.
2. Knowledge and/or experience of reuse of construction components	The participants should have at least some experience or understanding of reuse of construction components to be able to contribute to the co-creation. The process of reuse and the requirements it poses on the BM are very different from newly produced components, hence prior knowledge is needed.

3. Locate or operate in Helsinki region	The participants should locate or operate in Helsinki region.

In the second step, potential stakeholders that meet the criteria were categorized according to their stakeholder groups (e.g., property owner, manufacturer, reuse actor). The list was completed by recommendations from selected regional experts, such as the CECP. While the method contains the risk of biased sample, caused by the social networks of the individuals (Reed et al., 2009), the risk is mitigated by the small circles of experts and actors that have knowledge of and are interested in the reuse of construction components in Helsinki region. This lies on the limited awareness of the industry actors and the niche topic that reuse still is. Furthermore, those that hold knowledge of and are actively involved, are well-known by the inquired actors. Lastly, final selection was made, with eight participants set as the maximum. This was done to ensure that the extent of discussions and the number of varying perspectives stay manageable. The facilitator's lack of experience further influenced this. The representatives of the CECP led in making the final selection of the suitable actors for their role as key knowledge holders in Helsinki region. Thus, the participant selection is therefore based on well-established criteria and the knowledge of key knowledge holders.

Nearly all the invited were able to make it to the session. Two withdrew their participation shortly before the session, yet eight contributed. The participating stakeholders represented a range of actors: municipal zoning specialist, consultant, demolition contractor, manufacturer, retailer and subcontractor. While most of the organizations sent one representative, two representatives participated from two organizations. A separate appendix presents the participants and the organizations they represent.

3.5 Data analysis

Qualitative content analysis is applied to answer the first and third SRQs. More specifically, it is utilized to "systemically describ[e] the meaning of qualitative data" (Schreier, 2014, p.170) "for the purpose of discovering underlying meanings and patterns of relationships" (Babbie, 2013, p. 390). Qualitative content analysis is particularly suitable for analyzing the collected data as it helps to reduce its amount by supporting the researcher to focus on selected aspects, is highly systematic in examining the material at hand, and provides flexibility in developing the coding scheme (Schreier, 2014).

The coding scheme was developed using concept driven coding. The codes for analysing SRQ 1 were deducted from the TLBMC that serves as the analytical framework. Here, each of the nine aspects on the three layers of sustainability, is operationalized into a code. In total 13 codes were applied on the interview transcriptions (Appendix C). The software ATLAS.ti was used to assign the data to the categories of the developed scheme. While the deductively developed coding categories were applied to the materials in coding, it was simultaneously observed if relevant categories emerge (Mayring, 2014). Yet, no codes were derived inductively. The coding procedure was undertaken by the author and no additional software was used in doing so, since human interpretation can be considered as more precise, understanding the complexities related to the issue (Halkias et al., 2022). A second coding round was not conducted due to the limited scope and time available for the thesis. The data collected for analyzing the SRQ 3 was arranged according to the barriers, enablers and the role of public sector actors that were applied as codes (Appendix G). As the amount of collected data was few, no software was used for assigning the codes.

A comprehensive, two-phase data analysis was conducted to answer the SRQ 1. Firstly, a within-case analysis of each individual case was undertaken, utilizing data from the document review and semi-structured interviews. The key insights were arranged in tables, according to the elements of the

TLBMC. These were used as a basis for the subsequent cross-case synthesis, to produce generalizations of the results (Yin, 2018).

Co-creation further covered analysis of the collected data for the SRQ 2. The process inextricably links data collection and data analysis, in that the data analysis takes place already in the phase of data collection. This lies in the nature of AR, that involves participants producing and simultaneously evaluating information (Coghlan & Shani, 2009). As from two organizations, two representatives participated in the co-creation instead of one, the propositions presented by the two participants were not distinguished in the analysis but presented as a single perspective of the represented organization. The session recording was transcribed and the created BMC complemented with relevant information. As the data was collected (and analyzed) according to the BMC, they served as direct input for presenting results, as no additional coding was necessary.

3.6 Research evaluation criteria

Several threats to validity and reliability can emerge from the selected research design. Multiple actions were taken to counteract these as well as to ensure high research and output quality. In the following, those on external, measurement, and ecological validity as well as reliability are presented. These are considered as relevant with regard to the research design. Section 6.4 evaluates to what extent the study met the quality criteria.

Given the unique nature of the overall research objective, generalization of the results of the main RQ beyond the context of Helsinki region, is not attempted. However, in answering the first SRQ, the multiple case study involves six cases and a cross-case synthesis, strengthening the *external validity* of the findings in comparison to a single case (Merriam & Tisdell, 2016). In order to select cases that are both replicable and of which the synthesis produces externally valid findings, criteria for case selection were formulated and presented (see section 3.3) (Merriam & Tisdell, 2016). With the limited resources available, this thesis further produced as detailed documentation and thick description as possible, of the case settings, boundaries and outcomes to enable their replication by other researchers (Marshall & Rossman, 2014; Yin, 2018).

In general, the analysis of BMs can be ambiguous, context-dependent endeavour as a variety of definitions exist for them (e.g., Osterwalder et al., 2005; Zott et al., 2011; Jensen, 2013). The major measure taken in this study to eliminate this threat is using the widely acknowledged and applied theoretical framework of TLBMC (Joyce & Paquin, 2016), that is initially established on the globally known BMC (Osterwalder & Pigneur, 2010). The TLBMC was applied as an analytical framework to answer the SRQs 1 and 2. It offers established and defined concepts for measurement, thus strengthening the *construct validity* (Bryman, 2012).

Ecological validity stems from the applicability of the social scientific findings to people's everyday social settings (Bryman, 2012). Here a major threat to this type of validity is that in answering the SRQ 2, the stakeholders participating in the co-creation session might not express their sincere ideas and opinions due to the social pressure posed by participants from other organizations. Especially when participants from same branch are present, ideas might not be put on the table. This can result from, for example, one being afraid that another steals the idea or from being afraid of the reaction of the others. Here sampling of stakeholders played a crucial role in ensuring that only one representative from each branch is present at the workshop. During the session itself, an attempt was made to create empathetic environment. It was further highlighted that the participants should not share the discussions afterwards. In this manner it was ensured that the participants feel free and encouraged to express their thoughts.

External reliability in qualitative studies can be threatened by poor documentation of procedures undertaken in research (Bryman, 2012; Yin, 2018). This, in turn, can make it impossible to repeat it (Bryman, 2012; Yin, 2018). Further challenges to external validity are posed by the nature of the studied phenomenon, namely, the UMH BMs are a quickly evolving, context-dependent phenomena that can yield diverging results in future replications. Secondly, the results are interpreted from the single subjective perspective of the researcher (Bryman, 2012). Thirdly, data collection methods of semi-structured interviews, co-creation and document review offer flexibility that can hinder replication. In order to encounter these challenges, two measures are undertaken. Firstly, a case study database was developed, as proposed by Yin (2018). This involved organizing and documenting all the collected data, including the notes of the researcher, in a database separate from the original research report (Yin, 2018). This enables a secondary analysis of the data, conducted independently from the initial analysis (Yin, 2018). Secondly, the relevant steps, such as coding scheme (Appendix C), grey literature included in the document analysis (Appendix A) and single case studies (in separate appendix) are presented in the appendices.

4 RESULTS

4.1 SRQ1. How urban mining hub business models enable matching supply and demand of reusable construction components

This section presents the findings that were derived from the cross-case synthesis of the six single case studies (presented in a separate appendix). It investigated how the existing UMH BMs enable matching of supply and demand of reusable construction components in the selected Northwestern European cities. As the data was collected during the first quarter of 2024, the results describe how the UMH BMs enabled matching of supply and demand at that particular point in time. The analysis was conducted by applying the theoretical framework of TLBMC, in connection with the four value dimensions. Hence, the BMs were analysed through the three layers of sustainability, namely, economic, environmental and social as well as the value proposition, value creation, value delivery and value capture.

As revealed by the single case studies, the selected UMHs vary notably. In terms of organizational type, they can be roughly divided into three categories: private for-profit companies, private non-profit companies and organizations of private companies with a permanent project status. The organizations represent two different branches, namely, retailers and demolition companies. Besides, the organizations vary regarding the year of establishment from 1996 to 2023. Considering annual turnover, they vary from estimated 200 000 € to 15 million € (considering those cases where the information was available) and number of employees, from five to 20. Furthermore, two of the companies had a pilot project status when data was collected. Despite the aforementioned differences, the theoretical framework of TLBMC fostered comparability and cross-case synthesis.

4.1.1 Economic business model canvas

4.1.1.1 Value Proposition

The results on how the UMHs value propositions contribute to matching supply and demand of reusable construction components, are presented categorized into two sections: customer segments and value proposition. Regarding *customer segments,* a majority of the studied UMHs stated they prefer catering to large customers' needs and reported having received inquiries from major public and private organizations for reusable construction components. However, it was observed that the actual customer organizations greatly varied across the studied cases in terms of their type. The variance of customer types within individual UMHs was lower. This stems from the tendency of individual UMHs to cater either major commercial organizations, such as retailers, manufacturers, developers or architecture offices (Case A, Case B, Case C) or small renovation contractors, other small companies and private households (Case C, Case E, Case D and Case F). The latter group thus tended to serve directly the end-users of the components, whereas those former served customer segments, whose clients are the end-users. Regarding services, the customers represented mainly public and private real estate owners, contractors and architecture offices.

Considering the value proposition, significant within-case variation in the types of reusable construction components offered in their webstores, was observed. However, cross-case variation was little, as the cases offered corresponding categories of components. The types of components all the UMHs offered were non-structural elements (e.g., doors, windows, bricks, façade products), internal space elements (e.g., carpet tiles, false ceilings, glass partition elements), and furniture (e.g., kitchen cabinets, lightning elements, sinks, chairs). Nearly all of the cases further offered services elements (i.e., HVAC and electrical elements), with the exception of Case C. Only cases C and D offered structural elements (e.g., concrete elements, steel profiles, glulam timber), while Case B was observed as the only one to provide its manufacturing customers secondary raw materials (e.g., concrete, bricks, gypsum, bitumen). Across the studied UMHs, a great deal of the offered components can be described as so-called low-hanging fruits. These are oftentimes modular in nature, thus easy to deconstruct and reinstall, and require relatively little refurbishment if at all. Therefore, they can be less expensive to process, while not necessarily bearing the greatest environmental benefits, for example, when compared to the structural elements (e.g., steel and concrete).

The UMHs provided a variety of services, with the exception of Case C that was solely focussed on supplying components. The services were designed to create and facilitate matching supply and demand of components the UMHs provide or to benefit reuse of components in general. In so doing, the UMHs aimed to serve the customers, particularly professionals, that pose a variety of needs and requirements for services (Case F). Overall, the UMHs offered three types of services. The first type sought to create supply of reusable construction components, through purchasing components (Case E, Case F), accepting donations (Case D), selling on commission (Case D, Case F) and scouting of components (Case E). The second type of services tailor the components to suit the customers' needs (e.g., Case E produces timber products and upcycling of materials on commission, while Case F cleans ceramic tiles and rewires lamps on commission). Thirdly, two cases offered interim storage to allow the clients to store components until they can be delivered to a project site (Case A, Case D). Case B took a broader, interconnected approach by offering services that seek to create and coordinate the matching of supply (e.g., construction component availability mapping) and demand (e.g., architecture services).

All the studied UMHs had designed their value propositions to offer customers and the clients of their customers alternatives, that enable construction with lower environmental and CO2 footprints. The clients were, in turn, observed to possess a variety of motivations for purchasing reusable components. These included, most notably, compliance with regulation and achieving sustainability certificates through or otherwise being motivated to reduce environmental and CO2 footprints of construction (cases A, B, D). Furthermore, lower prices of reusable components as compared to those produced from virgin materials (cases A, D) and high or good quality (cases A, C, D, F) were deemed as important motivators. In some cases, the quality of reusable components was deemed to be even better than others on the market (Case D). Additionally, the looks of the reusable components (Cases A, E, F) as well as embedded cultural heritage and historical value (Cases E, F) were highlighted as qualities the customers seek. Availability was considered as a further benefit, with Case A emphasizing that they are oftentimes faster in delivering components, than the conventional manufacturers and retailers.

4.1.1.2 Value Creation

In order to create value and thus enable the matching of supply and demand of reusable construction components, the UMHs drew on a variety of *activities*, *resources*, *suppliers* and *partners* in the process. Results of the cross-case synthesis on activities, resources and suppliers indicated how the UMHs can be categorized into two distinct types of value creation processes. While five of the cases fall either into one or the other, one has features of both.

The first type of process was utilized by cases A, B and C that seek to acquire components from real estate owners that commission demolition and the assessment of the construction components in their properties. A common character shared by the three cases was the aim to streamline the value chain by supplying the components, where possible, directly from the deconstruction site to the purchaser, without storing them in between (see Figure 11). A further shared attribute was that only those reusable components that have been sold are deconstructed intact. Case C, however, made a partial exception in that it obtains some reusable components it considers as sufficiently valuable and in-demand, and delivers those to its warehouse prior to knowing whether they will be purchased. The three cases differed in the specific ways in which they match the supply of components to the existing demand. Case A relied on its digital platform. This automatically matches the reusable construction components, added on the platform during an inventory, to demand posed by the registered customers. Case B, in turn, capitalized on the customer relationships it had established with major manufacturers and retailers, and reinforced through contracts. These enabled the UMH to supply the components directly to customers. Another way it matches the supply and demand is through its services that are specifically designed to create supply and demand as well as to connect them. Case C, in turn, repeatedly contacted its established customers with the information of reusable components that it obtains from demolition projects it is commissioned to undertake. Despite the shared objective of minimizing the amount of activities and resources invested in the components, the three cases nevertheless possessed warehouses. Namely, Case A used the warehouse to store components, purchased by customers, against a fee. Cases B and C, in turn, used their warehouses as production halls and to store components, both those that have been purchased (case B and C) and those that await this (Case C).

Cases D, E and F relied on the second type of value chain, the warehouse value chain (see Figure 12). Case C, in turn, sold a minority of its components in this manner. Demolition companies served as the key providers of reusable construction components. Case E further received proposals from a variety of actors on reusable construction components offered for the UMH to purchase them. Prior to selecting components in their offer, their quality, value and whether they meet the current trends and demand, were scrutinized closely by the UMHs. Warehouse and webstore served as central elements in this type of value chain, enabling the matching of supply and demand. Namely, the reusable components are received and stored at the warehouse prior to or while they are marketed online and on webstores. While all the three UMHs offered their customers the possibility to purchase components online, Cases E and F further provided customers the opportunity to visit their physical shops that locate in connection with the warehouse. Besides storing components that await to be purchased, the warehouses involved workshop spaces for refurbishing and upcycling products (Case E, Case F).

The partners the UMHs rely on, varied greatly from architecture offices to demolition and waste management companies. In particular, partnerships were used to provide services in a collaborative manner (cases A, B, D), to increase the amount of sourced components (cases D, F), as well as to create novel products and processes that facilitate intact deconstruction of components and reuse of the materials and components (cases B, C).

4.1.1.3 Value Delivery

The findings on the types of *customer relationships* and *channels* the UMHs employ to enable matching the supply and demand of reusable construction components, aligned with those on value creation. Specifically, the insights on customer relationships and channels further link with the two main value chain types identified on value creation. Regarding the first type of value chain that seeks to streamline matching supply and demand, it was found that cases A, B and C seek to build and strengthen relationships with their main customer segments (retailers, manufacturers, developers and architects) (see Figure 11). Here, the main motivations occurred to be, firstly, the reliable demand of reusable construction components that these established customer relationships offer. Secondly, they result in lesser need to invest in the digital and physical infrastructure needed for major warehouse operations. The three UMHs, however, differed in the degree to which they have founded the matching of supply and demand on established relationships. Case B, most notably, solely relied on customer relationships it had established and consolidated in a collective. Similarly, Case A mainly relied on established customers, as it matches most of the supply and demand through its software. Case C, in turn, relied with 70% of the total of sold reusable construction components, on established customer relationships that are utilized to contact the customers to inquire them for potential interest for available components. The remaining 30% was sold to varying customers. All the three UMHs further made the reusable construction components available for purchase or inquiry. While cases B and C offered the possibility to inquire about the components on their websites, Case A possessed an actual webstore, through which commercial customers could purchase components. Case C, in turn, utilized existing digital marketplaces that enable the exchange of reusable construction components. None of the three UMHs possessed physical shops. Case C occasionally used its warehouse as a showroom to invite potential customers and partners to experience the quality of the materials themselves. In reaching out to their potential customers to establish relationships in the first place, the UMHs employed personal contacting on the managerial level.

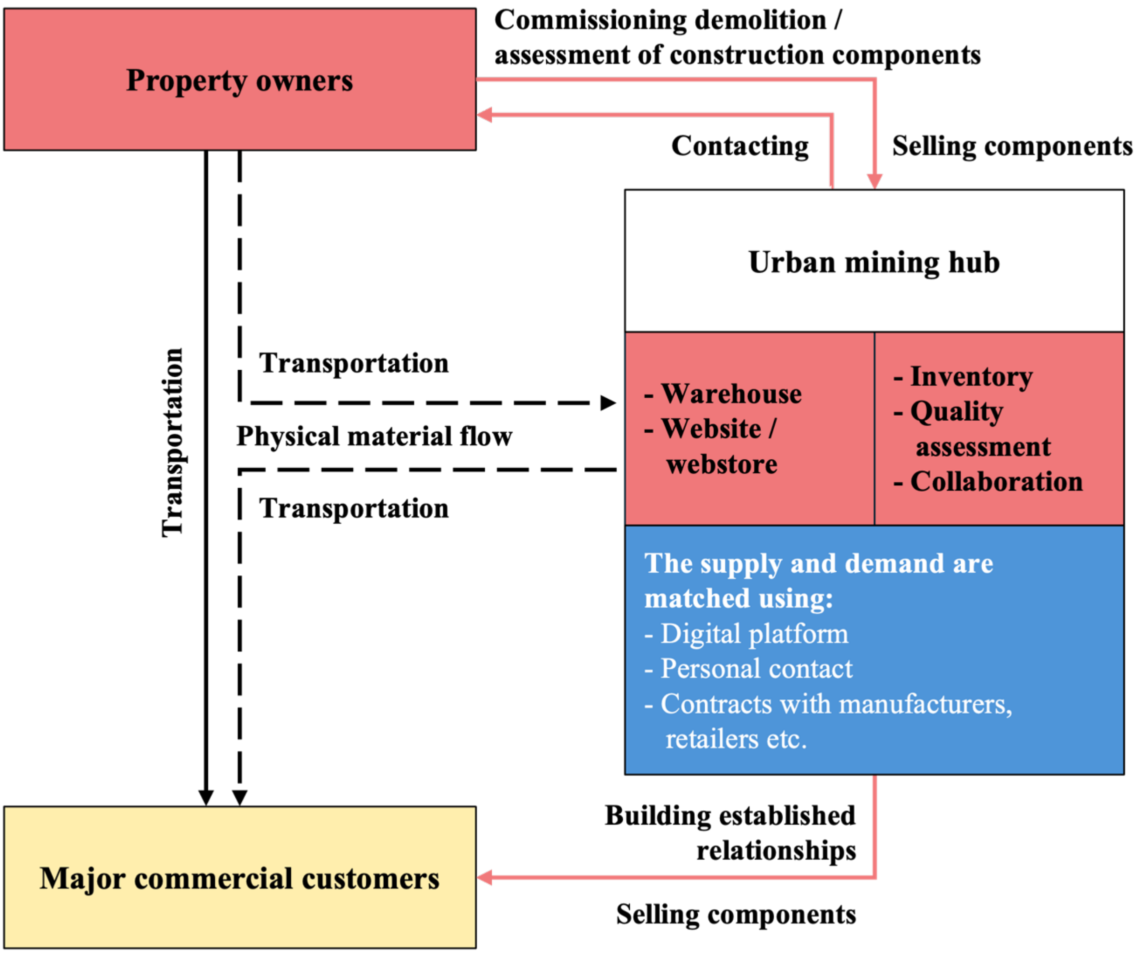

Figure 11. Streamlined value chain. The BM elements that comprise value creation (i.e., activities, resources and suppliers) are presented in red, while yellow denotes customers (color refers to the value proposition) and blue denotes channels (color refers to the value delivery). Black arrows illustrate material flows, while red arrows denote activities undertaken by the stakeholders, most notably, the UMH operator.

The distinction further applied to the second type of value chain with warehouse as its central element. It was observed that the cases D, E and F, rely on non-established or occasional customer relationships. This results from the purchasing behaviour of the UMHs' customer segments, namely the small renovation contractors, small companies and individual households tend to purchase components in small quantities and for few or one-off projects. In order to enable matching supply and demand of reusable construction components, digital and physical infrastructure were provided. Specifically, the UMHs offered their customers the opportunity to purchase components online via their webstores, while cases E and F further invited clients to visit their physical shops (see Figure 12). Case D only allowed its customers to visit the warehouse on appointment, to pick up the purchased products. In order to reach out to their potential customers to inform these about the value proposition, all the three UMHs employed similar digital channels, in corresponding manners. Namely, they regularly updated their webstores and posted on Instagram to market the newest reusable construction components in their offer. In their webstores, the components played a central role, with several pictures presented and detailed information given about relevant aspects.

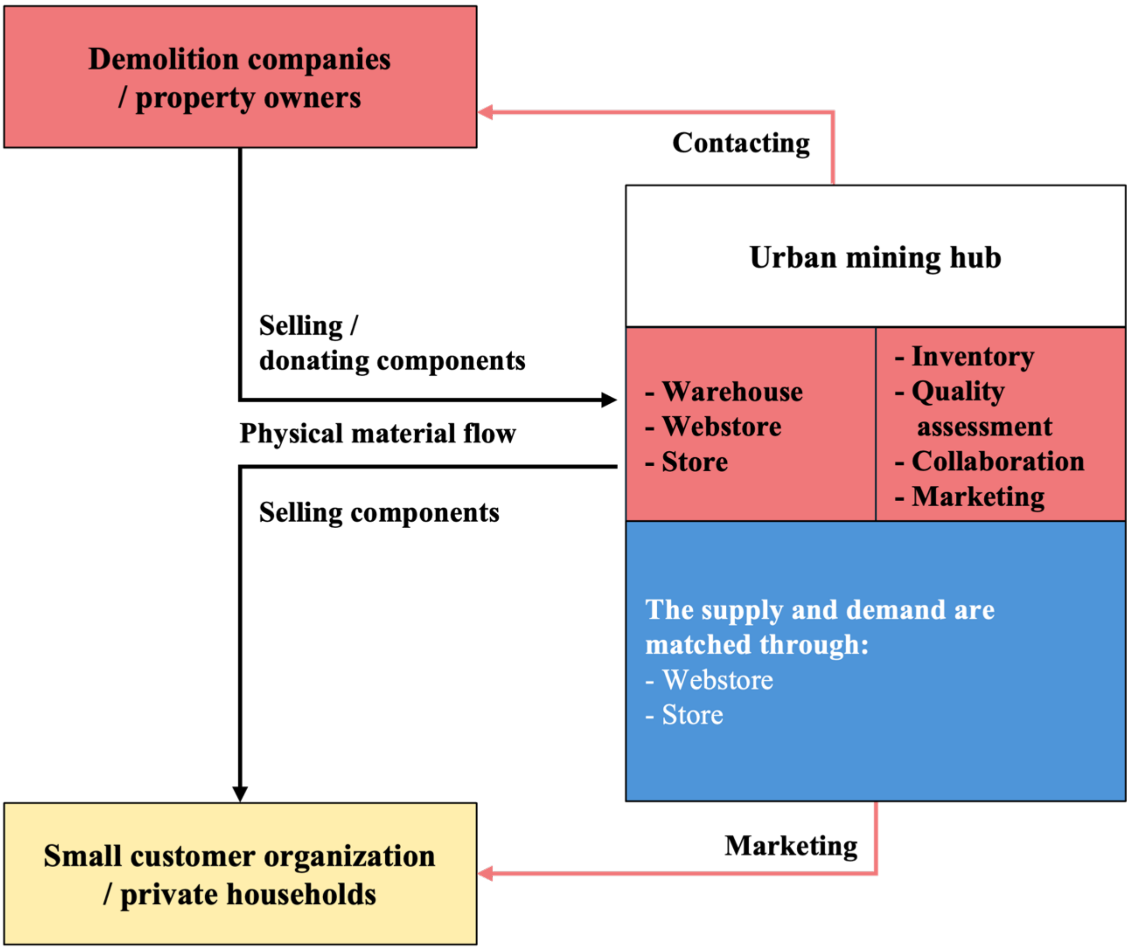

Figure 12. Warehouse value chain. The BM elements that comprise value creation (i.e., activities, resources and suppliers) are presented in red, while yellow denotes customers (color refers to the value proposition) and blue channels (color refers to the value delivery). Black arrows illustrate material flows, while red arrows denote activities undertaken by the UMH operator.

Shared findings across the six cases were identified regarding their marketing channels. Namely, all of the companies employ three key channels in corresponding ways. Firstly, each of them possessed a website or a webstore on which they informed those interested about their value propositions and operations. All of the cases further shared their motives for operating in a manner that deviates from the usual means of demolition and construction component value chain. Secondly, all six cases utilized one or more social media platforms for reaching out to their (potential) customers and informing them about their value propositions and operations. All of the companies possessed a LinkedIn company profile on which they shared about their value propositions, projects they have been involved in, success stories about implementing reusable construction components in projects, as well as collaborations with other companies and organizations. Thirdly, all of the companies, with the exception of Case E, reported that they, or an organization closely related to them, receive opportunities to speak about and present their approach at (industry) events, to networks and to the media.

4.1.1.4 Value Capture

The main sources of costs and key mechanisms of value capture were similar across most of the UMHs. In essence, the costs consisted of employee wages and land lease, whereas the means of value capture were mainly the sale of reusable construction components and sale of services. Despite these similarities, the extent to which the UMHs were capable of capturing value, varied significantly across the cases. In the following, the UMHs are categorized into three groups, based on their perceived ability to capture value. Regarding cases A and C, it is not attempted to assess their ability to capture value, as they are BMs of companies that possess other BMs. Disentangling what other BM factors might have affected the economic viability of the UMH BM was not sought due to its perceived complexity. However, the interviewed managers stated that the revenues generated by the operations at the UMHs' warehouses, do not cover their costs. The warehouse operations were nevertheless considered as sufficiently important to be kept, facilitating the overall operations of matching the supply and demand of reusable construction components.

The synthesis indicated that the UMH that is able to capture the most value is Case B. This ability results from its two core means of value capture, namely, the sale of demolition services and sale of deconstructed components and materials. Additional sources of revenue are generated by the services that Case B offers to map potential supply of components and materials, and to design with the available supply. By commanding the four roles of a demolition company, supplier of reusable construction components and secondary raw materials, mapper of potential supply and designer to create demand of reusable construction components, the UMH has established itself in a position where it is able to create secure supply and demand of reusable construction components but also coordinate their matching. In so doing, it has secured continuous revenue streams.

Findings on Case D, in turn, indicated that its operations are profitable and its ability to capture value is increasing. This growth can be traced back to, firstly and most importantly, the UMH's current status as non-profit company, as part of a pilot project. This position has enabled other actors around it to channel significant amounts of financial support prior to and during the first six months of its operations, to the UMH. Secondly, accepting only donated, reusable construction components of good quality and requiring the donators and customers to pay for the delivery of the components, has increased its cost-efficienccy.

Cases E and F reported about struggling to achieve profitability. While Case E stated that the company needs to work a lot to stay profitable, Case F found it challenging to cover costs on a monthly basis. This has forced the managers to seek donations and bank loans. Increasingly, Case F sought to reduce the financial pressure by collaborating with demolition companies to share the economic risks, caused by component acquisition, as well as the profits.

4.1.2 Environmental Lifecycle Business Model Canvas

Two aspects from the TLBMC's environmental layer were studied, namely *production* and *distribution*. Regarding the former, it was observed that all of the UMHs, apart from cases A and D, practiced one or more types of production at their warehouse facilities. The most common type of production across the cases was selectively refurbishing products (as found in cases C, E and F). Cases B, C, E and F stated they possess specific spaces, such as a production hall (Case E), timber workshop (Case C), and laboratories (Case F) dedicated to the different material treatments the UMHs specialize in, e.g., cleaning tiles from mortar (Case F). While cases E and F offered products based on customers' commission, cases B, C, and F, in turn, possessed production lines with continuous production. These included activities such as manufacturing timber products from deconstructed and residual wood (Case C) and separating materials from bricks and concrete into their initial ingredients in order to produce secondary raw materials for new products (Case B). The latter type was the only industrial scale production among the studied cases.

The distribution of the components to purchasers took place either by customers coming to pick up the components from the demolition site (Case C), UMH's warehouse (Cases C, A, E, D, F) or by UMH arranging delivery, either by its own transportation means (Cases E and F) or through a third-party delivery service (Cases A, E, B, F). Cases E and F further offered international shipping. Since the UMHs mainly located from less than five kilometres (Case C and Case D) to less than 10 kilometres (Case E, Case F and Case A) from capital or other major city centres', the UMHs were placed in the vicinity of areas that involve high density of construction and demolition activities. The short distances to the city centres made the UMHs accessible to potential customers, while the delivery distances remained brief. Solely the warehouse of Case B located 20 kilometres from a major city, due to the company's industrial scale activity and need for a large, yet inexpensive space.

4.1.3 Social Stakeholder Business Model Canvas

All of the UMHs were found to seek generating *social value* with their operations, with two main value types identified. Firstly, seeking to challenge and change the existing ways of production and consumption in the industry to reduce the environmental and climate impacts were stated by three cases (case A, B and E). Case B highlighted the importance of *"sharing and caring"* in doing so. That is, sharing knowledge and experiences as well as helping their partners and customers in changing their practices and processes towards facilitating reuse of construction components. Secondly, while all of the UMHs stated they had considered the possibility of offering employment for disadvantaged groups, only Case C had set up a training program targeted at long-term unemployed and youth at risk of becoming marginalized. Case D had sought to provide employment for an unemployed yet lacked the resources to offer proper supervision.

4.2 SRQ2. Business model for an urban mining hub in Helsinki region

This section seeks to answer the second sub-question, which examines the potential BM that can be developed for an UMH in Helsinki region. The data retrieved from the co-creation session are analysed and the potential UMH BM presented as organized according to the four value perspectives.

4.2.1 Value proposition

Private sector organizations were deemed as the main type of customers, with seven different customer groups identified. Five out of six organizations' representatives named construction companies as the key customer group to purchase reusable components (Manufacturer, Retailer and subcontractor, City representatives, Demolition company, Municipal zoning specialist). While they did not specifically state the size of target companies, it could be understood from between the lines that the participants intended rather large companies, as *"the small ones do not know about this [reuse of construction components], whereas the large ones know and talk about these on a very general level"* (Retailer and subcontractor). Furthermore, the *"large ones face the [societal] pressure to source [reusable components]"* (City representatives). The perceived core issue regarding construction companies is their tendency to *"seek the cheapest alternative"* (Manufacturer). This often excludes low-carbon products, those including recycled materials as well as reusable components from the projects, due to their often higher price, as noted by one of the participants: *"If the price of the [reusable] construction components would be cheaper, then those would be instantly chosen. If more expensive, then it should be the developers who should require using these materials."* (Demolition company).

Architects and designers (City representatives, Consultant, Manufacturer, Retailer and subcontractor), developers (City representatives, Consultant, Demolition company, Manufacturer), and property owners (City representatives, Consultant, Demolition company, Manufacturer) were each named by four participating actors. Architects and designers were considered as important, yet indirect influencers for their role as the ones potentially selecting reusable components (Retailer and subcontractor, City representatives). Developers were seen as important leaders, as they have the power to influence decisions on the types of components to be purchased (Manufacturer). Manufacturers received three votes (Consultant, Retailer and subcontractor, Municipal zoning specialist) while demolition contractors were stated by two organizations (City representatives, Consultant). The role of subcontractors was highlighted by one participant (Retail and subcontractor).

It was widely acknowledged that the UMH should offer a value proposition that allows its customers in construction and real estate industry to build with reduced CO2 emissions (Consultant, Manufacturer, Retailer and subcontractor, Demolition contractor with others indirectly confirming). Reusable construction components were seen as a central solution. Thus, the UMH should offer *"the widest possible product range"* (Manufacturer). It was further defined that *"no bulk products should be stored, at least yet."* (Retailer and subcontractor). No specific types of components were proposed, as the discussion centred around their qualitative aspects. These were reuse/installation readiness (Manufacturer, Demolition contractor, City representatives), visually appealing looks (Retailer and subcontractor), lower price compared to that of a new one (Demolition contractor), high or good quality (Demolition contractor, Manufacturer, Retailer and subcontractor), durability (Manufacturer) and high value of components (Retailer and contractor), whereby high value can also mean embedded high CO2 emissions (Retailer and subcontractor, with other participants nodding to confirm). In order to ensure high quality, the UMH should test selected components (City representatives) and guarantee that the product's functionality meets the current requirements (Retailer and contractor). These activities were considered to contribute to offering customers similar products and customer experience as when they purchase products offered by manufacturers or retailers (Demolition contractor). As formulated by the demolition contractor: *"That it is kind of like buying a new product from a store. So, in a way, there would be the certainty that it is good to use this product from here."*. Regarding services, the participants expected the UMH to offer interim storage service (City representatives) and turnkey -service packages (City representatives, Demolition contractor). The latter would cover the different steps from deconstruction to testing and quality assurance (Demolition contractor).

4.2.2 Value creation

The co-created UMH BM draws on several resources, activities, partners and suppliers to create value for its customers in Helsinki region. Regarding how the UMH acquires reusable construction components, majority of the participants saw demolition contractors as the most important suppliers (Manufacturer, Retailer and subcontractor, City representatives, Demolition contractor). Developers (Manufacturer, City representatives, Demolition contractor), property owners (Manufacturer, City representatives, Demolition contractor) and construction companies (Manufacturer, City representatives) were considered as further relevant suppliers. The role of public property owners was explicitly highlighted as they could be incentivised to make the decision to deconstruct components intact when receiving the information that there is genuine demand for those (Municipal zoning expert).

Two types of resources were considered as most central for enabling the matching of supply and demand of reusable construction components. Mutual understanding formed among the participants about the need for a webstore with a digital catalogue presenting the available reusable construction components (City representatives, Consultant, Manufacturer, Retailer and subcontractor) (see section 4.4.3 on value delivery). Alongside the component catalogue, warehouse was established as a central resource of the UMH operations, highlighted by the extensive attention it received (Manufacturer, Consultant, Demolition contractor). As the components cannot be stored at the construction sites over long periods of time (City representatives, Retailer and subcontractor), a warehouse, in *"a good location"* (Manufacturer), would serve to bridge the temporal gap (Consultant).

Three types of activities were highlighted as most relevant to the UMH operations. Firstly, in order to ensure short storage times (Consultant, City representatives), demand needs to be monitored (Consultant) and decisions made about which components are selected in the offering (Consultant, Retailer and subcontractor) and to be stored (Retailer and subcontractor). As formulated by the Consultant: *"And then maybe this could help the fast turnover of materials, by building some sort of internal system, where there would be quicker and more regular inventories. Something that tracks which materials are at risk of just sitting around unused, like if they're not getting any views, or not being brought forward. So that then these would be marketed, but also include things like clearance sales or other actions [to get rid of those components]. Something like that, because honestly, there's a real risk here that "leftover" material just becomes waste."*. Furthermore, quality assurance was deemed important (Demolition contractor, City representatives). However, the city representatives highlighted that the components should only be tested in their *"basic dimensions"*. Where necessary, testing should be outsourced to experts in laboratory settings (City representatives). Testing results should be properly documented, and they should demonstrate to what extent components are suitable for reuse and in which specific functions (City representatives). Refurbishment and modification were proposed to be undertaken to enhance the component quality (Demolition contractor). A mobile workstation could be utilized to clean components already at the demolition site (Demolition contractor).

A variety of partners were identified as important to the UMH in Helsinki region. A majority of them are important to the daily operations. These are, firstly, architects and designers (Manufacturer, City representatives) who possess information about, for example, renovation projects, that were deemed as particularly suitable for including reusable construction components (City representatives). This information could be shared with the UMH operator to explore opportunities for reusing components (City representatives). Secondly, manufacturers were highlighted (Manufacturer, Demolition contractor) due to their role as experts in their given components and materials (Demolition contractor). They were deemed to be best equipped to contribute to their refurbishment and quality assurance

(Demolition contractor). Thirdly, city and municipal actors were seen as important in offering support for finding a suitable lot for the warehouse (Municipal zoning specialist). Zoning authorities, in turn, possess information about public and private buildings to be demolished, thereby serving as key informants of the UMH (City representatives). Fourthly, developers and property owners, both public and private (Retailer and subcontractor, City representatives, Demolition contractor) as well as construction companies (City representatives, Manufacturer), were stated as potential partners. Lastly, partnerships that were seen to bring benefits in the long-term are those with, for example, research and educational institutes (Consultant), as well as alliances (Municipal zoning specialist). These can support with research on specific issues, integration of reuse related knowledge in educational programs (Consultant) visibility, knowledge and funding (Municipal zoning specialist).

4.2.3 Value delivery

In order to deliver value to its customers, the UMH in Helsinki region relies both on personal and casual customer relationships. While webstore as the key sales channel enables the latter, personal customer relationships are created through in-person communication (Manufacturer, Retailer and subcontractor, City representatives) and network building (Manufacturer, City representatives). In-person communication was considered as particularly suitable means to reach out to the potential customers in the first place, as formulated by the retailer and subcontractor with the example of architects: *"[...] architect sales face to face. Getting in isn't always easy. [...] And now that we're out there with something like this, and you actually have something meaningful to say, a product or a strong idea, then you're much more likely to get in."* Network building, both within and across branches, were deemed as a vehicle to stay in touch and strengthen the relationship with the customers (Manufacturer, City representatives). Networks further enable participants to connect and exchange on issues, ideas and practices related to reuse (Manufacturer), opening ways for further collaborations that potentially lead to developing solutions that advance reuse (Demolition contractor). Newsletters (Manufacturer, Retailer and subcontractor, City representatives), webstore (City representatives), word of mouth (Demolition contractor), industry publications, LinkedIn and other social media channels (Manufacturer) were deemed as further effective means to reach potential customers. Company website was highlighted as the cornerstone of all communications: *"Proper, well-working websites are at the core of all communication. "Traffic" is directed there through social media channels or newsletters."* (Retailer and subcontractor).

The UMH should strive to use several communication styles, in order to reach its potential customers. Profile raising communication on reuse of construction components was determined as a priority (Manufacturer, Retailer and subcontractor). Messages such as *"Reusable is just as good and even better than new"* should be brought across to the target customers (Manufacturer). Showcasing reuse actions (Retailer and subcontractor) and sharing stories, were deemed as important approaches (Manufacturer). Authentic benefit (Manufacturer) and sustainability claims (Retailer and subcontractor) were further aspects the UMH should convey to potential customers.

A webstore with a product catalogue was deemed as the main sales channel. It allows the customers to select and purchase components suitable for their projects (City representatives). Since design and construction processes are lengthy, the catalogue should further involve an integrated, long-term availability calendar that announces the timeframe when components are available (Consultant, Manufacturer). Preferably, the components are published in the catalogue several months prior to the beginning of demolition (Manufacturer, Retailer and subcontractor, City representatives, Municipal zoning specialist). Additionally, the webstore should involve a reservation system that allows architects and other actors to reserve these for their projects against a fee (Consultant). *"Architects should have the possibility to make reservations. Because [the reusable component that is selected for the design during the design phase] does not always match with [that available] when the component is needed. There should be some kind of function that lets them sort of "lock it in." Like, so they can somehow secure it for themselves. […] The problem really is the timeline here."* (Consultant). Furthermore, the digital catalogue should openly offer information about the available components and be as easily accessible as possible, and where necessary, user registration could be required (Retailer and subcontractor). As formulated by the Retailer and subcontractor: *"It would be open — at least to partners — maybe it would require some kind of registration or something. It has to be easy to approach."* (Retailer and subcontractor). By providing these functions, a digital catalogue would contribute to enabling deliveries of reusable construction components from deconstruction site directly to the subsequent construction site, as for example *"subcontractors could order some products already in advance [for a project]"* (Retailer and subcontractor).

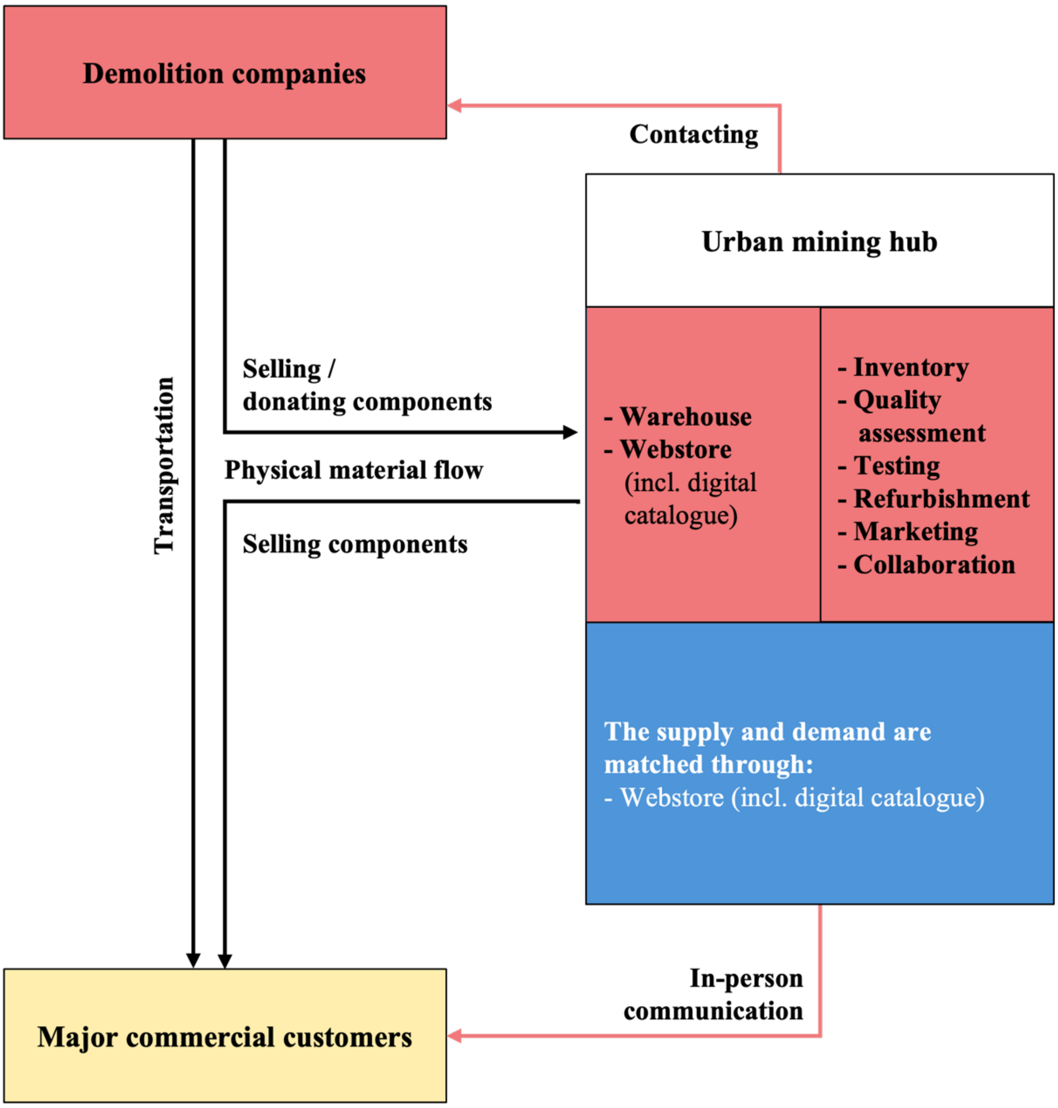

Figure 13. Value chain of the co-created UMH BM for Helsinki region. The BM elements that comprise value creation (i.e., activities, resources and suppliers) are presented in red, while yellow denotes customers (color refers to the value proposition) and blue channels (color refers to the value delivery). Black arrows illustrate material flows, while red arrows denote activities undertaken by the UMH operator.

Regarding what information the UMH should provide to its customers about the reusable construction components, the co-creation participants considered component measures, use age, condition, quality test results and suitability for reuse as central. In other words, information that particularly architects need in order to integrate components in designs (City representatives, Manufacturer, Retailer and subcontractor, Demolition contractor). The customers should further be informed about the initial manufacturer, where possible, to enable the customer to inquire additional details (Retailer and subcontractor). Information should be made available on the component's embedded CO2 emissions (Consultant, Manufacturer, Retailer and subcontractor) to allow purchasers to make informed decisions about acquiring components (Consultant, confirmed by Retailer and subcontractor). Particularly the real estate owners could benefit from the data as they could report the reduced emissions achieved from reuse (Consultant). Lastly, information should be provided on whether the UMH grants a warranty for the component (Demolition contractor).

4.2.4 Value capture

Eight costs and three value capture mechanisms were discussed during the co-creation. Regarding costs, two resource and six activity related costs were raised. The former are, firstly, the UMH land lease (Municipal zoning specialist). The proximity to densely built areas, that participants favoured (City representatives, Manufacturer), further influences this, as formulated by the Municipal zoning specialist: "*…of course location always affects everything: transportation costs, […] accessibility, but then again, if it's in a good location, the land lease and other costs will go up."* Secondly, sales platform (City representatives) with component catalogue (Retailer and subcontractor) were deemed to induce costs. The activity related costs, in turn, stem from the different value chain stages, starting from component acquisition (Manufacturer, Deconstruction, City representatives) and logistics (Manufacturer, City representatives, Municipal zoning authority) to component refurbishment (Manufacturer, City representatives) and testing (Manufacturer, Retailer and subcontractor, City representatives). The costs of the latter could be reduced by testing solely aspects considered as necessary regarding the given component as well as by conducting some tests already at the deconstruction site (City representatives). Only if customer asks to conduct further, specific tests, are these undertaken, and where necessary, they are outsourced to testing institutions and consultancies (City representatives). Lastly, waste management costs (Consultant, Municipal zoning specialist) can be reduced by negotiating proper contracts with respective companies, to keep the prices reasonable for the UMH (Consultant). In order to reduce the costs emerging from the value chain, the participants stressed the importance of optimizing the operations and carefully selecting the components to be stored (Manufacturer, Consultant, Retailer and subcontractor).

Two key value capture mechanisms were raised by the participants in alignment with the findings on value proposition. These are selling reusable construction components and services. The former was considered to be the main value capture vehicle, whereby the customers were believed to be willing to pay for components in which they see value (Demolition contractor) (factors presented in section 4.41 on value proposition). Regarding pricing of the reusable components, it was stated that a slightly higher price of 5-10% than that of new ones, would be acceptable (Manufacturer). Where possible, the UMH should use open book principle, where costs and margins can be viewed by customers (Retailer and subcontractor). This could create understanding of what the product price consists of and thereby resolve doubts about the particular "costliness" of the products (Retailer and subcontractor). Regarding services, the participants deemed it important that the UMH covers a variety of activities, thereby offering customers *"the whole package"* (Manufacturer) or *"turnkey services"* (City representatives). As a third value capture mechanism, external funding was deemed important, especially at the beginning of the

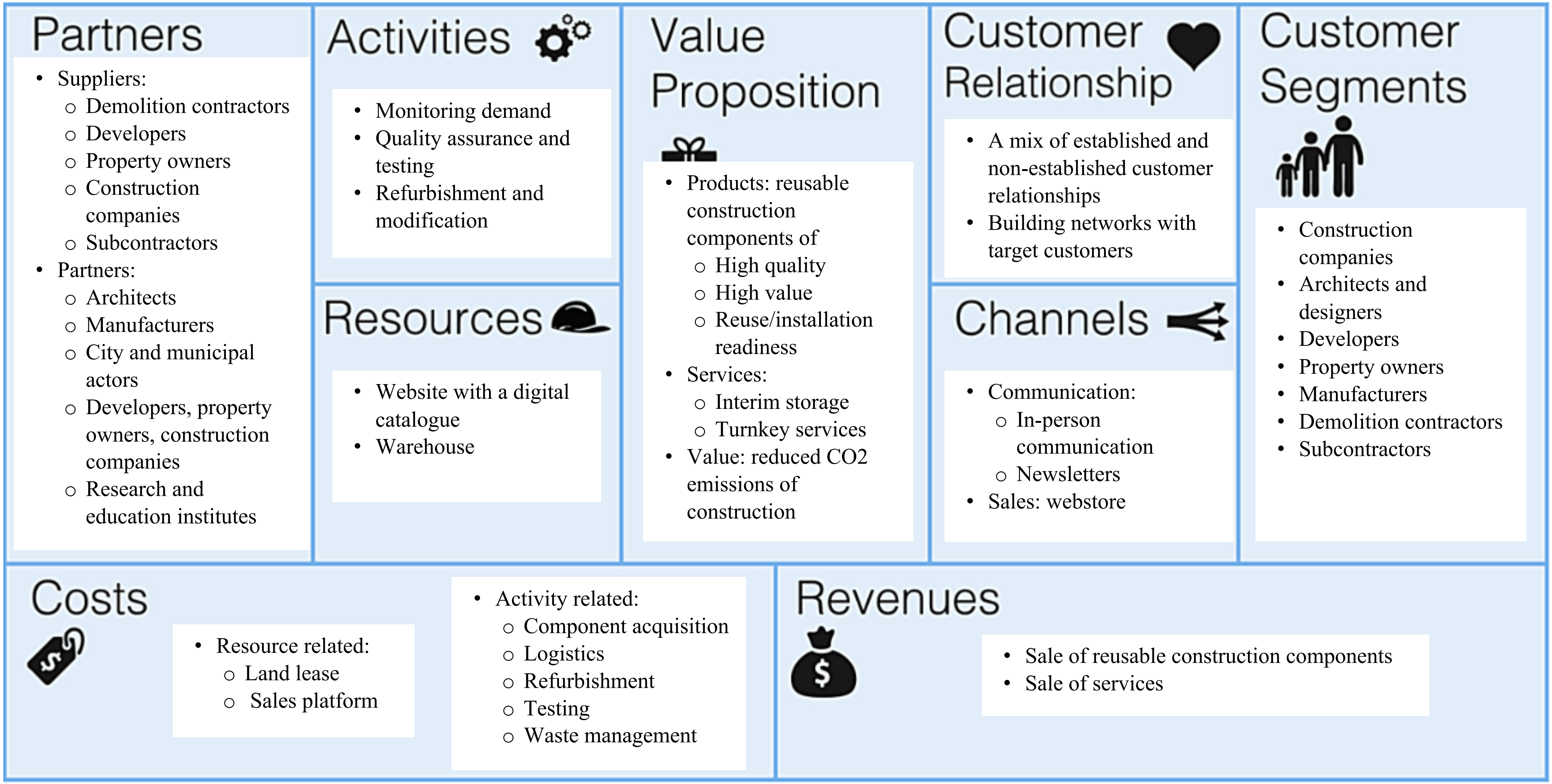

Figure 14. UMH BM for Helsinki region. Based on Osterwalder & Pigneur (2010).

operations (Consultant, Retailer and subcontractor). It would help to create conditions for achieving profitability of the UMH operations. For this, the Consultant proposed to set a target time and a funding model: *"maybe there should also be a target for when the business side is expected to become profitable. Like, if that goal was set for five years, then you'd need to start thinking about external funding for those first five years. Maybe even through some kind of gradually decreasing support model."*

4.3 SRQ3. Barriers and enablers of an urban mining hub business model implementation in Helsinki region

This section answers the third sub-question which seeks to identify barriers and enablers of UMH BM implementation in the context of Helsinki region. Two independent interviews were conducted to extract insights, one with two city representatives and another one with an emerging UMH operator. While one question was asked about barriers, two questions were asked about enablers, thus more attention was paid to enablers. Additionally, the UMH representative explicitly preferred to pay greater attention to enablers. Overall, four barriers and nine enablers were observed (summarized in Table 5). In total, five of the named factors relate to culture and know-how, four to reuse infrastructure and three to business. Two factors concern regulation.

4.3.1 Barriers

Four barriers were identified to impede the UMH BM implementation in the Helsinki region. Both interviews indicated two barriers. Two were culture and know-how related factors. Firstly, the UMH operator highlighted that while public sector actors were seen as committed to promoting reuse of construction components, the operator nevertheless perceived a "*lack of sincere attention to the market players' needs*" and *"willingness to act"* accordingly. *"The problem is partly that public actors do not listen to the market sufficiently and either take no action or take actions that are exactly the opposite of what the market would expect."* (UMH operator). The lack of attention was perceived to be reflected in the reuse activities that funded projects are dedicated to promoting, as these were considered to often be too sluggish for the market actors' needs. This was seen to be an issue particularly for small, agile companies operating solely on reuse. (UMH operator) Secondly, the city representatives emphasized the *lack of knowledge* of how to arrange and streamline an UMH value chain in a manner that makes it economically viable, and thus, attractive for the different parties involved (city representatives).

As a business-related barrier the UMH operator stated the *uncertainty of demand*. Reuse of construction components is conducted on a project basis and the uncertainty of whether upcoming projects integrate reuse activities, hinders UMH operators to invest in resources, such as facilities and acquisition of reusable construction components (UMH operator). Regarding reuse infrastructure, the city representatives named the *lack of suitable plot of land* as a significant barrier. This is perceived as *"certainly one of the key issues, and perhaps a distinctive feature of the Uusimaa region"* (city representatives). This results from the costliness of the land, densely built capital region and the pressure to build more residential areas due to growing population (city representatives). The strict stance taken by the City of Helsinki to ensure that all companies are treated equally, and no competition is distorted, was considered as a further issue in the context of Helsinki, particularly as this leads to a situation where the City cannot directly designate a plot of land to an UMH operator (city representatives).

4.3.2 Enablers

Nine types of factors that enable the implementation of an UMH in Helsinki region, were discovered in the interviews. Four were stated by the UMH operator and another three by the city representatives, with one factor named by both. Two factors related to culture and knowledge were highlighted. These were the *client organization's internal commitment* to reuse, as stated by the UMH operator. *"The trade of building components has been promoted by commissioning parties who have been willing to develop the reuse of building components and who have been prepared to invest resources in learning new things."* (UMH operator). Secondly, the city representatives emphasized the importance of spreading *awareness* and creating *transparency* on the UMH operations. These serve as important enablers and contributors to achieving a reputation as a trustworthy actor. Indeed, building trust in and counteracting doubts that exist regarding reuse and the quality of the reusable construction components were seen as important not only in relation to potential customers and partners in the industry, but also the environmental and building control authorities. (city representatives)

Two business related enablers were identified in the interviews. Firstly, representatives from both organizations stated the enabling role of *public actors as clients*, particularly in purchasing reusable construction components and services. For this, the public actors have several tools at hand. Namely, such customer relationship could be based on a tendered framework agreement, where the public authority commits itself to order a certain amount of reusable construction components per year. As depicted by the UMH operator: *"Framework agreements with three suppliers will very likely ensure that components start moving from demolition sites to the operators' warehouses [prior to the client's construction site]."* (UMH operator). A further instrument is tendering or organizing an innovation challenge (city representatives). Here, a city could commit to procure services or components from the winner for a certain amount and could make a plot of land available to the operator for temporary use (city representatives). A further enabler, highlighted by the UMH operator, are accurate *estimations of demand* of reusable construction components. Specifically, these would describe whether and to what extent the contracting companies plan to commission projects that pose demand for reusable construction components. The information would help the UMH operators to respond to the demand by investing in advance in the necessary resources, such as facilities and personnel, as well as in acquisition of reusable components. Thus, it would support overcoming the impediment of demand uncertainty. (UMH operator)

The city representatives highlighted three reuse infrastructure related enablers. Firstly, they raised the role of public authorities in supporting the establishment of the warehouse, which they considered as their main task. Specifically, they proposed *support in finding* or even *offering a suitable plot of land* for UMH operations. Making it temporarily available for the UMH operator could reduce the barriers to start the operations, as described by the city representatives: *"it feels like, in Finnish conditions, this would first need to be tested in an experimental way to see how exactly to align the whole chain of operations and what needs to be done. It's hard to see anyone jumping straight into business with it. So, in that sense, some kind of temporary use on a plot with a light tent structure or something, just so that the founding process would not become overly heavy."* (city representatives). However, certain conditions need to be fulfilled for a public authority to be able to support searching and offering such land. To provide direct support for an UMH operator would require a pilot project status. Thus, the city representatives proposed "*Something like a pilot project for this, to test it out. And then it might enable a bit more substantial support from the public sector, especially if it's a non-profit initiative."* (city representatives). As the third infrastructure related enabler, the city representatives proposed *third-party verification* as a means to assure component quality in an independent manner. This follows from the need to ensure the quality of components before their reuse. The verification could be conducted on the reuse operations, components, or both (city representatives).

Table 5. Identified barriers and enablers.

	Barriers	***Enablers***
Culture and know-how	• Lack of knowledge of how to arrange the value chain for economic viability for parties involved • Public actors' lack of attention on market players' needs	• Client organizations' commitment to reuse • Spreading awareness and creating transparency on the UMH operations
Business	• Uncertainty of demand	• Estimations of future demand • Public actors as clients
Reuse infrastructure	• Lack of suitable plot of land	• Support in finding or offering a suitable plot of land • Quality assurance through third-party verification • Pilot project status
Policy and regulations		• Regulation of demolition • Regulation supporting reuse

Lastly, two regulation related factors were proposed by the UMH operator. Specifically, *demolition* should be *regulated* in a manner that disallows property owners from demolishing a building in a destructive way. Simultaneously, the regulation should guide the property owners towards reusing the components. (UMH operator)

5 DISCUSSION

This chapter presents and discusses the extracted findings that serve to answer the sub-questions of this thesis. It begins by presenting how the existing UMH BMs enable matching supply and demand of reusable construction components. Secondly, the co-created UMH BM for Helsinki region is discussed. The chapter concludes by addressing the experienced barriers and enablers of UMH BM implementation in Helsinki region. Each of the sub-sections provides propositions to be included in the UMH BM for Helsinki region. These are based on the insights formed in discussing the SRQs.

5.1 SRQ1. How urban mining hub business models enable matching supply and demand of reusable construction components

The first SRQ sought to understand *how the existing urban mining hub business models enable matching supply and demand of reusable construction components in the selected Northwestern European cities.* A descriptive embedded multiple case study with six UMHs was conducted to gain a comprehensive understanding of the means the UMHs use to enable matching supply and demand. The scope was mainly laid on the economic layer due to the novelty of UMHs as a phenomenon and the economic viability posing a central issue in establishing and operating them. Additionally, since the studied UMHs' ownership is private, economic viability creates the foundation on which operations and the other two values are built on. Thus, only selected aspects from environmental and social layers were studied. Regarding the economic layer, a core finding of this thesis is that the studied cases tend to follow one of the two distinctive value chains, as revealed by the cross-case synthesis. Specifically, the results indicated two different processes for enabling the matching of supply and demand of reusable construction components. Findings on the types of value propositions the UMHs possess, however, are more mixed. Regarding their ability to capture value, the UMHs vary significantly and do not clearly align with the distinction identified on value chain.

The findings on *value propositions*, and more specifically on customer segments, indicate that while a majority of the UMHs prefer catering to large commercial customers, there is great variance across cases in the type of customer organizations they serve. Within the studied individual cases, the diversity of served customer segments is smaller. This observation links with the type of value chain in the sense that those UMHs that tend to rely on streamlined value chain, serve mainly large companies such as manufacturers, retailers and developers, whereas those that rely on the warehouse value chain mainly cater to the needs of small companies, such as renovation contractors, hospitality industry companies, and individual households as customers. Prior research on UMHs located in the Netherlands, suggest similar preference of studied UMHs to sell to large commercial customers as these offer an avenue for selling larger quantities, and thus, releasing resources for other activities (Isselman, 2023; Köhrer, 2024; Van Uden, 2025). Furthermore, the studies observe that the UMHs mainly cater to manufacturers, architects, contractors, wholesalers and retailers specialized in the reuse of construction components (Köhrer, 2024; Van Uden et al., 2025). Wholesalers were observed as particularly desirable to trade with, due to the perceived easiness and cost-efficiency (Köhrer, 2024). These studies hence indicate similarities with those cases observed to possess a streamlined value chain.

Regarding the offered products and services, significant, within-case variation was observed in the types of components the UMHs offer. As majority of the cases offer similar types of components, variance across cases is, however, smaller. This is further reflected in the existing studies that identified UMHs to offer similar component categories (Köhrer, 2024; Van Uden, 2025). Interestingly, the literature further indicates that most asset-intensive businesses in the field, such as the demolition companies and component retailers, typically provide high-value products (Bestul & Gruis, 2024; Whalen, 2019) and an increased scope of services (Bestul & Gruis, 2024). The latter results from, firstly, the capacity of services to generate revenues to cover costs, and secondly, from the value chains of these companies. Namely, the companies cover a variety of steps in the value chain, providing them opportunities for services development (Bestul & Gruis, 2024). The results of this study align with the above insights, as both types of companies, demolition contractors and retailers, offered high value products, with a majority further providing a variety of services that cover different activities in the value chain.

The cross-case synthesis unveiled two types of *value chains,* one that is streamlined and another that is based on a warehouse as its central element. Half of the studied UMHs utilize the former type of value chain that seeks to deliver the reusable components from deconstruction sites directly to purchasers. The other half, in turn, relied on the latter type of value chain, with warehouse as a major step closing the temporal gap between deconstruction and purchase of the components. This distinction was observed to be inextricably linked with whether an UMH seeks to build relationships with its customers or not, as well as what channels they utilize to reach out to their potential customers. Those UMHs that were observed to capitalize on the streamlined value chain, were further identified to seek establishing customer relationships with established companies, in order to secure continuous demand for the components they supply. Thereby, personal contact was used for reaching out to the potential customers and to ensure matching of supply and demand. In relying on direct supply to customers, these UMHs possessed mainly small warehouses and no physical shops. In adopting these value chain features, the UMHs integrate themselves as part of the existing supply chains of virgin components. On the other hand, those UMHs that rely on the warehouse value chain were observed to draw upon rather non-established, occasional customer relationships. These operators invested comparably more in warehouse operations and marketing their products on different channels to communicate about their value proposition to potential customers. However, the actual matching is left to customers who purchase the products from webstore and shops. In proceeding this manner, the UMHs create parallel, competing supply chains to those of virgin products.

The extant studies conducted in the context of the Netherlands, offer insights on cases that capitalize on the streamlined value chain. Namely, they prefer selling to "fixed partners", as this eliminates the need to search potential customers each time new components become available (Köhrer, 2024, p. 38). It was further observed that in order to sell components to these partners, the UMHs use "direct selling" (Köhrer, 2024, p. 41). That is, contacting customers, sharing the relevant information about the components, while the customer then either accepts or rejects the offer (Köhrer, 2024). This was perceived to create regularity in the sales process. Other channels that serve to match the supply and demand were observed to be digital marketplaces, while only a few UMHs were identified to possess own webstores. (Köhrer, 2024; Van Uden, 2025) All these three means offer avenues for selling components as early as possible, while they are still installed in the original building, in order to minimize the need for storage (Van Uden, 2025). Accordingly, most of the UMHs do not offer physical shops or showrooms and these were associated with selling to small businesses and private households, of which the latter were deemed as a particularly labour-intensive customer segment (Köhrer, 2024).

Despite the distinction in value chains, the analysis on the six UMHs revealed that key costs and *value capture* mechanisms are same in a majority of the cases. The UMHs, nevertheless, differ significantly regarding their ability to capture value. Three central factors can be pinpointed to influence this. Firstly, *services* can generate significant additional income. Particularly at the beginning of the UMH operations, services, such as interim storage, can generate sufficient income and thereby allow time for the component sales to take off. Expanding the company's value proposition to utilize the available competencies can create multiple, beneficial revenue sources (Bestul & Gruis, 2024). In so doing, some of the studied UMH operators created a strategic set of services that lever the company in a position where it can create supply and demand of reusable construction components and coordinate their matching, thus supporting its value capture ability.

Secondly, the way the UMH's *value chain* is organized influences its ability to capture value (Jung et al., 2015). Namely, it can either increase or decrease costs that result from the activities and resources targeted at sourcing and matching reusable construction components. In following the warehouse value chain, the cases purchase the reusable construction components prior to having the security of selling them or having received a confirmation from a potential purchaser. In proceeding this manner, they take two types of financial risks. First, it can take a long time to sell the components, and storage costs (Rakhshan et al., 2020). Second, in case the risk of a product not being purchased realizes, further costs are born from waste management (Rakhshan et al., 2020). In both cases, these costs emerge on the top of those costs that result from investing resources in the process from acquiring the components, managing them at the warehouse, including cleaning and storing, to marketing (Nußholz & Whalen, 2019). As a result, the labour related costs embedded in a product are inherently higher when applying the warehouse value chain. Besides, customers' willingness to pay for reusable construction components can be limited, resulting in narrow margins or unprofitability (Nußholz et al., 2020; Nußholz & Whalen, 2019). Indications of these issues can be observed in cases E and F that utilize the warehouse value chain, with both reporting they struggle to achieve or stay profitable. The studied UMHs with streamlined value chain take a contrary approach in that solely those components for which a subsequent purchaser is known, are deconstructed, and where necessary, purchased. Oftentimes they delivered these directly to a purchaser without storing them in between. This type of value chain can result in lower operating costs, with costs related to storage and treatment being, at least partly, outsourced to a purchaser that explicitly pays for them. Proceeding in this manner can relieve the financial burden on the UMH. Similar insights are provided by a study conducted in the context of the Netherlands. Namely, it reveals that some UMHs prefer to sell to wholesalers for this specific logic. It is considered as more efficient and less expensive in comparison to the logistical network and warehouse operations needed for the warehouse value chain (Köhrer, 2024). A further benefit is that the process resembles the current standard process, where construction companies and others purchase the components from wholesalers, thus making it attractive for these companies as well (Köhrer, 2024).

Third identified factor that influenced UMH's ability to capture value are the *external financial* and other types of *support* prior to, at the beginning of or continuously throughout the operations, supported by the literature (Rose & Stegemann, 2018). Particularly financial support played a key role in enabling some of the UMHs to become profitable soon after the start of operations, or to operate the warehouse in the first place. In addition, the commitment of public property owners and developers to purchasing, for example, interim storage, served as a further significant support mechanism.

Based on interviews with Dutch practitioners, previous literature has identified that UMHs are expected to shrink or disappear entirely in long term, despite growth in the market of reusable construction components, particularly B2B. This results from the anticipation that the identification and matching of supply and demand will be controlled digitally. On the road to that outcome, UMHs serve as an intermediate step, instead of being the ultimate solution often presented by policymakers. (Köhrer, 2024; Van Uden et al., 2025) Practitioners consider the current system inefficient (Köhrer, 2024), and expect hubs to become more focussed on logistics, moving components to manufacturers and retailers (Van Uden et al., 2025). Particularly manufactures have a central role in this transition, as they possess most knowledge about and skills regarding their given components and materials (Köhrer, 2024). Thus, being perceived as the most capable of efficiently handling them as such or processing them into new products, while granting guarantees (Köhrer, 2024). While the managers interviewed for this study did not formulate precisely similar future prospects, three corresponding indications can be found in the qualities of UMHs with streamlined value chains. Firstly, while two of these cases already delivered components directly to their commercial customers, one was pondering to shift entirely to this model. Secondly, digitalization of the existing building stock and coordinating the matching of supply and demand digitally were identified as important activities. Thirdly, all of the UMHs with streamlined value chain had established collaborations with manufacturers and capitalized on their knowledge, skills and processes.

Based on these insights, the following five propositions are given to enhance the economic and operational viability of the co-created UMH BM:

Proposition 1: In targeting large commercial companies, retailers and manufacturers should be considered as further important customer segments due to their capacity to pose continuous demand for the components and materials the UMH supplies. Thereby, they open an avenue for the UMH to fit in the existing supply chains that serve major commercial customers. This lies in the retailers and manufacturers role as direct suppliers of major industry actors. As such, they possess the ability to complement deliveries with new products, where necessary. This, in turn, potentially increases the attractiveness of reuse of construction components as commercial customers are able to purchase them easily and directly from the same provider. Furthermore, the relationships with these types of customers are often established and the components delivered directly to the purchasers from the deconstruction site, circumventing the need for a warehouse. These types of relationships further provide a basis for collaboration and open an avenue to capitalize on the knowledge, skills and processes of manufacturers. By integrating manufacturers and retailers to its customer base, the UMH can potentially futureproof its BM.

Proposition 2: By offering a strategically designed set of services, the UMH can lever itself into a position where it can control and create supply of and demand for reusable construction components, as well as coordinate their matching.

Proposition 3: By establishing relationships, or "fixed partnerships", with each of its target customers, the UMH can increase predictability and facilitate continuous demand for the components it supplies. While establishing customer relationships can require significant initial investments from the UMH managers, the long-term investments can be fewer as, for example, lesser to no marketing efforts, nor running a webstore or physical shop, are needed.

Proposition 4: Only components that have been sold or reserved and for which the customer pays a storage fee, should be stored. In proceeding this manner, costs related to the activities and resources essential to warehouse operations and marketing, can be outsourced.

Proposition 5: Arranging especially financial but also other types of support from public and private actors prior to, at the beginning of and during its operations, can create conditions that enable the continuity of the UMH operations. Furthermore, commitment of public actors to purchasing components and services serve as a further important support mechanism.

5.2 SRQ2. Developing an urban mining hub business model for Helsinki region

The second SRQ of this thesis asked *What kind of a business model can be created for an urban mining hub in Helsinki region, from the perspective of regional stakeholders?* In order to provide an answer to the question, a co-creation session was organized with relevant regional stakeholders. Here the scope was laid on the economic layer of the TLBMC. This section compares the insights gained in the co-creation of the UMH BM to those derived from the cross-case synthesis and discusses the insights in relation to existing research.

Regarding *value proposition*, and specifically whom the UMH, located in Helsinki region, should create value, private sector organizations were indicated as the primary customer segment purchasing components. The co-created UMH BM pinpoints seven types of stakeholders, most importantly, construction companies, followed by architects, developers and property owners. Similarly, the cross-case synthesis indicates private sector actors as the primary customers. Interestingly, the lived experience of the case study cases, however, deviates from the objective of the co-created UMH BM to have major construction companies as the primary customer group. This results from small construction and renovation contractors purchasing reusable components, while major ones are clients of retailers and manufacturers. Regarding product offering, the co-created UMH BM does not specify types of components. This can result from the fact that the co-creation did not involve representation from architects, construction companies or developers, that are ultimately those purchasing components or selecting them for designs (Roos et al., 2010). Instead, qualities guiding the selection of components were listed with focus on high quality and value, attributes that are similarly highlighted by the case study results and the extant literature (Bestul & Gruis, 2024; Van Uden et al., 2025; Whalen, 2019).

The co-created UMH BM for Helsinki region has features of both, the streamlined and warehouse *value chains*. As the key platform for matching the supply and demand of reusable construction components, the co-created UMH BM relies on a webstore. This involves an integrated product catalogue with a range of information about the components. Existing literature, in turn, reveals that UMHs consider maintaining and updating a webstore as burdensome and prefer to rely on existing digital marketplaces instead (Isselman, 2023; Köhrer, 2024; Van Uden, 2025). Furthermore, while offering relevant information is considered as central, particularly so that architects and designers can design with them, drawbacks to it were identified in the literature. Namely, collecting and recording data are resource intensive activities and sellers can be held liable for the product characteristics they advertise. Thus, listing only the necessary information can be in an UMH operators best financial and legal interest (Bestul & Gruis, 2024). Warehouse was deemed as a further central resource to the co-created UMH BM and the case study cases, in that it facilitates bridging the temporal gap between deconstruction and reinstallation of components. While the existing literature sheds light on cases that seek to deliver majority of the components directly to the customers, warehouses nevertheless play a central role in their operations, enabling storage, refurbishment and production activities (Köhrer, 2024; Van Uden, 2025).

Demolition contractors were considered as most important suppliers, both by the co-created UMH BM and the extant literature (Köhrer, 2024; Van Uden, 2025). Notable is that many of the UMHs studied in the literature are demolition companies or closely related, for example, sister companies (Köhrer, 2024; Van Uden, 2025). The types of partners and the purpose of partnerships that were assigned to the co-created UMH BM differed from those observed in the case study cases. Namely, the co-created UMH seeks to establish partnerships with a variety of actors that can offer information and other relevant resources. The case study cases, in turn, employ collaborations with fewer partners and mainly to provide services, increase the amount of sourced components and to create novel products and processes that facilitate intact deconstruction and reuse of components. In so doing, some of the case study cases were able to tap on resources that enable them to create supply and demand of reusable construction components and coordinate their matching.

Based on these insights, the following proposition is given to enhance the economic and operational viability of the co-created UMH BM:

Proposition 6: Collaborating with partners from different fields (e.g., architecture, manufacturing) can enable an UMH to broaden its offering of services and create novel tools and procedures. In so doing, the UMH can lever itself into a position where it can create supply of and demand for reusable construction components, as well as coordinate their matching.

5.3 SRQ3. Barriers and enablers of an urban mining hub business model implementation in Helsinki region

The third SRQ asked *What are the barriers and enablers of the urban mining hub business model implementation in Helsinki region?* Two interviews were conducted, one with a public and another with a private industry actor. A profound difference was observed in the perspectives of the interviewed organizations. Namely, the UMH operator highlighted factors external to the UMH operations, mainly related to demand and the role of market actors, both public and private. A feature common to these factors is the dependency of the UMH operations on them. The city representatives, in turn, gave priority to creating supporting conditions for the UMH operations and improving the economic and operational viability of the UMH BM. The distinct perspectives coherently align with the organizations' inherent assumptions. The UMH operator as a private company is dependent on demand posed by and the reactions of market actors (Von Hippel, 1986), whereas the city representatives' task is to use the range of tools at their disposal to support companies in adopting novel reuse practices and advancing reuse business opportunities (Eneqvist, 2023).

A key culture and knowledge related factor that impede the implementation of UMH BM in Helsinki region is perceived to be the lack of knowledge of how to arrange the value chain for economic viability. This deficiency of clear evidence on economic viability for the different parties relevant to reuse operations makes participation in the value chain less attractive. While the extant literature does not directly indicate this as an issue, it reveals the general lack of knowledge of reuse of construction components prevailing in the industry, both in the Nordics (Ericsson et al., 2024; Fufa et al., 2023; Gerhardsson et al., 2020; Hradil, 2014; Huuhka & Hakanen, 2014; Knoth et al, 2022; Kummen et al., 2023; Nordby, 2019) and beyond (Chileshe et al., 2015; Yeung et al., 2015). The novelty of the phenomenon manifests, for example, as scepticism towards economic viability (Ericsson et al., 2024), due to the perceived uncertainty or lack of measurable economic incentives (Ericsson et al., 2024; Zu Castell-Rüderhausen et al., 2021). However, as the industry learns, economic profitability is expected to emerge for the different parties involved, through experience, competence and improved temporal efficiency (Ericsson et al., 2024).

Regarding reuse infrastructure, support in finding suitable lot of land and lack thereof, were highlighted by the interviewees as an enabler and a barrier. A (non-profit) pilot project status was proposed as an avenue for channelling public support, such as dedicating a temporary lot for UMH operations. This was further deemed to enable experimenting on the potential BM, prior to establishing the UMH as a regular company. The extant literature similarly highlights the lack of storage space as a barrier to reuse of construction components (Rogers, 2011; Rose & Stegemann, 2018). The lack of low-cost land is a particularly prevalent issue in densely populated Europe (Cruz Rios et al., 2021). However, instead of considering pilot projects as mechanisms to channel public support, the extant literature takes a construction project perspective on pilots and considers them primarily as vehicles to enhance practical knowledge of reuse, its dissemination and cooperation among the different actors in the value chain

(Knoth et al., 2022; Nordby, 2019; Sandberg et al., 2022). Nevertheless, examples from successful UMH pilots exist as well, as showcased by Ombygg in Oslo (Sirkulaer Resurssentral, n.d.). Thus, UMH pilot projects can further contribute to creating understanding of how the value chain should be arranged in the first place, to ensure economic viability for the different parties involved.

As a further reuse infrastructure related enabler, the interviewees named third party verification of component quality. This results from sufficient component quality being a precondition for their reuse. Overall, component testing for quality assurance is a widely recognized factor, considered both as an important enabler (Fufa et al., 2023; Knoth et al., 2022; McNamee et al., 2023; Nordby, 2019; Sandberg et al., 2022) and a barrier, in terms of its costs (Dunant et al., 2018; Tingley et al., 2017) and absence (Hobbs & Adams, 2017; Knoth et al., 2022). In the context of Finland, the industry discourse around quality assurance of reusable construction components is mainly focussed on verifying the individual components or component batches through tests (Tähtinen et al., 2025). However, it can further take place in terms of verifying the process through which component quality is guaranteed, as done in Belgium (V. Meesters, personal communication, 05.03.2024).

Public sector actors' role as clients was highlighted by both, public and private sector interviewees as an enabler of UMH BM implementation in Helsinki region. This is reflected specifically in the literature on Nordic countries, which lies on the extensive role of the state that provides public actors tools to steer market and the broader society (Thorhallsson & Elínardóttir, 2020). Accordingly, the existing studies highlight similar factors as those proposed by the interviewees, namely undertaking procuring and tendering that facilitate reuse of construction components (Fufa et al., 2023; Gerhardsson et al., 2020; Knoth et al, 2022; Nordby, 2019).

Regulation of demolition and reuse supporting regulation were addressed as further enablers of UMH BM implementation in Helsinki region. These are widely acknowledged in the literature as potential vehicles for increasing the amount of supply of reusable construction components and minimizing destructive demolition (Ericsson et al., 2024; Fufa et al., 2023; Huuhka et al., 2015; Huuhka & Hakanen, 2015; Knoth et al, 2022; Nordby, 2019). While their absence is considered as posing significant barriers (Ericsson et al., 2024; Fufa et al., 2023; Knoth et al, 2022). Specifically, the extant literature points to the lack of supporting regulations and that those existing are perceived as hindering reuse of construction components (Knoth et al., 2022). This mainly results from the deeply entrenched linear economic model that the current legislation is based on (Hamida et al., 2023; Knoth et al., 2022).

Based on these insights, the following proposition is given to enhance the economic and operational viability of the co-created UMH BM:

Proposition 7: By starting as a pilot project, and particularly as a non-profit pilot project, an UMH can attract direct public (and private) funding and other types of support. The status as a pilot project can further facilitate experimenting with and developing its value chain and the overall BM, to support economic viability and attractiveness for the involved actors. Besides, pilot project can support the learning of other actors, through creation and dissemination of practical knowledge, regionally and beyond. Furthermore, it can facilitate the enhancement of collaboration practices between different actors in the value chain.

6 CONCLUSION

This chapter answers the main RQ based on the findings discussed in the previous sections. Subsequently, it presents the theoretical contributions and practical implications provided by this thesis and evaluates the research quality against established criteria. The chapter concludes by addressing further limitations of this study and provides recommendations for future research.

6.1 Answering the main research question

This section recapitulates the results to answer the main research question of this thesis *What kind of an urban mining hub business model enables effective matching of supply and demand of construction components in Helsinki region?* Thus, a privately owned UMH BM for Helsinki region is presented in the following.

According to the insights gained on the value proposition, commercial organizations are the primary target group of the UMH. The specific organizations considered as most relevant customers are large construction companies, architects, developers and property owners as well as manufacturers and retailers. The demand posed by construction companies, architects, developers and property owners is project based, which can create irregularity and necessitate a large customer pool to ensure continuous demand. Manufacturers and retailers tend to pose steady demand for components due to the large customer pools they possess. The UMH establishes relationships with these target customers to increase predictability and facilitate continuous demand. To achieve this, the UMH relies on in-person communication and building networks with the target customers.

Considering the reusable construction components the UMH offers, essential attributes are high value, quality and installation readiness. A set of services is offered that strategically levers the UMH in a position where it can create supply and demand for reusable construction components and coordinate their matching. Storage, refurbishment and testing of components are offered as services to be ordered, instead of being integrated as part of the value chain. In so doing, the UMH caters to the industry actors' need to obtain solutions to reduce the CO_2 emissions of construction.

The UMH value chain adopts the streamlined value chain to ensure meeting the regional stakeholders' needs while increasing the UMH's value capture ability. A webstore serves as its central platform for matching supply and demand of reusable construction components. This involves an integrated product catalogue with a variety of information about the components, a long-term availability calendar and the possibility to reserve components against a fee. In so doing, the co-created UMH BM seeks to make the components available as early as possible to enable direct deliveries to customers. Simultaneously, a warehouse serves to store the components where necessary. Demolition contractors serve as the key suppliers of reusable construction components, followed by developers and real estate owners. Collaboration is practiced with actors from targeted fields to tap on to the information and other relevant resources that partners can offer. It further serves as a means to develop and offer different services and create novel tools and procedures that further enable the services and operations. Overall, the objective is to create supply and demand for reusable construction components as well as coordinate their matching.

The main costs the UMH needs to cover are resource and activity related. In order to reduce these costs, the UMH needs to optimize its operations. On the other hand, two key means of value capture that the UMH capitalizes on are selling services and selling reusable construction components. Depending on the component, slightly more expensive prices can be acceptable, particularly if the operator is transparent about what the prices consist of. Other factors contributing to the UMH's value capture mechanisms are external funding, particularly prior to and at the beginning of its operations. In order to secure this type of funding and other forms of support, such as a plot of land designated for the UMH operations, the UMH could start as a pilot project, or even as a non-profit pilot. The status of a (non-profit) pilot project can facilitate achieving direct public (and private) funding and other types of support, while enabling testing out and further developing the value chain prior to establishing large-scale UMH operations. Additionally, pilot project status can facilitate the enhancement of collaboration practices between different actors in the value chain.

6.2 Theoretical contributions

This study provides contributions to the UMHs BM research stream focused on the TLBMC, economic BMC, value dimensions and CBMI research streams, as well as literature on barriers and enablers of reuse of construction components. Accordingly, the first contribution is to shed light on UMHs from the BM perspective, that has previously received no proper attention in the academic literature and very limited in grey literature (Ahlén, 2021; Bestul & Gruis, 2024; Gremmen, 2018; Sandberg & Hultegård, 2021). Namely, this thesis generates understanding of how the different UMH BMs enable the matching of supply and demand, a perspective that has not been properly studied in the extant academic literature, despite being considered as the most important function of an UMH (Tsui et al., 2023). Specifically, this thesis distills two types of value chains that enable matching the supply and demand. In order to provide these empirical insights, the theoretical frameworks of *the TLBMC,* and most notably, the *economic BMC* and *the four value dimensions* are applied in data collection and analysis.

Secondly, by studying UMH BMs in the five different geographical and institutional contexts this study provides empirical understanding of the types of value propositions the UMHs offer, and how the UMHs create, deliver and capture environmental, social, and most importantly, economic value.

Thirdly, this thesis contributes to the emerging research on the potential BMs of reuse operators *in the geographical and institutional context of Finland* (HAMK, n.d.). Specifically, empirical evidence is offered on the qualities of the economic BM that is considered as suitable to an UMH in the context of Helsinki region. The results describe the type of value proposition the UMH BM can adopt and how it can create, deliver and capture value in order to cater to the needs of the regional stakeholders.

Fourthly, this study contributes to *CBMI literature* in twofold ways. Firstly, BMI for reuse of construction components has received limited attention in the CBMI literature (Nußholz et al., 2019; Nußholz et al., 2020; Nußholz & Milios, 2017; Nußholz & Whalen, 2019). This thesis further expands this understanding by applying CBMI on the novel field of UMHs. Thereby, relevant regional stakeholders, their preferences and needs were integrated in the process, and a BM innovated that attempts to meet these requirements. This offers the second contribution. Namely, co-creation is utilized as a CBMI method to collect and analyse data with and from the participating stakeholders, to create an UMH BM for Helsinki region. This opens an avenue to the utilization of co-creation as a method of BMI and CBMI, as literature on these is virtually non-existent. Indeed, co-creation has traditionally been established as two trends in the BM literature. Both of these see customer as a contributor to, either the product chain, with customer acting as a coproducer in taking over specified activities, or business value, where the customer becomes the codeveloper in service production, thereby creating shared value (Prahalad & Ramaswamy, 2000; Prahalad & Ramaswamy, 2004; Voorberg et al., 2015). By engaging stakeholders in the CBMI, this thesis lays a foundation for further scientific exploration of the integration of stakeholder perspectives in the development of CBMs and UMH BMs.

Lastly, this study contributes to the literature on the *barriers and enablers of construction component reuse* (Ericsson et al., 2024; Fufa et al., 2023; Gerhardsson et al., 2020; Hobbs & Adams, 2017; Hradil, 2014; Huuhka & Hakanen, 2015; Knoth et al., 2022; Kummen et al., 2023; Nordby, 2019; Park & Tucker, 2017; Rakhshan et al., 2020). More specifically, it expands the existing understanding to the barriers and enablers of UMH BM implementation, a topic that has not received attention in the extant literature. Furthermore, by placing its focus on Helsinki region, this thesis provides insights on a geographical and institutional context that has not yet been studied in the academic literature. In so doing, it gives an impetus for further exploration of barriers and enablers of UMH BM implementation in the region.

6.3 Practical implications

Besides theoretical contributions, this study offers practical implications for UMH operators, construction and real estate industry actors as well as for municipal authorities and policymakers. In general, the findings offer much requested, enhanced understanding of how UMH BMs can be organized and what elements they entail. Most importantly, they give insights into how these components are coordinated to enable operations, thereby matching the supply and demand of reusable construction components. In this manner, the study provides benchmarking avenues from a range of geographical and institutional contexts, most notably from Helsinki region.

For *UMH operators,* the study provides important findings of established UMH BMs by highlighting two main ways of organizing value chains. It further reveals how these serve the targeted customer segments and their implications on the UMHs' value capture ability. Consequently, the findings can help UMH operators understand how they can strategically organize their BMs, and give initial indications of which factors support the UMH's ability to capture value. With the co-created UMH BM, tailored specifically for the context of Helsinki region, and complemented with best practices from the cross-case synthesis, this thesis offers advice for already established reuse operators in the region as well as those that are planning to initiate similar businesses. Most importantly, by having integrated relevant regional stakeholders, their knowledge, needs and insights in the process, the study proposes an UMH BM deemed as suitable for the region. Proceeding in this manner further creates legitimacy for the BM and gives insights of what should be considered in creating other UMH BMs. Lastly, by presenting barriers and enablers, this thesis creates understanding of how to overcome existing barriers, for example, regarding demand uncertainty. Additionally, the presented insights can be utilized to lobby the local and national policymakers for removing the barriers, and instead, implementing factors that enable the implementation of UMH BMs.

For *construction and real estate industry actors*, the findings offer understanding of what an UMH can offer to different stakeholders and how these can benefit from the value proposition. Specifically, the results contribute to an increased understanding of how the industry actors can benefit from and contribute to creating economic, environmental and social values. The study introduces the different roles these actors can take in relation to the UMH operations and in the reuse ecosystem in general, both in Helsinki region and beyond. Lastly, insights are provided into how industry actors can remove the perceived barriers and thereby support UMH BM implementation, for example, through lobbying. For industry associations such as the Finnish Green Building Council, this study highlights the importance of creating common vocabulary and definitions, for instance, for the different CCH types, to ensure that industry actors talk with same terms.

For *municipal authorities,* the results offer benchmarks from contexts similar to the Helsinki region and thereby create understanding of what kind of roles can exist for municipal authorities. These further indicate how municipal actors can, ideally, strategically support the implementation of an UMH in general, and in the specific context of Helsinki region in particular. Furthermore, insights are given on what an UMH can offer to municipal actors and how these can benefit from the value proposition. Lastly, meta level insights arise about how the perspectives of a reuse operator and municipal actors differ on the main barriers and enablers of an UMH BM implementation, in Helsinki region. While the perceptions pragmatically align with the organizations' inherent assumptions about how the BM implementation should be supported, mutual understanding needs to be created among these two key groups to ensure successful implementation of an UMH BM. This can take place, for example, in the form of market dialogue to align understanding of the impediments and what can be undertaken to overcome these.

For national and local level *policymakers,* this thesis offers specificc advice on which topics to focus on regarding UMH BM implementation. Specifically, it indicates what are the impediments and how these can be removed and the UMH BM implementation supported.

6.4 Research quality evaluation

This section revisits the research quality criteria to evaluate to what extent the study meets these. Three types of validity, namely, external, construct and ecological validity, as well as external reliability are addressed (Bryman, 2012; Yin, 2018). In order to enhance *external validity* of the research on SRQ 1, six case studies were conducted with a subsequent cross-case synthesis. A cross-case analysis of six to ten case studies is deemed to provide a basis for deducing generalizations (Yin, 2018). This study can thus offer findings that are generalizable to similar cases in similar contexts. The transferability was further supported by delineating the rationale for the case study selection in transparent and extensive manner (Yin, 2018). Similarly, the methods applied in data collection and data analysis were elucidated in the chapter on methodology, thereby improving the generalizability of the qualitative results (Lincoln & Guba, 1990). The results on SRQ 2 and 3 are not attempted to be generalized, given the unique focus on Helsinki region.

Three measures were undertaken to meet the criterion of *construct validity*. Firstly, the well-established theoretical framework of TLBMC was utilized in the analysis of results, while its economic layer was applied in the CBMI. Both frameworks involve clearly defined concepts that serve their operationalization, thus enabling a sharp focus in the analysis. Secondly, triangulation was undertaken by using different data collection methods across the research process and particularly in the single case studies. The resulting UMH BM for Helsinki region can hence be seen as particularly strong, as it is based on the results of the cross-case synthesis and the co-creation session. Thirdly, a clear and traceable chain of evidence was established from data collection to results. The produced output relies strongly on the co-created BM. It was completed with relevant findings from the cross-case synthesis, only where clearly justified. The construct validity of this study could have been further improved by having the single case study drafts reviewed by the interviewed managers. Due to the limited time they had available to contribute to the research, this was, however, not undertaken.

Three measures were undertaken to increase *ecological validity* of this study. Firstly, by organizing a co-creation session that integrated a variety of relevant industry actors' perspectives, this study aimed to "capture the daily life conditions, opinions, values, attitudes, and knowledge base" (Cicourel, 1982, p.5) of the industry actors to produce as socially valid UMH BM as possible, for Helsinki region (Bryman, 2012). To achieve this, participants were sampled from different stakeholder categories in the industry (e.g., manufacturer, municipal authorities, etc.) to ensure lack of direct competition. While a variety of the actors, that were deemed as most important to the UMH business did participate, two key groups were not present despite invitations, namely, developers and property owners. The lack of their perspectives weakens the validity and can limit the acceptability of the developed UMH BM, from the perspective of the absent groups. Furthermore, participants were mainly invited based on their engagement in the activities of the CECP and those that had not been, had otherwise engaged with the issue prior to the session. This limits the representativeness of the participants and thus the co-created UMH BM. The second means applied to increase ecological validity was seeking to keep the atmosphere of the co-creation friendly, open and empathetic. The participants were further asked to not share outsiders what was said during the workshop. The objective hereby was to ensure that the participants could openly express their ideas and opinions during the co-creation. Third, all the semi-structured interviews were conducted in a manner that enabled a natural environment for the interviewees, thus supporting the ecological validity of the findings (Bryman, 2012). Overall, by founding the resulting UMH BM primarily on the co-created model, the risk of integrating researcher's personal biases and false interpretations in the UMH BM, is reduced. In complementing the resulting UMH BM with findings from the cross-case synthesis, the decisions are clearly outlined and justified. These measures sought to improve the ecological validity of the resulting UMH BM for Helsinki region.

In order to counteract threats to *external reliability* (see section 3.6) three types of measures were undertaken. Firstly, methods of data collection and data analysis were made as explicit as possible within the limited time available for this study (Yin, 2018). Secondly, a separate case study database was established to organize and document all the collected data (Yin, 2018). Thirdly, relevant steps and information are presented in the appendix. The single case studies and the list of case specific grey literature are presented in a separate appendix that can be made available upon request, thus enabling potential replication.

6.5 Limitations and recommendations for future research

This section presents identified limitations of this study and provides recommendations for further research. Three recommendations arise from the limitations, while three are provided based on observed lack of academic literature and identified, interesting research avenues. Regarding limitations, the lack of developer and property owner representatives in the co-creation presents a shortcoming of the created UMH BM. This results from the fact that they present two highly relevant customer segments to the UMH operations. The absence of their knowledge, needs and preferences in the co-created UMH BM lowers the likelihood that the UMH genuinely serves their needs and is utilized by these groups. Furthermore, the lack of their perspectives can weaken the BM's suitability for all relevant stakeholders. It is the diversity of perspectives that strengthen group deliberation (Karadzhov et al., 2024). Against this background, it is recommended that the co-created BM for Helsinki region is further iterated by incorporating developers', property owners' and other relevant stakeholders' perspectives. Further rounds of iteration can be undertaken with other stakeholders, until saturation of input and perspectives is reached. As the knowledge of the potential UMH BMs continues to accumulate, it is important to co-create novel UMH BMs for Helsinki region, to optimize and strengthen the value propositions, and means of value creation, delivery and capture of those existing and those to be created.

The second major constraint of this thesis is its limited focus on the environmental and social layers of the TLBMC, both in the multiple case study and in the co-created UMH BM. While some of the elements on environmental and social layers were studied in the multiple case study, the study does not provide a comprehensive understanding of what types of environmental and social value the UMHs offer, and how do they create, deliver and capture this value. The co-created UMH BM for Helsinki region, in turn, does not address any elements from the two layers. The narrow focus lies on the limited resources available for this study. In order to address these knowledge gaps, it is recommended, firstly, that further interviews are conducted with same UMH managers on environmental and social layers to complement the case studies. On the other hand, it is essential that further multiple case studies are conducted on different cases to provide robust evidence on how the UMH BMs create, deliver and capture economic, environmental and social value. Thereby, it should be ensured that the case study results are validated by the interviewees. Secondly, it is proposed that all the three layers of sustainability are as equally addressed as possible, in co-creation sessions regarding Helsinki region and beyond. Considering Helsinki region, the co-created economic BMC can be complemented with further sessions on environmental and social layers, until saturation of input is reached.

Thirdly, a flawed assessment of the type of replication was made when selecting the cases for the multiple case study. Namely, this thesis aimed for literal replication of the selected multiple cases, with the expectation to receive similar results across the six cases. After initial analysis of the semi-structured interview results, it was, however, observed that the cases produce two different types of results in terms of their value chain. A successful literal replication would have required prior knowledge of the outcomes to ensure similarity of the cases (Yin, 2018). This would have necessitated conducting multiple case studies prior to selecting cases for the actual study. This, however, was not possible due to the limited resources available for this study. Nevertheless, the study succeeds in providing valuable insights of the different UMHs and distils two key value chains that UMH possess. Further multiple case studies on UMH BMs are, however, needed to produce detailed understanding of the mechanisms that they develop to match supply and demand of reusable construction components. Both literal and theoretical replication are needed to strategically enhance existing UMH BMs and those to be created. While theoretical replication can provide valuable evidence on why and how cases differ in terms of their ability to match supply and demand, literal replication can offer in-depth insights into the specific elements that enable matching supply and demand.

Three further recommendations are provided based on the limited understanding of UMH BMs and interesting research avenues identified in the course of research. Firstly, the differences in UMH BM's ability to capture value should be further investigated, as the economic viability of UMHs is a topic of debate and scepticism. It is hence proposed that multiple case studies with theoretical replication are first conducted to contrast extreme cases in terms of their value capture capacity. The results can offer valuable information about how and why the cases differ in this aspect. Based on the extracted insights, a follow-up, multiple case study with literal replication can be conducted to gain in-depth insights into how specifically the factors, identified as either facilitating the UMH's ability to capture value or weakening it, influence the value capture capacity. The indications provided in this study can be tested as hypotheses in a future study, as no theory exists yet about which factors influence the UMHs ability to capture value.

Secondly, it is proposed that UMH BMs, that create and capitalize on ecosystems in order to create and deliver value to its customer segments, are examined through the circular ecosystem management perspective (Gomes et al., 2023). The derived information can contribute to understanding of how matching the supply and demand of reusable construction components takes place in the ecosystems created, sustained and scaled up by the UMH. The results can further offer valuable insights for strategic enhancement of existing UMH BMs and those to be created.

Thirdly, the lack of mutual understanding of CCH definitions and inadequate UMH conceptualization ask for enhancing those existing (Tsui et al., 2023; Van Uden, 2024). The two main value chains identified in this thesis pose a major question and a starting point for how the UMHs should be conceptualized. Namely, whether an UMH should be defined by the configuration of its value chain in parallel to or instead of qualities such as the size of the warehouse and the types of products it deals with, as identified by Tsui et al. (2023). For example, can a reuse operator that employs warehouse value chain be defined as a material bank, while one that capitalizes on streamlined value chain is an UMH. Thus, more research is proposed to refine the concept of an UMH.

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APPENDICES

APPENDIX A. Grey literature

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APPENDIX B. UMH BM for streamlined value chain

Partners

- Suppliers:
  - Property owners
- Partners:
  - Architects
  - Waste management companies
  - Manufacturers

Activities

- Inventory
- Quality assessment
- Building established customer relationships
- Transportation
- Collaboration

Resources

- Digital infrastructure:
  - Digital platform
  - Website/webstore
- Physical infrastructure
  - Warehouse
- Social infrastructure:
  - Personal contact
  - Contracts with purchasers

Value Proposition

- Products:
  - Non-structural elements
  - Internal space elements
  - Furniture
  - Services elements
  - Structural elements
  - Secondary raw materials
- Services (excl. Case C):
  - Interim storage
  - Architectural and design services
  - Component availability mapping
- Value: construction with reduced environmental and CO2 footprints

Customer Relationship

- Established customer relationships

- Sales:
  - Digital platform
  - Personal contact
  - Contracts with manufacturers, retailers
- Communication:
  - Website/webstore
  - Social media (esp. LinkedIn)
  - Public speaking

Customer Segments

- Retailers
- Manufacturers
- Developers
- Architects

Costs

- Employee wages
- Land lease
- Demolition assets (Cases B and C)
- Component acquisition

Revenues

- Sale of reusable construction components
- Sale of services

APPENDIX C. UMH BM for warehouse value chain

Partners

- Suppliers:
  - Demolition contractors
- Partners:
  - Demolition contractors
  - Waste management companies

Activities

- Quality assessment
- Cleaning and refurbishment of components
- Marketing
- Warehouse management
- Collaboration

Resources

- Digital infrastructure:
  - Webstore
  - Warehouse management system
- Physical infrastructure
  - Warehouse

Value Proposition

- Products:
  - Non-structural elements
  - Internal space elements
  - Furniture
  - Services elements
  - Structural elements (Case D)
- Services (excl. Case C):
  - Creating supply of components
  - Tailoring components to customers' needs
  - Interim storage
- Value: construction with reduced environmental and CO2 footprints

Customer Relationship

- Non-established customer relationships

Channels

- Sales:
  - Webstores
  - Physical stores
- Communication:
  - Website/webstore
  - Social media: LinkedIn, Instagram
  - Public speaking

Customer Segments

- Small renovation contractors
- Other small companies
- Private households

Costs

- Employee wages
- Land lease
- Component acquisition (excl. Case D)

Revenues

- Sale of reusable construction components
- Sale of services