Economic Viability of Circular Construction Business Models

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Conceptual Formulation

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Topic: ECONOMIC VIABILITY OF CIRCULAR CONSTRUCTION BUSINESS MODELS

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Introduction

According to a Bain & Company poll from 2021, over 33% of executives believe that disruptive circularity start-ups will have an impact on their sector, and 50% believe that in the following ten years, circularity will become the "new normal" for all businesses (World Economic Forum, 2022). Strategically speaking, a circular business model is necessary, not trendy. To allow circular business models, new ways of thinking, the capacity to create new alliances throughout your value chain and with your rivals, the willingness to scale up current operations, and the ability to modify existing supply networks will all be essential.

Circular economy according to EMF, 2012 replaces end-of-life' concept with restoration. (Ellen Macarthur Foundation, 2012) To achieve circularity, materials must be reused and kept closer to the consumer to minimise the material losses. However, the execution of circularity completely depends on the supply chain which is further influenced by the demand from the clients. Considering the environmental concerns and assuming that the authorities shall take a strict stand in helping businesses implement circularity, the study aims to develop circularity-based construction business models (CCBM). (R. T. Hazem, 2019)

A primary guiding document in this regard is the "Circular Business Models for the Built Environment" together developed by the Arup and BAM under the Europa.eu, highlights how the added value as a result of circularity has possibilities of motivating the stakeholders to adopt circular business models. According to the report, the circular economy offers plenty of opportunities and risks to current companies. Established marketplace has witnessed dynamic growth due to the disruptive innovators with new business strategies based on the principles of the circular economy. (Guglielmo Carra, N.d)

"Environmental risk is particularly evident", in the construction industry (Górecki, 2019). CCBMs not only support to meet the gradually growing demand in the industry but also shall assist companies in reducing both their expenses for raw materials and garbage handling. Considering the hefty taxes being imposed on disposal, companies can gain significant financial advantages by reducing the amount of waste produced.

In the study, it is suggested that one way to quicken the shift to a circular economy is by giving building companies a solid guarantee of getting a competitive edge and persuading them of their unavoidable need for it. (Górecki, 2019) Therefore, the

creation of suitable rewards to grow this new market is necessary to make this concept a reality. Several issues such as over exploitation of natural resources, generation of construction waste reduction, generation of pollutants will be addressed through the formulation of circular construction business models, while simultaneously aiding in cost reduction, improving resource efficiency and providing a competitive advantage to the business.

Research Questions & Objectives

The research objective is to determine measures that the construction companies can take to integrate circularity in their business models. The research questions, the study has to address are as follows:

- What are Circular Business Models in the construction industry or any affiliated industry?
- What are the practical initiatives implemented in the construction industry that are making progress towards developing functional CCBMs?
- What are the barriers to bridge the gap between the available approaches of CCBMs and their practical utilisation in the industry?
- How can the aforementioned findings be utilised by Construction companies to implement and deliver an effective CCBM?

Research methodology.

The study is conducted using a three-stage process. A keyword search and the purposive strategy are used to perform a literature review during the first stage. Relevant theories, frameworks and best practices related to CCBMs, and affiliated industries are identified and analysed. Four research questions are setup to take forward the entire study. First two questions are analysed with the help of literature review. Apart from the generic research on Circular Business models, data is collected on existing initiatives and case studies and innovative practices implemented by construction companies towards the development of functional CCBMs. Based on the literature review results, qualitative data is collected.

Due to the uniqueness of the research subject, an inductive and pragmatic strategy is adopted in the second stage, utilising a qualitative method to gather views from key

stakeholders in the industry. Semi-structured interviews are used to research the subject using a survey technique. Questions are structured to gather the opinions on bridging the gap between existing circular approaches and their practical utilisation in the industry and to put forward their ideas for a functional CCBM. A Thematic Qualitative Analysis is used to obtain the results.

Simultaneously, 5D and 7D analysis of a BIM model is carried out to understand the material and cost fluctuations in a Circular model to a linear model. The exercise brings in a deeper understanding on the optimal use of materials and resources during the entire lifecycle of the project and to identify areas where circular aspects can be integrated to minimise cost fluctuations.

Data analysis will lead to examining the gaps and challenges between research and practical implementation of CCBMs. Also, the study recommends potential steps that construction companies can implement to improve functional CCBMs and the areas where it can be integrated to create added value.

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Abstract

This thesis analyzes the economic viability of circular construction business models (CCBMs) in the European construction industry, with a special emphasis on the Central Europe. It intends to identify and evaluate strategies that not only allow for the integration of circular practices into construction businesses without risking their economic viability, but also potentially enhance their profitability and competitive edge. The study adopts a mixed-method approach, combining systematic literature reviews, a conceptual framework based on the ReSOLVE framework and the Business Model Canvas, and in-depth case studies of organizations such as Bouygues Construction and Rebel Group. This study delves deeply into current definitions, real-life initiatives, and the economic and regulatory obstacles that affect CCBMs. It logically evaluates the operational and economic impacts of using circular practices in construction, providing actionable insights for businesses seeking to transition to sustainability. The findings show that the early barriers to CCBMs, such as high upfront costs and uncertain return on investment, are outweighed by long-term financial gains, social and environmental benefits like reduced waste, resource efficiency, and market leadership in sustainable construction techniques. The thesis emphasizes the importance of strategic planning, regulatory support, and new business models in successfully implementing and scaling CCBMs, providing significant insights into both academic literature and industry practices.

Keywords: Circular Construction Business Models, Circular Economy, Circular Business Models

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List of Abbreviations

CE	Circular Economy
CBM	Circular Business Model
BM	Business Model
CCBM	Circular Construction Business Model
CCBMC	Circular Construction Business Model Canvas
EMF	Ellan Macarthur Foundation
WEF	World Economic Forum
EEA	European Environmental Agency
BMC	Business Model Canvas
LEED	Leadership in Energy and Environmental Design
LE	Linear Economy
LBM	Linear Business Model
BIM	Building Information Modelling
BREEAM	Building Research Establishment Environmental Assessment Methodology
ROI	Return on Investment
R&D	Research and Development
PESTLE	Political, Economic, Social, Technological, Legal, and Environmental

Chapter 1. Introduction

According to a Bain & Company poll from 2021, over 33% of executives believe that disruptive circularity start-ups will have an impact on their sector, and 50% believe that in the following ten years, circularity will become the "new normal" for all businesses (World Economic Forum, 2022). Strategically speaking, a circular business model is necessary, not trendy. To allow circular business models, new ways of thinking, the capacity to create new alliances throughout your value chain and with your rivals, the willingness to scale up current operations, and the ability to modify existing supply networks will all be essential.

This thesis investigates the implementation of Circular Construction Business Models (CCBMs), which seek to shift the traditional end-of-life notion into one of restoration and continued usage, as emphasized by the Ellen Macarthur Foundation. Such models are critical not just for minimizing environmental effect, but also for increasing economic viability (Ellen Macarthur Foundation, 2021a) through more efficient resource utilization and waste reduction. The move to circularity, however, is dependent on the construction industry's ability to innovate supply chain operations and nurture new collaborations across competitive lines to effectively respond to rising regulatory and consumer sustainability expectations (Hazem & Breesam, 2019).

A pimary guiding document in this regard is the “Circular Business Models for the Built Environment” together developed by the Arup and Royal BAM Group under the Europa.eu, highlights how the added value as a result of circularity has possibilities of motivating the stakeholders to adopt circular business models. According to the report, the circular economy offers plenty of opportunities and risks to current companies. Established marketplace has witnessed dynamic growth due to the disruptive innovators with new business strategies based on the principles of the circular economy. (European Circular Economy Stakeholder Platform, 2018) CCBMs not only support to meet the gradually growing demand in the industry but also shall assist companies in reducing both their expenses for raw materials and waste handling. (Górecki, Núñez-Cacho, Corpas-Iglesias, & Molina, 2019) One simple example is the

the hefty taxes being imposed on disposal; companies can gain significant financial advantages by reducing the amount of waste produced.

Briefly, the goal of this research is to identify frameworks and tactics that can help the construction sector transition to a more circular model. It contends that adopting circular concepts is not only essential for environmental sustainability, but also a strategic advantage that can lead to increased economic resilience and innovation in the construction industry. The ideal is to generate actionable insights that will assist construction companies in transitioning to and thriving within this new circular paradigm, ensuring profitability and sustainability.

1.1 Background Study

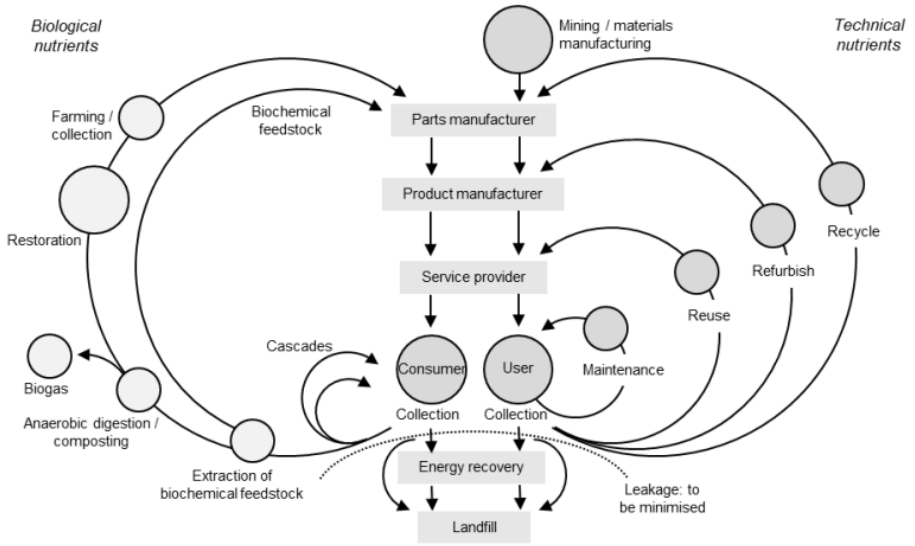

Figure 1-Circular Economic Flow (Ellen Macarthur Foundation, 2021a)

Circular economy according to Ellen Macarthur Foundation, replaces end-of-life' concept with restoration (Ellen Macarthur Foundation, 2021a). To achieve circularity, materials must be reused and kept closer to the consumer to minimise the material losses. Circularity in construction entails creating structures that, at the end of their useful lives, can be recycled, remade, or dismantled rather than being dumped in a landfill. (European Circular Economy Stakeholder Platform, 2018) Studies suggest that demand for a circular economy will increase economic development by up to 4% over the next ten years. (European Environment Agency, 2021)

According to the European Environmental Agency, framework for enabling business models framed around circularity principles serve as innovation that can disrupt the industry and with the help of other enablers can help achieve circular transformation. (European Environment Agency, 2021)

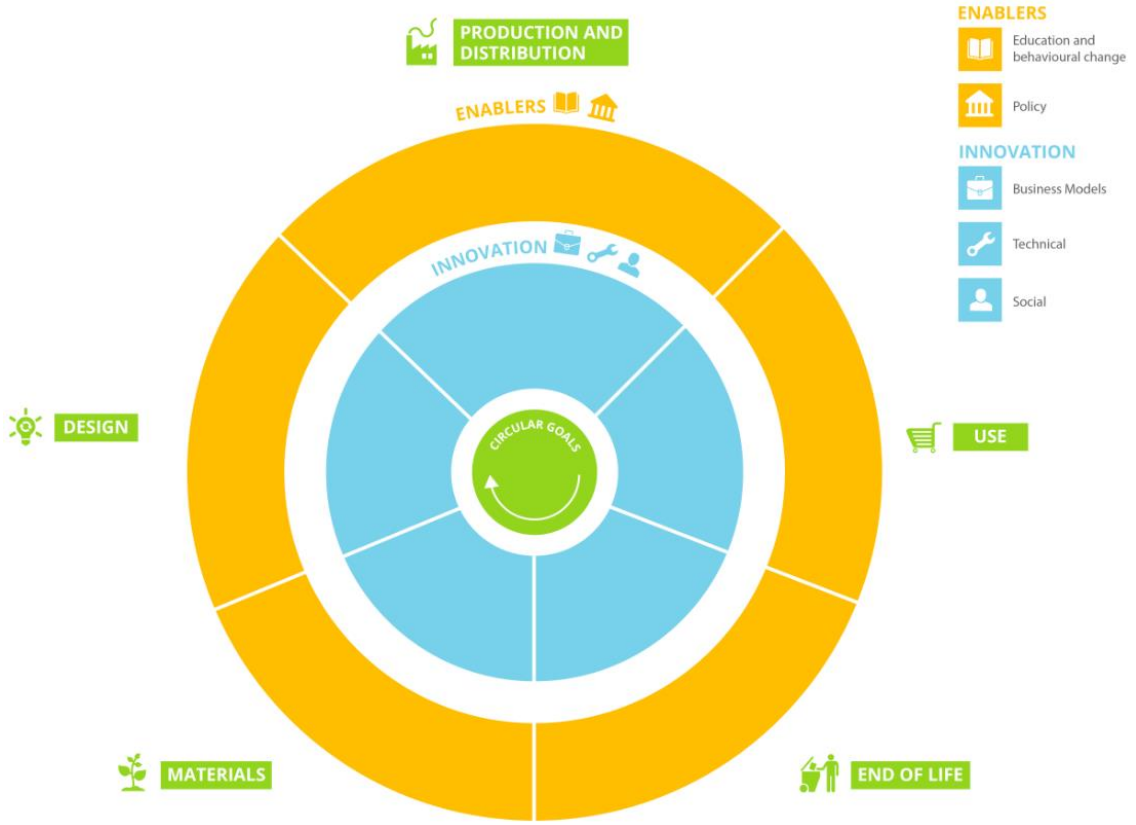

Figure 2-Analytical framework for Circular Business Model (European Environment Agency, 2021)

Due to the wastes produced by building and demolition activities, which make up a sizable percentage of global waste, circularity is becoming more essential in the construction business. The industry can lessen its effect on the climate, preserve natural resources, and open up new business possibilities by adopting circular principles. (European Circular Economy Stakeholder Platform, 2018) From the use of sustainable materials to the creation of structures and buildings that can be quickly dismantled and have parts that can be repurposed or reused, there are many ways to accomplish circularity in construction.

However, the execution of circularity completely depends on the supply chain which is further influenced by the demand from the clients. Considering that the circularity

transformation is the need of the hour due to environmental concerns and assuming that the authorities shall take a strict stand in helping businesses implement circularity, the study aims to develop circularity based construction business models. (Hazem & Breesam, 2019) There is a clear need to look for methods to convert a conventional construction process into a sustainable one because actions carried out throughout the entirety of the building life cycle have a detrimental effect on the environment. (Górecki et al., 2019)

A primary guiding document in this regard is the “Circular Business Models for the Built Environment” together developed by the Arup and BAM under the Europa.eu, highlights how the added value as a result of circularity has possibilities of motivating the stakeholders to adopt circular business models. According to the report, the circular economy offers plenty of opportunities and risks to current companies. Established marketplace has witnessed dynamic growth due to the disruptive innovators with new business strategies based on the principles of the circular economy. (European Circular Economy Stakeholder Platform, 2018)

The different business models integrating circularity to make construction more sustainable is given by (Roland Berger, 2021).

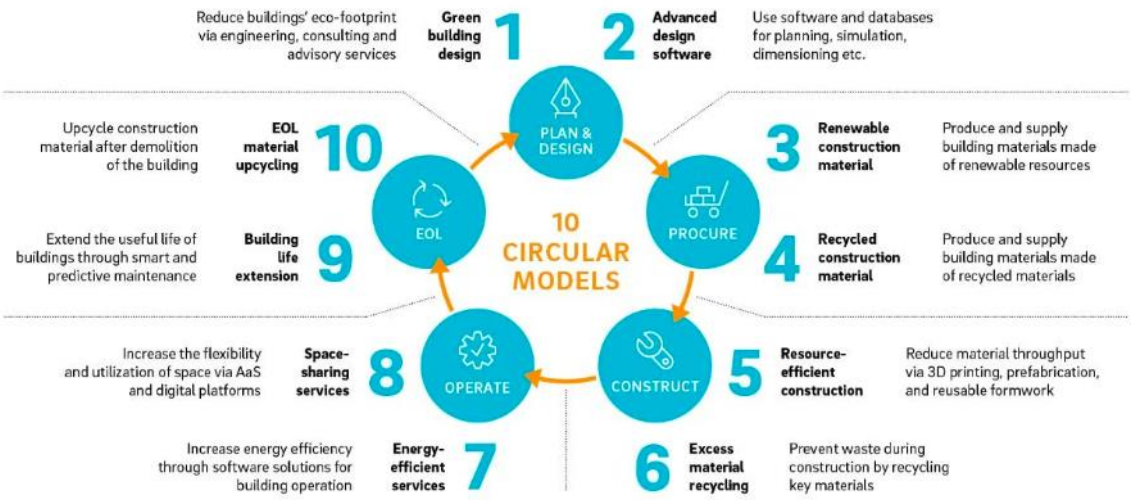

Figure 3-Different Business Models integrating Circularity (Roland Berger, 2021)

Circular business models not only support to meet the gradually growing demand in the industry but also shall assist companies in reducing both their expenses for raw materials and waste management. By reducing the amount of garbage that is disposed of in landfills, the companies can also gain significant financial advantages considering the hefty taxes being imposed on disposal. According to Gorecki et.al, “environmental risk is particularly evident,” in the construction industry. (Górecki et al., 2019)

In order to fully incorporate within the supply chain, which way CE is most effective, Gorecki et al. propose three distinct business models (general contractor, real estate development and integrated supply chain typical for project management) that are suggested as a path towards total integration within supply chains that are used as a method for controlling the flow of materials and waste in sustainable construction projects.

In the study, it is suggested that one way to quicken the shift to a circular economy is by giving building companies a solid guarantee of getting a competitive edge and persuading them of their unavoidable need for it. (Górecki et al., 2019) Therefore, the creation of suitable rewards to grow this new market is necessary to make this concept a reality.

Several issues such as over exploitation of natural resources, generation of construction waste reduction, generation of pollutants will be addressed through the formulation of circular construction business models. While simultaneously aiding in cost reduction, improving resource efficiency, and providing a competitive advantage to the business.

1.2 Research Objective

The primary objective of the research is to identify and evaluate strategies that encourage construction businesses to integrate circularity in their business models, by not affecting their economic viability and profitability; or even better, by enhancing them. This dual focused objective is to not only to investigate concrete ways for implementing circular practices, but also to analyze the braoder financial and

operational implications, ensuring that the transition promotes sustainable growth and competitive advantage in the construction industry.

Inorder to fulfill the objective, four research questions are established, which are expected to be answered at various stages of the research.

- How are Circular Business Models currently defined and applied in the construction industry?

- What are the practical initiatives implemented in the construction industry that are making progress towards developing functional CCBMs?

- What are the economic and regulatory barriers to bridge the gap between the available approaches of CCBMs and their practical utilisation in the industry?

- How can the aforementioned findings be utilised by Construction companies to implement and scale an effective and profitable CCBM?

1.3 Scope of Research

The scope of this thesis is primarily focused on assessing the economic viability of Circular Construction Business Models (CCBMs) within the Central European context, with specific emphasis on case studies from the Netherlands and France. These areas were chosen because of their innovative contributions to the development and application of circular economy-based sustainable building techniques.

This research examines current definitions and applications of CCBMs in the European construction sector through a review of the literature, among other important topics. It also focuses on specific case studies in the Central European environment to provide insights into the adoption of circular processes and highlight both financial rewards and obstacles. To help with the transition to more environmentally friendly building techniques, a comparative study of the benefits and drawbacks of linear and circular business models must also be done. The study also addresses the identification and resolution of impediments to efficient CCBM implementation, suggests solutions, and

investigates the legislative and economic implications that could promote wider acceptance of these models.

1.4 Research framework

This research aims to explore the economic viability of Circular Construction Business Models (CCBMs) through a comprehensive, mixed-method approach, integrating both qualitative and quantitative methods. The study is conducted using a four-stage process- a systematic literature review, the development of a conceptual framework to assess circularity in construction businesses, case study analysis and application of the framework in one of the business case studies to obtain the results.

Initially, a systematic literature review will be conducted to gather and analyse existing knowledge on circular business models in the construction industry. Key databases such as ScienceDirect and Google Scholar will be utilized to source relevant academic papers, industry reports, and policy documents. The keywords "circular construction," "circular business models," and "circular construction businesses" will be used to ensure a thorough search.

Secondly, the study will focus on creating a conceptual framework to evaluate circularity in construction businesses after the literature review. This will entail using an existing model or modifying and combining current models to produce a new Conceptual CCBM Canvas that is especially suited for the construction sector.

Thirdly, selected companies who have adopted circular practices will be the subject of in-depth case studies aimed at validating and improving this framework. The case studies will offer practical insights about the operational and financial effects of CCBM implementation. Financial performance evaluations, document analysis, and comparative analysis will all be used to gather data.

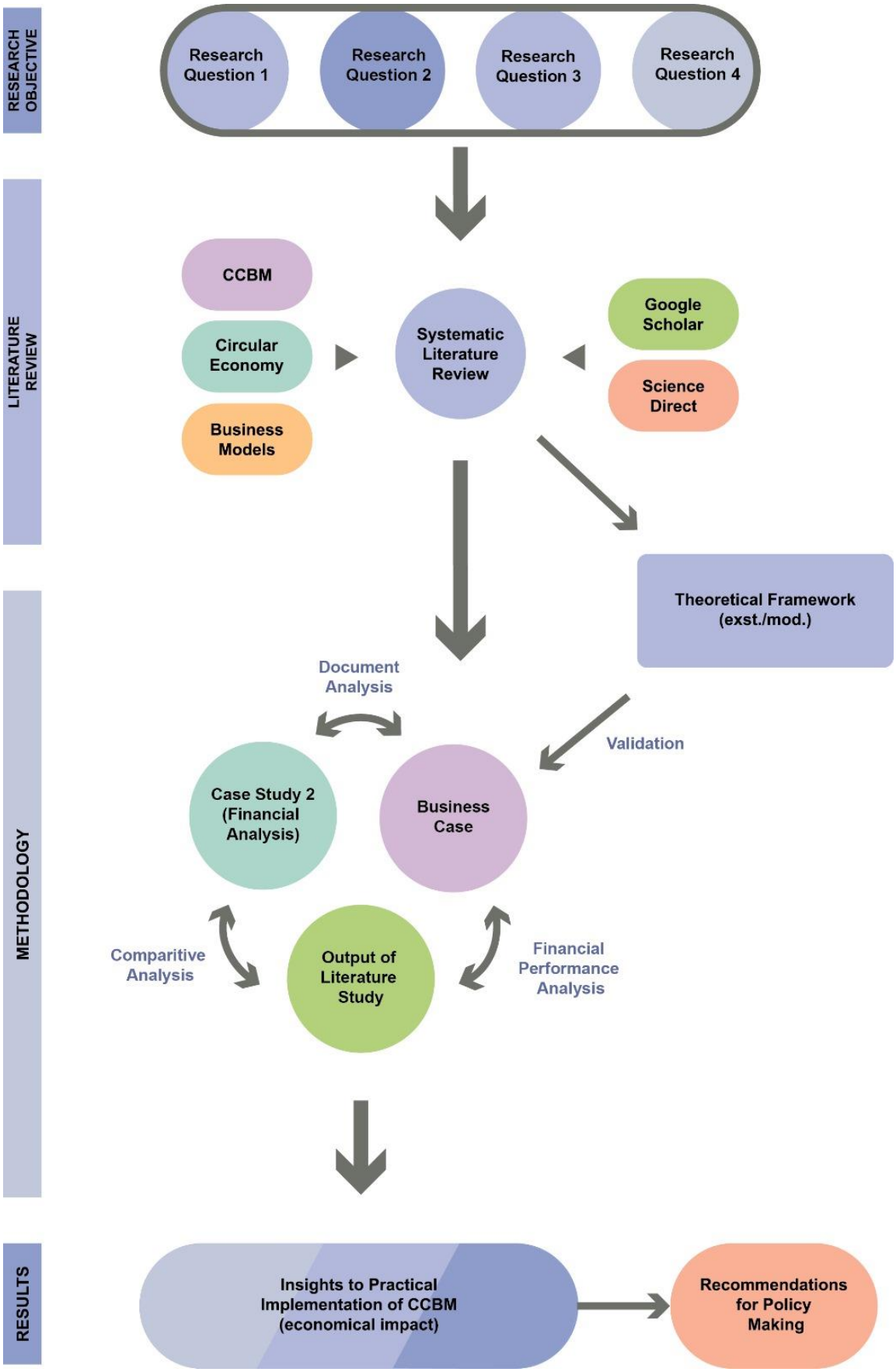

Figure 4-Research Framework

The combination of qualitative and quantitative methods will enable a comprehensive analysis of the economic viability of CCBMs. The study will pinpoint the main implementation barriers, views from the economic sector, and implications for policy development. Strong CCBM analysis, practical insights for construction organizations, and contributions to academic research and industry practices are among the expected results. In the conclusion, this study will offer practical recommendations for the construction industry's successful adoption and shift to circular business models.

Chapter 2. Literature Review

The circular economy's tenets are driving a revolutionary transition in the building sector toward sustainability and resource efficiency. A thorough analysis of the body of research on circular economy and its implementation in the building industry is given in this chapter. It starts by going over the basic ideas and precepts that support the circular economy. This is followed by a thorough analysis of circular building techniques. The topic then shifts to how circular ideas are applied in the construction industry, showcasing cutting-edge tactics and tools that encourage material recycling, waste minimization, and lifecycle thinking.

This chapter also highlights the operational, environmental, and financial distinctions between the construction industry's circular and traditional business models. The literature analysis also highlights the main obstacles to the adoption of circular construction business models, such as monetary, cultural, and legal issues. The chapter seeks to provide a theoretical foundation supporting the economic feasibility of circular construction business models through this critical examination, laying the groundwork for the ensuing empirical study.

2.1 Circular Economy: An Overview

A holistic approach to economic growth that benefits companies, society, and the environment is known as the circular economy.(Geissdoerfer, Savaget, Bocken, & Hultink, 2017) In contrast to the conventional linear economy, which works on the 'take, make, discard' approach, the circular economy seeks to redefine growth by emphasizing advantages for the entire society. It entails designing waste out of the system and progressively severing the link between economic activity and the use of limited resources.

2.1.1 Key definitions

- The circular economy is an economic concept based on the ideas of designing out waste and pollution, regenerating natural systems, and keeping products

and materials in use in order to eliminate waste and the continuous use of resources. (Ellen Macarthur Foundation, 2013)

- Circular Economy is a closed-loop system in which products and materials are continuously cycled back into use, reducing the need for new resources. (Stahel, 2016)

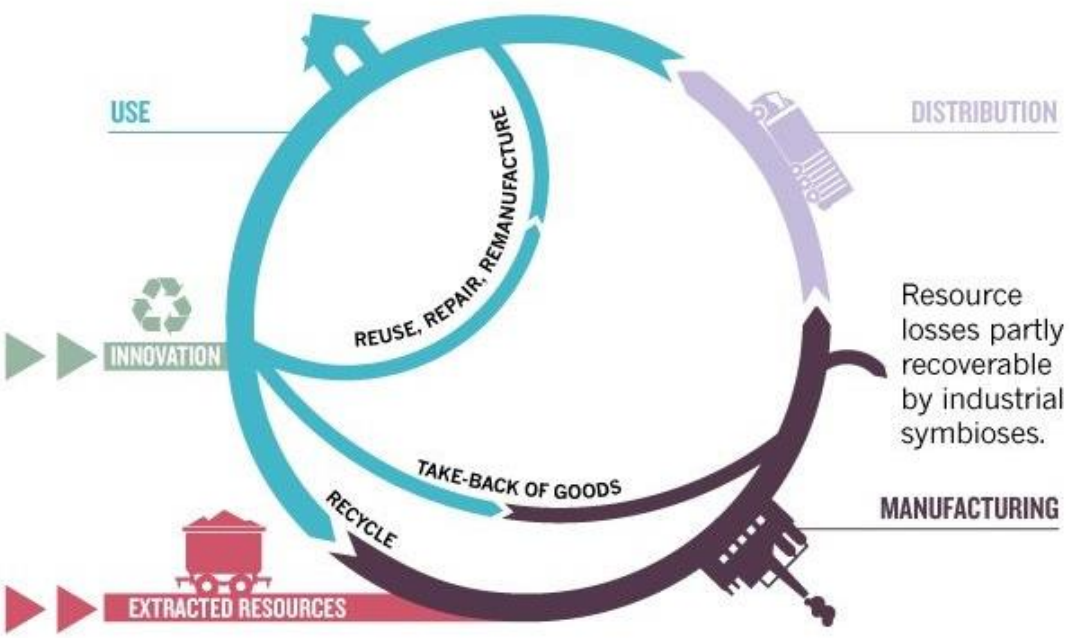

Figure 5- Circular Economy defined by Walter R. Stahel (Stahel, 2016)

2.1.2 Key proponents

- Walter Stahel: Being a proponent of a closed-loop economy since the 1970s, he is regarded as one of the originators of the circular economy concept. A generous portion of the current understanding of circular economic principles can be attributed to his work.
- The Ellen MacArthur Foundation: Founded by the former sailor Ellen MacArthur, the foundation has played a crucial role in promoting the circular economy through collaborations with governments and corporations, campaigning, and research.

The circular economy, which has its origins in a number of sustainability movements and notable proponents such as Ellen MacArthur Foundation and Walter Stahel, offers a solid foundation for creating resilient and sustainable business processes, especially in the construction sector.

2.1.3 Key Principles

The Circular Economy Principles, at the heart of the implementation of Circular Construction Business Models (CCBMs), have their roots in resource conservation and waste management tactics (EMF, 2020). The Ellen MacArthur Foundation, a leading proponent of the circular economy, asserts that these principles place particular emphasis on the following crucial elements:

- **Regenerative Design:** According to this theory, systems, materials, and products should be developed and used in a way that promotes the renewal of natural systems. It assures the effective use of materials throughout their life cycles and encourages the use of renewable resources while reducing the usage of non-renewable ones. (EMF, 2020)
- **Resource Efficiency:** With a focus on resource usage optimisation, this approach seeks to maximise the value derivable from goods and materials (EMF, 2020). It promotes the use of sustainable energy sources, lower raw material usage, and more effective manufacturing techniques (EMF, 2020), which reduce waste production.
- **Waste Management and Prevention:** This approach emphasises the reduction, reuse, and recycling of materials to minimise the environmental effect, which is consistent with the idea of "waste as a resource." It emphasises the significance of minimising reliance on landfills and incineration for waste disposal and completing material loops (Joint Research Centre (European Commission), 2016).
- **Product Longevity and Durability:** According to the principles of the circular economy, items should be made in a way that allows for simple maintenance, repair, and upgrading (Interreg Europe, 2019). This idea strives to lessen the need for added resources generally and decrease environmental responsibilities by prolonging the lifespan of goods.
- **Systems thinking and collaborative business models:** This principle encourages the development of systemic techniques to deal with complex environmental and economic concerns by fostering cooperation among stakeholders (Interreg Europe, 2019). In order to promote sustainable and circular practises, it highlights the significance of holistic thinking, collaboration

across value chains, and the integration of multiple business models (EMF, 2020).

Circular Construction Business Models (CCBMs) can effectively contribute to sustainable development and economic viability by thoroughly integrating these circular economy principles into the construction industry, fostering a paradigm shift towards a more environmentally aware and resource-efficient future.

2.1.4 Circular Ideas in Practice

For the construction industry and linked industries to promote sustainable practises and achieve economic viability, circular thinking must be applied. The use of **circular economy ideas in practise** is demonstrated in a number of key areas:

- Strategies for Material Selection and Procurement: Supporting the use of recyclable and sustainable materials, such as recovered or reused materials, helps to reduce the consumption of raw materials. The circularity of building practises is enhanced by implementing efficient procurement methods that prioritise the use of renewable resources and encourage ethical sourcing (Guerra et al., 2021).
- Modular and Prefabricated Construction Methods: Using modular and prefabricated construction techniques together makes it easier to use materials efficiently, generate less waste, and disassemble and reconfigure structures quickly (Guerra et al., 2021). These methods encourage adaptability and flexibility by enabling the reuse and recycling of building materials (Erasmus+ Programme, 2020), encouraging a circular approach to construction projects.
- Systems for Waste Management and Recycling: Implementing thorough systems for waste management and recycling on construction sites guarantees that construction waste is properly sorted, segregated, and recycled. Utilising recycling facilities on-site and encouraging the use of recycled materials in upcoming building projects help to maximise resource efficiency and reduce environmental impact. (Guerra et al., 2021)
- Building adaptability and lifetime assessments: Conducting detailed lifecycle analyses of buildings makes it easier to spot potential for improved energy

performance, maintenance efficiency, and adaptive reuse. Buildings may be easily reconfigured, renovated, or repurposed when they are designed with flexibility in mind. (Guerra et al., 2021) This increases their lifetime and lowers the demand for new building supplies.

- Collaborative Value Chain Integration: Promoting teamwork among stakeholders, such as designers, contractors, suppliers of materials, and waste management firms, encourages a comprehensive approach to circularity. Resource efficiency, waste reduction, and sustainable practises are promoted throughout the construction and related industries by establishing efficient communication channels and putting shared value chain initiatives into practise.

Construction and related industries may attain economic sustainability while making a substantial contribution to sustainable development and environmental stewardship by successfully adopting these circular ideas.

2.2 Defining CCBMs

The supply of infrastructure, urbanisation, and economic growth all rely heavily on the building sector. It is connected to serious environmental problems, though, such resource depletion, waste production, and carbon emissions. In response to these difficulties, the idea of circular construction business models (CCBMs) has arisen as a revolutionary strategy that aims to balance the development of the construction sector with sustainability objectives. (Munaro, Freitas, Maria do Carmo Duarte, Tavares, & Bragança, 2021)

According to (Roland Berger, 2021), construction business models that adhere to sustainability and circular economy concepts are known as circular construction business models (CCBMs). Through the use of closed-loop systems, where resources are optimised, waste is eliminated, and environmental consequences are minimised, these models seek to replace conventional linear building methods. (Roland Berger, 2021)

A Circular Construction Business model (CCBM) is fundamentally different from the linear "take-make-dispose" approach that has historically defined the construction industry. (European Circular Economy Stakeholder Platform, 2018) The circular

economy is based on the maximisation of resource utilisation, the reduction of waste, and the mitigation of environmental effects.

In a CCBM, the whole lifetime of construction projects is redesigned to create a closed-loop system, from design and material selection to construction and end-of-life. This implies that resources and materials be utilised for as long as feasible and that their worth is maintained even after a building's useful life has ended. (Hazem & Breesam, 2019) CCBMs seek to maximise material value, minimise waste, and lessen the environmental impact of building operations.

A BM is made up of four interconnected components: value delivery, value capture, value proposition, and value creation (MW Johnson, 2008). Furthermore, while describing CBM in the context of construction, six components were found to be important: the lifecycle view, stakeholder engagement, value creation, value delivery, value proposition, and value capture. Based on the body of knowledge regarding CBM that already exists, the elements were determined using the qualitative content analysis technique. Following figure shows the features characterising CBM in the construction context, drawing on the previous talks from the chosen literature review.

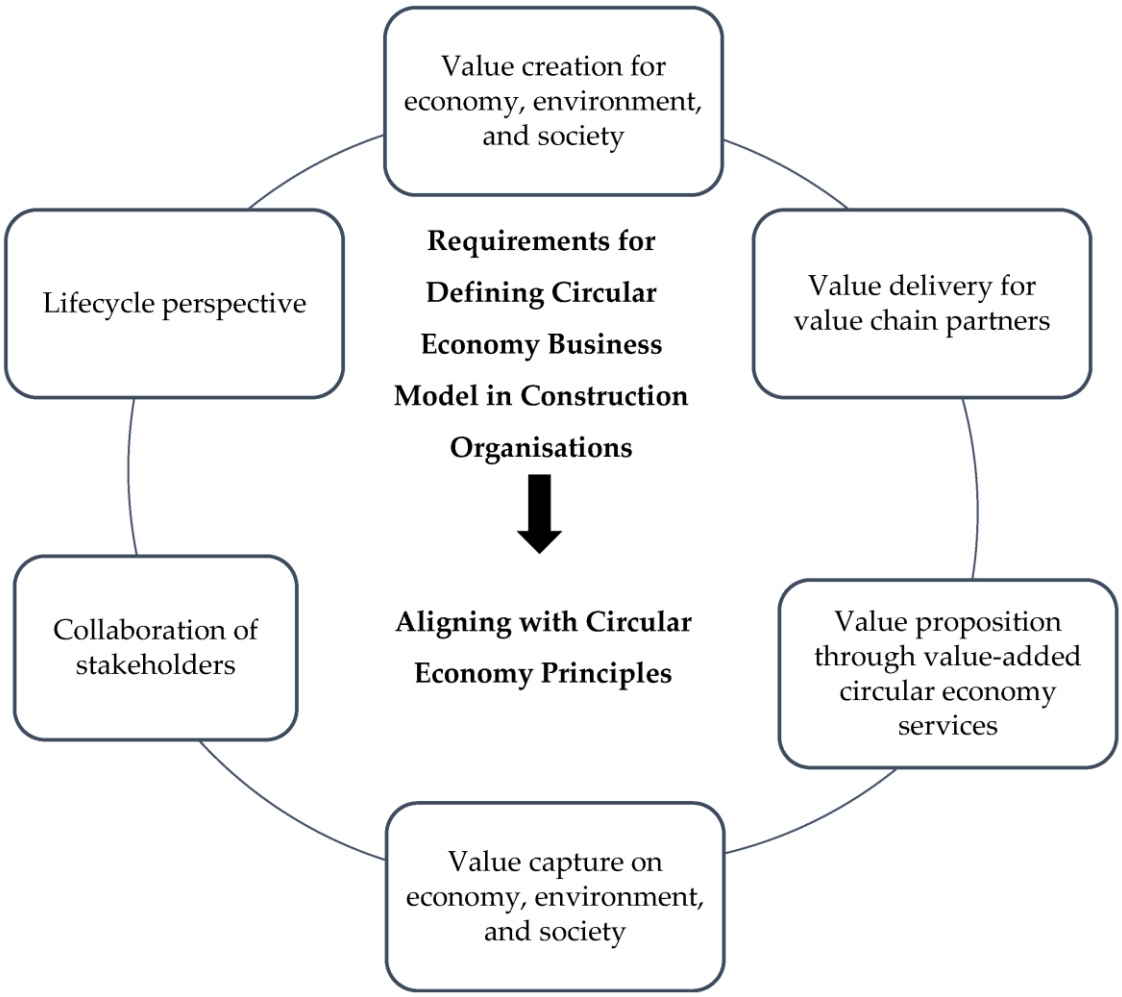

Figure 6-Requirements for defining circular economy business model in construction organisations. (Jayakodi, Senaratne, & Perera, 2024)

- **Value Creation:** Currently, BMs are widely used in other economic sectors for the purpose of designing, comparing, and evaluating an organization's value creation logic. As a result, they are less investigated and debated in the construction industry. This concept, which differentiates a company from competitors and gives it a competitive edge, is essential to a successful business, according to modern business management literature. Value creation of the economy, environment, and society through building projects is the primary emphasis of construction organisations' value creation efforts. (Morris, Schindehutte, & Allen, 2005) The design and construction phases of construction projects are the primary responsibilities of construction organisations. As a result, the company benefits from designing for circularity and employing innovative circular construction technology.

- **Value Proposition:** The value proposition describes how valued goods are packaged and offered to clients in a way that satisfies their needs, including extra value-added services and products. According to (Ibáñez-Forés, Alejandrino, Bovea, & Mercante, 2023), organisational indicators used to evaluate the CE include circular services offered to the organisation, such as reverse logistics and promoting shared facilities or equipment. Key performance indicators used to evaluate the CE in a building project include end-of-life strategies, product as a service, after-sale services strategies in the design stage, and after-handing. (Morris et al., 2005)
- **Value Delivery:** The term "value delivery" describes the general layout of the revenue, cost, and profit structures related to the business enterprise providing that value. When it comes to client segments, the construction business is different from other industries since these segments usually play the function of an investor or order, making them more limited, recurring, and expensive. (Morris et al., 2005) Therefore, for value chain participants engaged in value chain operations, value delivery is regarded as having financial, economic, and environmental worth.
- **Value capture:** The core of BM design is the capacity to capture value. Value creation and capture are required to achieve a cyclic competitive advantage, but value capture is never guaranteed. Over time, a sizable amount of a task, product, service, or activity may not always come from the sources creating increased value from it. Conversely, if there is insufficient integration with the other BM components, a significant amount of the potential value generation may be lost or reduced. In construction organisations, implementing the CE adds social, financial, and economic value. (Huovila & Westerholm, 2022)Therefore, in order to capture value, a number of strategies must be used.
- **Collaboration of stakeholders:** Early on in a building project, stakeholder involvement is crucial. Huovila and Westerholm explain that in order to guarantee that the materials' value will be preserved throughout disassembly, collaboration between the designer and other value chain participants is essential, and this needs to be evaluated. Working together will enable the organisation to successfully apply the CCBM in order to maximise output. (Huovila & Westerholm, 2022)

- **Lifecycle perspective:** Construction companies do not complete building and infrastructure development lifecycles. Within the construction sector, primary contractors oversee one or more stages of a project's lifespan, working with a variety of companies. But the other phases of the construction development lifecycle depend heavily on the design and building phases. (Núñez-Cacho Utrilla, Górecki, & Maqueira, 2020)

  In general, CCBM can be summed up as generating value for the economy, society, and environment over the course of a construction project by facilitating communication with stakeholders in the construction process, delivering value to value chain participants, providing clients with value-added services, and capturing value through the application of appropriate techniques.

2.3 Linear vs Circular Business Models in Construction

With the goal of improving sustainability and resource efficiency, the construction industry is undergoing a paradigm shift away from conventional linear models and toward novel circular business models. This section explores the key differences between the traditional and circular construction models, looking at their guiding ideas and methods of operation.

Linear Models:

Conventional construction business models are based on a sequential process that includes procuring raw materials, producing goods, utilizing them, and finally getting rid of waste (Ghisellini, Ripa, & Ulgiati, 2018). This resource-intensive paradigm, often known as the **"take-make-dispose**" model, (Adams, Osmani, Thorpe, & Thornback, 2017) degrades the environment and produces a large amount of garbage. Important characteristics of linear model consist of the following:

- **Resource Extraction:** Conventional models mostly depend on the ongoing extraction of virgin materials, which depletes resources and deteriorates the environment. (Adams et al., 2017)
- **Production and Consumption:** A large amount of waste is produced as a result of the emphasis on mass production and consumption without taking the lifecycle of the materials into account. (Adams et al., 2017)

- **Waste Generation:** Demolition and material disposal are common end-of-life activities that add significantly to the amount of waste generated during construction. (Adams et al., 2017)
- **Economic Focus:** Short-term financial rewards are prioritized over long-term sustainability or environmental effects. (Adams et al., 2017)

Circular Models:

On the other hand, circular construction business models are predicated on the circular economy's tenets, which give sustainability and resource efficiency top priority. The goal of these models is to develop **closed-loop systems** that continuously **recycle, repurpose, and reuse** resources (Ghisellini et al., 2018). Crucial elements consist of the following:

- **Design for Disassembly:** To reduce waste, buildings are made with readily removed parts that can be recycled or reused. (Adams et al., 2017)
- **Material Recovery:** This approach minimizes the requirement for new raw materials by concentrating on repurposing resources from existing buildings for use in future construction projects. (Adams et al., 2017)
- **Lifecycle Thinking:** Taking into account a material's complete lifecycle, from extraction to end-of-life, in order to ensure that its environmental impact is as little as possible. (Adams et al., 2017)
- **Economic Resilience:** Prioritize long-term financial viability by utilizing resources wisely, cutting waste, and implementing creative building techniques. (Adams et al., 2017)

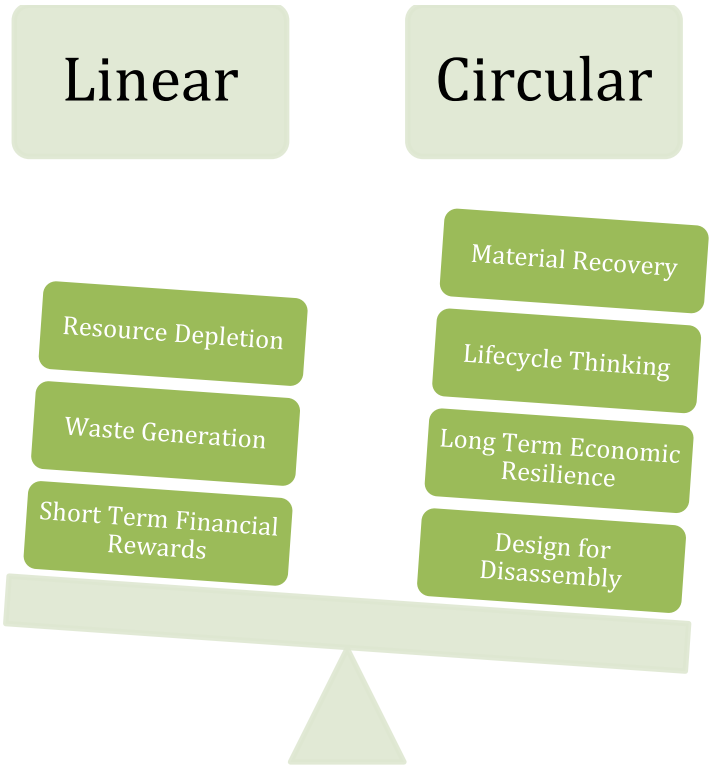

Figure 7-Comparison of Linear vs Circular Business Models: (adapted from Adams et al., 2017; Ghisellini et al., 2018)

By putting an emphasis on resource efficiency and waste avoidance, the shift from traditional to circular business models in the construction industry offers considerable environmental and economic benefits. But making this shift will need addressing a number of crucial success criteria and overcoming significant obstacles, which calls for cooperation from all industry stakeholders.

2.4 Circular Business Models in Construction: Advantages, Success factors and Barriers

This section describes the status quo of the CBMs in construction. It gives insights on the advatages of adopting CCBMs in the industry, the success factors that cannlead to an effective CCBM implementation and the barriers hindering its practical implementation. The barriers are discussed in a broader perspective in this section, but later by cross analysis with the case studies, the ideas mold specifically in economic perspective.

2.4.1 Advantages of CCBMs

In the construction industry, circular business models are superior to traditional linear models in many ways, improving sustainability, economic efficiency, and environmental effect. (Ghisellini et al., 2018) talks about the following features that makes these business models superior to linear ones.

- **Resource Efficiency:** Reusing and recycling materials is emphasized in circular construction processes, which lowers the need for virgin resources. This minimizes the negative effects of resource exploitation on the environment and results in significant material cost reductions. Reclaimed materials and components can help build more environmentally friendly construction projects by lowering their environmental impact and encouraging more sustainable resource management techniques. (Ghisellini et al., 2018)
- **Waste Reduction:** The quantity of waste produced is greatly decreased by circular construction, which designs buildings for disassembly and reuse. In addition to reducing disposal expenses, this also eases the strain on incinerators and landfills. (Ghisellini et al., 2018)
- **Economic Savings:** The long-term financial advantages of circular construction outweigh any higher initial costs. Overall cost savings are a result of decreased material costs, lower waste disposal costs, and possible revenue from recycling and reusing items. (Ghisellini et al., 2018) By prolonging the lives of buildings and their components, circular models can improve the financial performance of construction projects and eventually provide greater value for money.
- **Environmental Benefits:** By reducing the need to produce new materials and using less energy, circular construction approaches help to significantly reduce greenhouse gas emissions (Ghisellini et al., 2018). Circular models' associated reduction in pollution and preservation of natural resources contribute to the larger objectives of environmental sustainability.

With these benefits, circular models are positioned as a creative and practical substitute for conventional building techniques, promoting the development of a built environment that is more robust and sustainable.

2.4.2 Success factors of CCBMs

This section emphasizes the crucial success criteria required for the successful implementation of Circular Business models in Construction. This research gives us a thorough grasp of how circular business models might transform the building sector while resolving social, political, and environmental issues.

- **Innovative Design Techniques:** It is essential to incorporate **design to disassemble** techniques and reuse construction components. This entails choosing recyclable or reusable materials and employing **modular building** approaches (Pomponi & Moncaster, 2017). By approaching building design from an integrated **lifetime perspective**, material usage may be maximized, waste can be decreased, and sustainability can be improved.
- **Stakeholder Collaboration:** To effectively integrate circular principles throughout the construction process, all stakeholders, including architects, engineers, contractors, and waste management firms, (Ghisellini et al., 2018; Pomponi & Moncaster, 2017)must collaborate.
- **Regulatory Support:** Creating laws and rules that encourage environmentally friendly building techniques (Ghisellini et al., 2018) while discouraging inefficient ones.
- **Technological Advancements**: Using cutting-edge tools like material tracking systems and building information modelling (BIM) to enhance resource management and lifecycle evaluation. (Pomponi & Moncaster, 2017)
- **Market Demand:** The implementation of circular models is being driven by the growing demand from investors and consumers (Ghisellini et al., 2018) for sustainable buildings and construction methods.

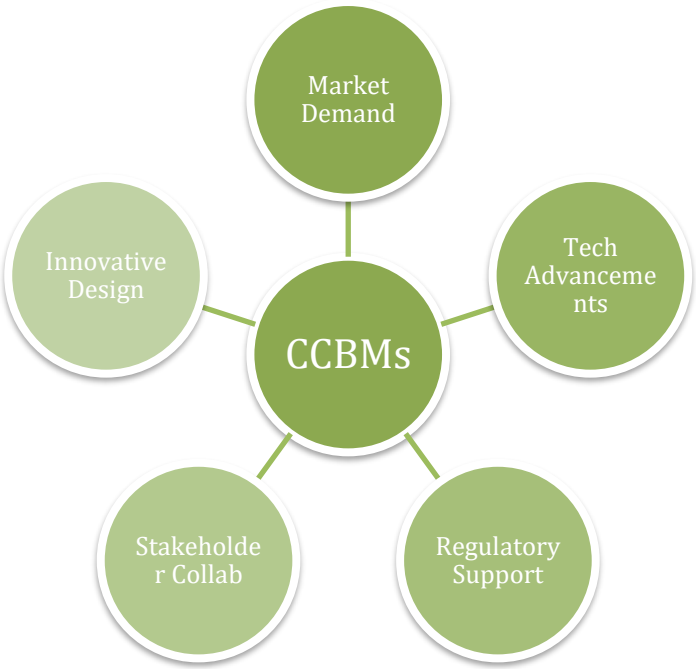

Figure 8-CCBM Success factors (adapted from Ghisellini et al., 2018; Pomponi & Moncaster, 2017)

The successful implementation of circular business models requires addressing critical success factors mentioned above which collectively facilitate the transition towards sustainable construction practices.

2.4.3 Barriers to CCBM Implementation

Although Circular Construction Business Models have many benefits, there are a number of obstacles that need to be overcome before they can be widely used. The main obstacles to the adoption of CCBMs are examined in this section, including knowledge and skill shortages, technology constraints, regulatory barriers, and economic concerns.

Regulatory Challenges:

One of the biggest obstacles to the adoption of circular construction business models (CCBM) is regulatory compliance. According to (Rizos, Bryhn, & Alessi, 2021), these difficulties can be broadly divided into three categories: regulatory complexity, supportive policy deficiency, and legislative gaps.

- Bureaucratic Complexity: Circular construction projects may require a laborious and drawn-out application and approval process. The intricacy of these governmental processes deters businesses from undertaking creative circular projects. (Rizos et al., 2021)
- Inadequate Supportive Policies: Circular economic models are frequently given less weight than linear ones in current rules. Policies created expressly to encourage and support circular approaches in building are lacking. Businesses could find it financially and operationally challenging to switch to circular models without legislative support. (Rizos et al., 2021)
- Legislative gaps: Regulations differ between states and regions, making it difficult for businesses to operate in a fragmented market. It is difficult for firms to create standardised procedures that go by all applicable regulations because of this variance. (Rizos et al., 2021)

Culture and Organisational Gaps:

The implementation of Circular Construction Business Models (CCBM) is severely impeded by organisational and cultural gaps. Organisations frequently oppose altering long-standing procedures because they are at ease with the status quo and doubt the advantages of novel approaches. The absence of strong leadership and a sharp vision to spearhead circular projects exacerbates this opposition. Organisational silos also hinder the kind of productive cooperation and communication required for systemic transformations. Targeted education and advocacy initiatives are required in light of the overall lack of awareness and comprehension of circular economy principles among industry stakeholders as well as within organisations, which exacerbates these issues. (Technopolis Group, Fraunhofer ISI, Wuppertal Institute, & Thinkstep, 2016)

Skills and Awareness Gaps:

Gaps in knowledge and expertise make it extremely difficult to apply circular construction business models (CCBM). A lot of companies do not have enough training programmes to give employees the skills they need to use circular building methods, like understanding circular design concepts and sustainable material selection. Furthermore, stakeholders—including companies and customers—generally lack knowledge about the advantages and practices of circular construction. Adoption is hampered by this ignorance, hence targeted advocacy and education campaigns are

needed to increase awareness and develop the necessary skills. (Technopolis Group et al., 2016)

Technological Barriers:

One major factor impeding the development and application of circular construction business models (CCBM) is technological hurdles. (Hina, Chauhan, Kaur, Kraus, & Dhir, 2022) comprehended these obstacles by considering various crucial elements:

- Limited Technology Access: Cutting-edge technologies that support circular architecture, like creative recycling techniques and eco-friendly materials, could not be broadly accessible or reasonably priced. (Hina et al., 2022)
- Integration Issues: Circular methods might not be compatible with the infrastructure and technologies currently in place (Hina et al., 2022). It might be expensive and difficult to upgrade or integrate modern technologies.
- Research and Development (R&D) Investment: Research and development (R&D) investments for novel technologies that facilitate circular building are frequently inadequate. Technological breakthroughs arise slowly in the absence of sufficient finance and innovation emphasis. (Hina et al., 2022)

Economic Considerations:

Economic considerations include financial obstacles that affect CCBM's viability.

- High Initial Costs: Making the switch to circular practices frequently necessitates a large initial outlay of funds. Costs for process reform, training, and modern technology (Hina et al., 2022; Pomponi & Moncaster, 2017) are included in this.
- Uncertain ROI: Circular approaches may have a long-term, uncertain return on investment (ROI). Most of this uncertainty is directly related to lack of certainty in the cost of procured materials, refurbishment costs, labour costs and logistics (Pomponi & Moncaster, 2017; Technopolis Group et al., 2016). Businesses find it challenging to defend their initial investment decisions considering this uncertainty.
- Market Dynamics: The circular products and recycled materials sector are still in its infancy. Businesses implementing circular models may be exposed to financial risks due to fluctuations in pricing and demand (Pomponi & Moncaster, 2017; Technopolis Group et al., 2016).

- Lack of Financial Incentives and Assistance: The provision of financial incentives, such as grants, subsidies, and tax breaks, by the government and institutions is frequently deficient (Pomponi & Moncaster, 2017; Technopolis Group et al., 2016). Businesses might find it difficult to pay for the higher expenses related to implementing circular construction models without these financial incentives.
- The cost of integrating technologies: It might be costly to incorporate new circular technologies into current ones. In addition to the cost of buying new equipment, these expenses also include anticipated downtime and lost production during the changeover. (Technopolis Group et al., 2016) The cost of these integration expenses may discourage businesses from adopting circular business models.
- Economies of Scale: Securing economies of scale poses a noteworthy obstacle for construction projects that follow a circular design. A lot of circular projects begin small, and significant market growth and investment are needed to expand up to a level that is economically feasible (Hina et al., 2022). The cost benefits of circular practices might not be completely realised if they do not reach a critical mass.
- Profitability comparison with new construction: Circular construction frequently entails greater expenses in the current technological and financial environment because it requires specialised labour, sustainable materials, and cutting-edge recycling and reuse technology. (Hina et al., 2022) Because of this, circular building typically has lower profit margins than conventional construction, which deters companies seeking quick financial gains from investing in it.

A diverse strategy is needed to overcome these economic obstacles, including heightened government backing, market expansion, and calculated expenditures on infrastructure and technology.

2.5 Previous Research on Economic Viability of Circular Construction

The economic feasibility of circular building business models has been the subject of numerous research, which have shed light on both the advantages and disadvantages

of this approach. (Ghisellini et al., 2018) emphasize cost reductions, resource efficiency, and long-term asset value while highlighting the substantial lifetime economic benefits of circular construction. (Pomponi & Moncaster, 2017), in contrast, concentrate on the financial risks and obstacle-such as high initial expenditures, protracted payback times, and regulatory uncertainties—that prevent the widespread adoption of circular processes. When taken as a whole, these studies provide a thorough grasp of the benefits and challenges of putting circular building business models into practice.

2.5.1 Lifecycle economic benefits in Circular Construction

(Ghisellini et al., 2018) provide a comprehensive examination of **the lifecycle economic benefits** associated with circular construction practices, in the article: '**Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review.'** Their research highlights several key areas where circular construction models offer economic advantages over traditional linear models:

(Ghisellini et al., 2018) emphasizes on designing buildings for durability, adaptability, and ease of maintenance. This approach leads to **reduced operational costs over the building's lifecycle**. For example, materials and systems that are designed for easy repair and replacement can extend the useful life of building components, minimizing the frequency and cost of major repairs. (Ghisellini et al., 2018) Buildings constructed with high-quality, sustainable materials often **require less frequent maintenance**, further **lowering long-term costs**.

The design and construction of structures that are easily modified or recycled to suit shifting needs throughout time is encouraged by circular construction methods. This adaptability **extends the building's entire lifecycle** by lowering the requirement for demolition and new construction. By emphasizing **modular construction** methods, **buildings retain the value of the original investment** even when they are renovated, expanded, or reconfigured without requiring significant additional material inputs. (Ghisellini et al., 2018)

Because of their **long-term sustainability and sustainable qualities**, buildings that are designed and built according to circular principles frequently **have greater asset values**. Investors and buyers who value sustainability, energy efficiency, and less environmental effect will find these structures more appealing. (Ghisellini et al., 2018) Round features help properties attract higher market values and rental rates, giving owners and developers better returns on their investment.

By making the most use of recovered and repurposed resources, circular architecture reduces the requirement for new materials. This **lowers the cost of materials** while also lowering the risks related to price volatility and material scarcity. Over the course of the building's existence, significant cost savings are achieved through **efficient resource utilization and waste reduction**. (Ghisellini et al., 2018) Prefabricated components, for instance, can cut waste, labour costs, and construction process delays.

Developers and owners can avoid fines and penalties by using circular construction processes to help them comply with increasingly strict environmental rules. The marketability and value of a building can also be increased by adhering to green building standards and certifications, such as LEED and BREEAM. **Incentives such as tax rebates, grants, and** subsidies that support **sustainable construction techniques** are frequently advantageous to circular buildings. (Ghisellini et al., 2018)

By producing living and working environments that are healthier, more flexible, and resilient, circular construction can improve the social value of buildings. By drawing and keeping renters and promoting good community ties, these **social benefits can result in** financial **profits**. (Ghisellini et al., 2018) By encouraging sustainable practices, locally sourced materials, and green jobs, buildings that integrate circular concepts can help boost local economies.

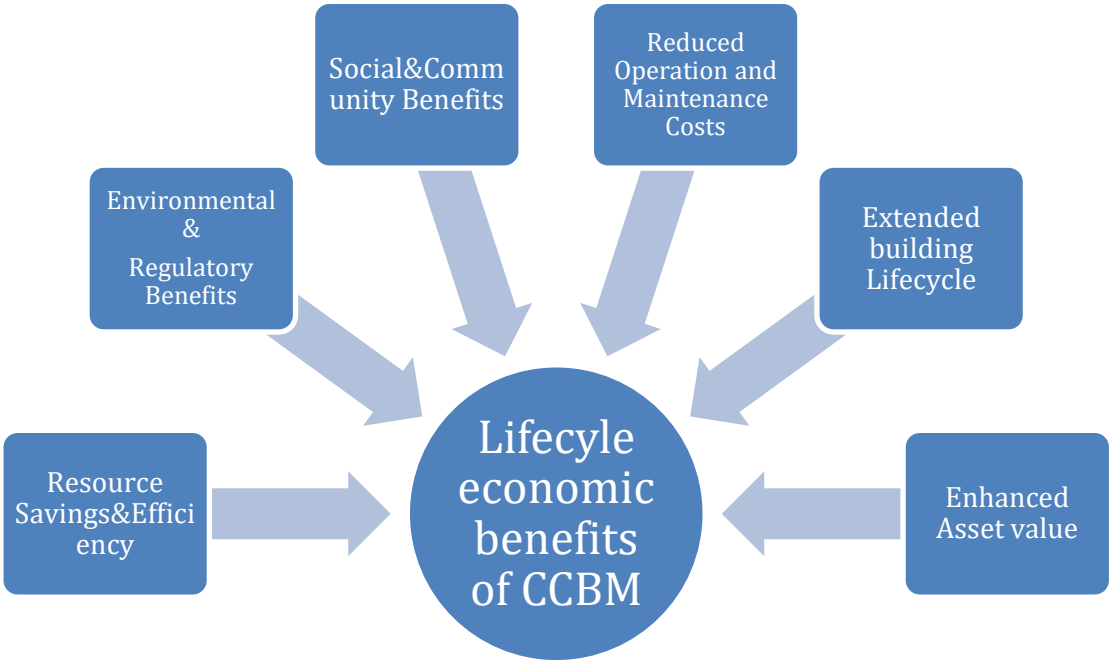

Figure 9-Lifecycle economic benefits of CCBMs (Ghisellini et al., 2018)

Above discussed are the key takeaways from the article by (Ghisellini et al., 2018). The article comprehensively discussed the potential economic benefits of adopting circular construction as business model, nevertheless it highlights the idea of long term and holistic approach towards the same.

2.5.2 Financial Risks and Barriers in Circular Construction

A thorough examination of the financial risks and obstacles related to circular construction business models (CCBMs) is given by (Pomponi & Moncaster, 2017) in the journal **'Circular economy for the built environment: A research framework'**. High initial costs, longer payback periods, uncertain financial returns, a lack of financial incentives, restricted access to financing, the economic viability of recycled materials, and regulatory and market uncertainties are some of the difficulties that these materials present. These issues were covered in the previous section on barriers to CCBM implementation.

In summary, the main financial obstacle is the large **upfront costs** associated with circular construction projects. The research, design, and sustainable materials needed for these projects might come at a hefty upfront cost compared to more conventional building techniques**. Longer payback periods** make this worse because the financial

gains from circular practices-like lower operating and maintenance costs appear gradually. (Pomponi & Moncaster, 2017)

Investing in CCBMs is made more difficult by the **uncertainty around financial rewards**. This unpredictability is exacerbated by shifting regulatory regimes, fluctuating material costs, and shifting market situations. Additionally, investors find it challenging to precisely forecast returns because to the absence of defined standards for evaluating the financial performance of circular initiatives. Adoption of circular processes is further impeded by a **lack of strong financial incentives** and support systems as well as **restricted access to bank and financing**. (Pomponi & Moncaster, 2017)

Figure 10-Financial Risks in CCBMs (Pomponi & Moncaster, 2017)

It is critical to understand that solving these financial issues is necessary for the wider adoption of circular building. This entails establishing market mechanisms that encourage sustainable practices, including financial incentives, and establishing regulatory frameworks that are supportive. The building sector may shift to more sustainable and commercially viable circular business models by surmounting these financial obstacles.

2.6 Summary of Literature Review

The building industry is undergoing a change due to the circular economy, which is pushing it toward more sustainability and resource efficiency. By continuously cycling products and resources back into use, the circular economy aims to eliminate waste, in contrast to the traditional linear economy that follows a "take, make, discard" approach. By drastically reducing the dependency on limited resources, this strategy fosters a sustainable economic model that is advantageous to all members of society.

Walter Stahel, who has championed closed-loop systems since the 1970s, and the Ellen MacArthur Foundation are two prominent figures in the circular economy movement. The latter has been instrumental in advancing circular concepts through advocacy, research, and collaboration. Particularly in the construction industry, where the focus is on regenerative design, resource efficiency, waste management and prevention, product lifespan, and systems thinking, these principles are fundamental for developing resilient and sustainable business operations.

In practice, there are a number of approaches that the construction sector can use to include circular ideas. These include the use of prefabricated and modular construction methods to increase material efficiency and decrease waste, the implementation of extensive waste management and recycling systems on construction sites, and the selection and procurement of sustainable and recyclable materials. Comprehensive lifetime assessments of buildings can also be used to find areas where energy efficiency and adaptive reuse can be enhanced, and cooperative value chain integration encourages resource conservation and sustainable business practices across the board.

Closed-loop processes, as opposed to conventional linear procedures, are the basis of Circular building Business Models (CCBMs), which provide a revolutionary approach to construction sector. There are many advantages to the construction industry switching from linear to circular models, such as increased sustainability, lower environmental impact, and more economic efficiency. Considering the entire lifecycle of materials to reduce waste generation, repurposing materials from existing structures for new projects, and designing buildings for ease of disassembly and reuse are all highlighted by circular models. By utilizing creative construction methods and resource

efficiency, this strategy not only supports long-term financial viability but also conforms to changing regulatory frameworks that encourage sustainable practices.

Nevertheless, there are some challenges in putting CCBMs into practice. Organizational, cultural, and legal obstacles may make it difficult to implement circular processes. Technological hurdles are also important because it is frequently difficult or expensive to obtain state-of-the-art technologies that facilitate circular construction. These problems are made worse by integration problems with the current infrastructure and a deficiency of funding for research and development. Additional challenges come from economic factors like large upfront expenses, hazy ROIs, and a dearth of financial incentives. The use of CCBMs is made more difficult by market factors, such as the developing circular products industry and the absence of institutional and governmental funding.

Despite these challenges, research emphasizing the long-term advantages of circular construction lends convincing evidence to its economic feasibility. According to studies, embracing circular methods has several benefits, including lower costs in long term, more efficient use of resources, and higher asset value. For example, minimizing waste and lowering material costs can be achieved by designing structures with durability and adaptability, which can also lessen maintenance and operating costs. Furthermore, obtaining green building certifications and adhering to stringent environmental standards can raise the marketability and value of circular buildings, offering developers and owners additional financial incentives.

Chapter 3. Research Methodology

The study approach used to examine the economic viability of circular construction business models (CCBMs) is described in this chapter. To answer the research questions, it starts with outlining the research design, which combines qualitative and quantitative methods. The approach entails modifying a theoretical framework, applying the Business Model Canvas and ReSOLVE framework to create a Conceptual CCBM Canvas, and utilizing a business case to evaluate the suggested model. The case studies provided practical insights into the implementation and effectiveness of CCBMs in real-world scenarios. The utilization of a multifaceted approach facilitated an extensive examination of theoretical concepts and real-world applications, with the goal of identifying feasible tactics that construction businesses might implement to attain sustainability in terms of both the economy and the environment.

3.1 Research Design

The research design of this thesis employs a mixed-method approach, integrating both qualitative and quantitative methods to explore the economic viability of Circular Construction Business Models (CCBMs). The research is conducted through a systematic literature review, the development of a conceptual framework to assess circularity in construction businesses, case study analysis and application of the framework in one of the business case studies to obtain the results. The study focused on Europe, exploring cases from the Central Europe.

A systematic approach was taken to gather comprehensive information on Circular Construction Business Models (CCBMs) for the literature review. ScienceDirect and Google Scholar were used as key databases and search engines to source relevant academic papers, industry reports, and policy documents. The term "circular construction," "circular business models," and "circular construction businesses" were used for keyword search. The review covered topics such as defining circular economy principles, comparing linear and circular business models, and identifying practical initiatives, success factors, and barriers in the construction industry. This thorough review served as the basis for developing the theoretical framework and identifying gaps in current research, which guided subsequent analysis and case studies.

Since a dedicated theoretical framework for Circular Construction Business Models does not exist, this research adapts and combines existing frameworks to create a new conceptual model for assessing circularity in construction businesses. Integration of the ReSOLVE framework and Business Model Canvas to develop a novel conceptual CCBM Canvas tailored for assessing circularity in construction businesses becomes a key methodological element during the research. The effect of the hybrid canvas is evaluated on a business case study.

The next part of the methodology includes detailed case studies of Bouygues Construction and Rebel Group. These case studies provide practical insights into the adoption and financial implications of circular practices in the construction sector. The first case study, Bouygues Construction, is assessed using both traditional and modified CCBM canvases to demonstrate the practical application and benefits of the new conceptual model. The Rebel Group case study focuses on comparative economic analysis of linear and circular initiatives and the long-term financial gains of circular construction practices, particularly in projects like circular viaducts.

Qualitative and quantitative data collected through a combination of document analysis, previous studies, and financial performance reviews of the case study companies are analysed to identify key barriers to CCBM implementation, economic perspectives, and policy implications. The CCBM canvas is used to reassess Bouygues Construction to understand its effectiveness over traditional canvas. The results are used to refine the framework and develop recommendations for effective policy-making and long-term financial planning in circular construction businesses. The future scalability of integrated or collaborative circular construction companies are examined.

The anticipated outcome would be a robust analysis of CCBMs, a comprehensive understanding of its economic viability and practical implementation of CCBMs in the construction industry. Synthesis of findings provides actionable insights on economic profitability and business model viability for construction companies aiming to transition to circular business model.

This comprehensive research design ensures a thorough investigation into the economic viability and practical implementation of CCBMs in the construction industry, providing valuable contributions to both academic literature and industry practices.

3.2 Theoretical Framework towards CCBMs

This section discusses the theoretical frameworks that already exists and are in practice for different purposes. Since there are no existing theoretical frameworks that can be used to test Circular Business Models in Construction, this chapter discusses The ReSOLVE framework developed jointly by The Ellen MacArthur Foundation and McKinsey. The author intends to use and develop a unique framework using the existing framework which can further be used for analysing a construction business.

3.2.1 The ReSOLVE framework

The Ellen MacArthur Foundation and McKinsey created the ReSOLVE framework, which provides a thorough guide for converting linear to circular systems. Regenerate, Share, Optimise, Loop, Virtualize, and Exchange is what it stands for, and it is important for encouraging circularity in the building and construction sector. Improved building materials, standardisation, and flexible, multipurpose spaces are all encouraged by the framework. (One Planet network, N.a) It is possible to comprehend how the ReSOLVE framework might be used in the construction sector to improve resource efficiency, reduce waste, and assist developing markets in tackling the issues associated with climate change adaptation and mitigation. In addition to being in line with sustainable development objectives, this all-encompassing strategy may also open new financial prospects for circular building business models.

Figure 11-The ReSOLVE framework (The Earthbound Report, 2016)

- **Regenerate:** Regenerate refers to a wide range of practices that uphold and improve the biocapacity of the planet. This includes the switch to renewable energy from finite fossil sources. It involves protecting or restoring ecosystems as well as recovering land. (The Earthbound Report, 2016) This includes returning biological resources to the environment, as in the case of composting.
- **Share:** The circular economy and the "sharing economy" are related ideas. By sharing, things are fully utilised, and waste and duplication are removed. Repair and the second-hand market fall under the category of "share" as well because they both slow down the "loop speed" at which items move through the economy and guarantee that they are only returned for recycling or reprocessing when absolutely necessary. (The Earthbound Report, 2016)
- **Optimise:** This refers to cutting down on wasteful energy and material use in both the production and use of goods. Utilising technology to optimise resource usage is also part of it. (CE Grow Circular, 2022)
- **Loop:** In a circular economy, inorganic (or "technical") resources are reused while organic materials are composted. Better yet, products or parts can be refurbished instead of being recycled. In either case, resources are not lost to the economy through landfilling but are instead processed, recycled, and added back into the system. (CE Grow Circular, 2022)

- **Virtualize:** This refers to delivering utility virtually—books or music, online shopping, fleets of autonomous vehicles, and virtual offices. (The Earthbound Report, 2016)
- **Exchange:** The last category covers the procedures involved in upgrading or substituting outdated methods with new ones, as well as the introduction of recent technology. For instance, internal combustion engines will be replaced with electric motors. (The Earthbound Report, 2016)

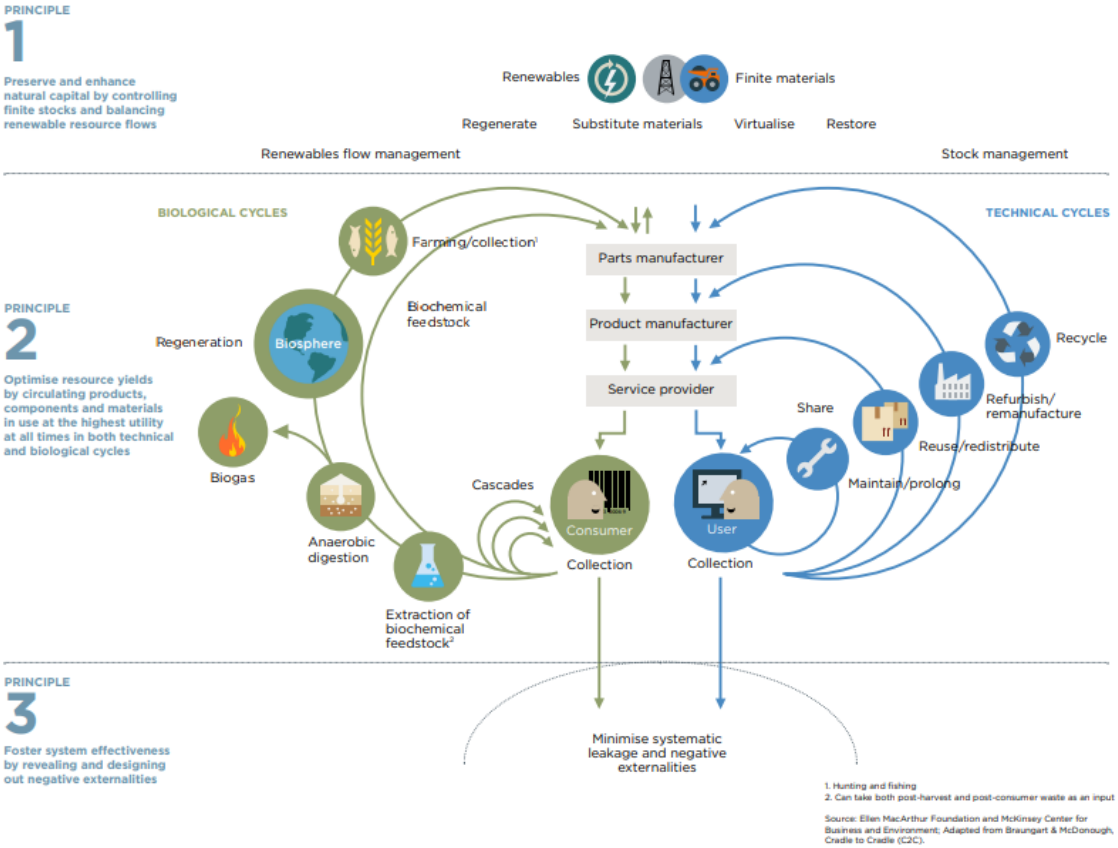

Figure 12-The ReSOLVE framework (Ellen Macarthur Foundation, 2015)

This is not a circular economy to-do list. Rather, according to McKinsey, "each action represents a major circular business opportunity." These activities all, in diverse ways, boost the utilization of physical assets, extend their useful lives, and switch from using finite to renewable resources for resource consumption. A powerful compounding

effect is produced when each action accelerates and supports the performance of the others.

3.2.2 Business Model Canvas by Osterwalder

Researchers and professionals have examined and shown the CBM architecture from various angles. The most often utilised categorization techniques are CBM strategies and the ReSOLVE framework. Although the theoretical significance of CBM to the CE transition is well acknowledged, further comprehension of their practical implementations is necessary. Moreover, a number of other frameworks, such the Business Model Canvas (BMC) and McKinsey's 7S framework, might be used to define the value chain of the CE. Among the several methodologies/frameworks, researchers have utilised the BMC extensively, which is a tool created by Osterwalder (Osterwalder & Pigneur, 2010).

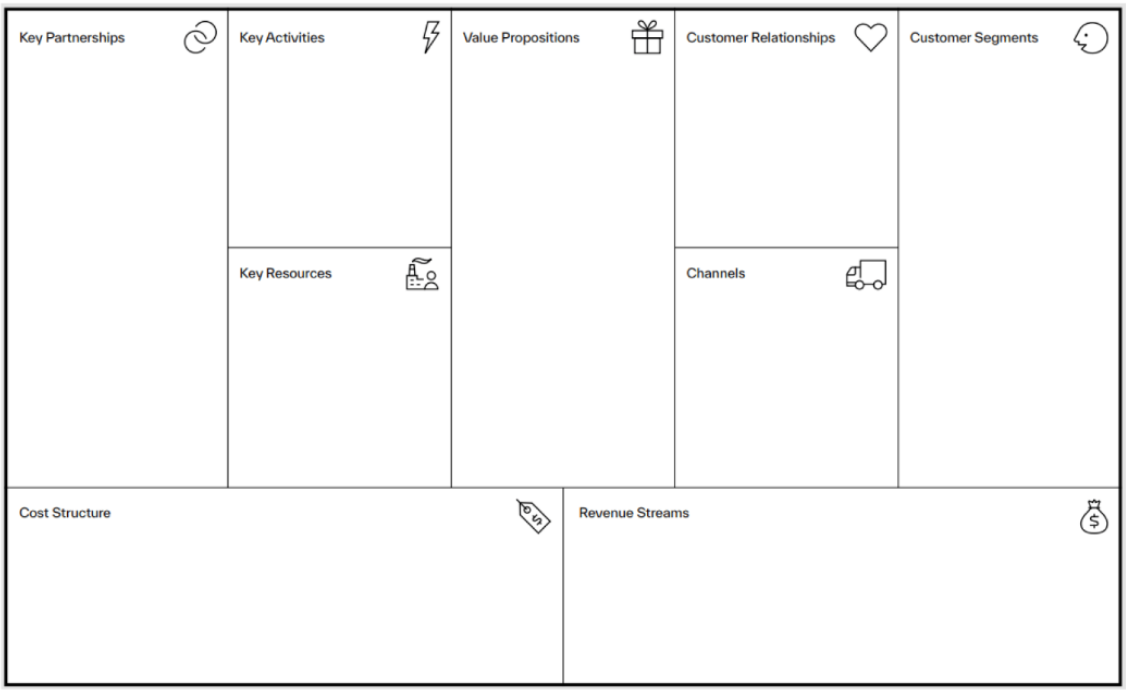

Figure 13-Traditional business model canvas (Osterwalder & Pigneur, 2010)

While maintaining the BM's clarity and ease of understanding, the BMC effectively conveys the complexity of how businesses function. It is therefore a useful tool for conducting BM innovation and understanding an enterprise's BM. Users can use a BMC to visually display the elements of a BM and any relationships or impacts on value

production. A visual tool for debating, discussing, and looking at potential modifications to the underlying BM is the BMC. Users stress an organization's value-adding benefits and obtain a more thorough grasp of it (Qastharin, 2016).

The authors go on to say that practitioners have mostly embraced the BMC created by Osterwalder and Pigneur (Osterwalder & Pigneur, 2010). Key partners, key activities, value proposition, customer relationships, customer segments, necessary resources, channels, cost structure, and income streams are the nine building blocks that make up this BMC.

The nine essential building parts that make up the Business Model Canvas show how a business plans to function and generate value (Osterwalder & Pigneur, 2010). These elements consist of:

- Key Partnerships: Joint ventures with other organisations that support the smooth operation of the business.
- Key Activities: Essential tasks that the business must complete in order to function well.
- Key Resources: Objects needed to add value and sustain the company.
- Value propositions: Products or services that add value for a certain customer segment are known as value propositions.
- Customer relationships: The kinds of connections a business makes with customer segments.
- Channels: The means by which the business interacts with and delivers a Value Proposition to its customer segments.
- Customer Segments: The various demographic or organisational subgroups that a business seeks to reach and cater to.
- Cost Structure: The financial effects of the methods the company model uses.
- Revenue Streams: Each customer segment's source of income for the business.

Together, these components offer a thorough summary of a business's approach to creating value and gaining a competitive edge in the marketplace.

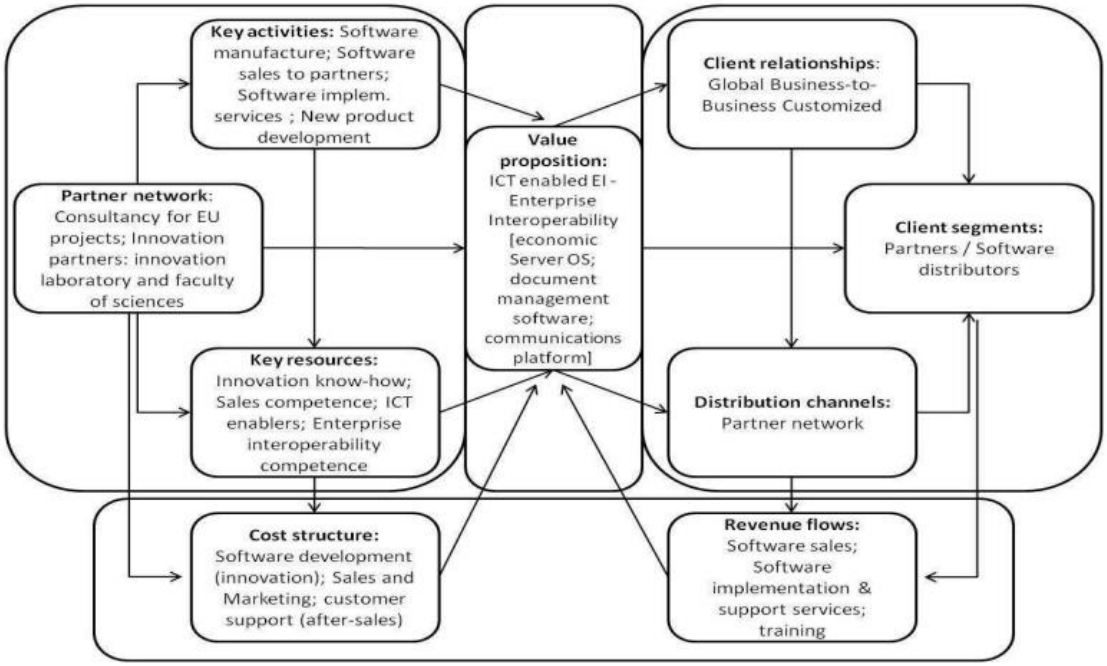

Figure 14- The Business Model Ontology canvas (Osterwalder & Pigneur, 2010)

The flow and connectivity between the various components of the business model are depicted by the arrows in the Business Model Canvas. The arrows' directions reflect a dynamic link between the components by showing how each affect or feeds into the others. As an illustration, "Key Activities" flow into "Value Proposition," suggesting that an organization's activities are essential to developing its value proposition. The arrows pointing from "Key Partners" to "Key Activities" imply that collaborations are necessary to carry out fundamental company operations. These linkages could stand for the flow of recycled materials, knowledge sharing, or the connection between project design and execution in a circular construction business model.

Although the Business Management Cycle (BMC) lays out the expectations for the business at a specific moment in time, it is frequently reduced to a checklist and fails to tell the story of "how" an organisation might improve its capabilities, operations, and processes (Qastharin, 2016). A key component of business transformation, comprehending organisational capacities is not made easier by the BMC. Although the BMC can comprehend a BM's metamorphosis well, it is unable to direct an organization's transformation from one state to another.

3.2.3 Conceptual CCBM canvas for Circularity assessment of Businesses

An important source for this thesis is (Lewandowski, 2016)'s paper on creating circular economy business models, which expands on the conventional business model canvas by adding circular economy ideas. Lewandowski's circular business model canvas include traditional elements, but its main focus is on 'Take-Back System' and 'Adoption Factors' as ways to generate circularity. While addressing internal capabilities like organisational culture and expertise as well as external factors like technology and legislation that drive circular adaptation, these elements also emphasise the significance of material loops and reverse logistics. (Lewandowski, 2016)

- Take-back system: the layout of the system for managing returns, including the channels and customer interactions involved.
- Adoption factors: A variety of organisational capacities and external circumstances are required to facilitate the shift to a circular business model.

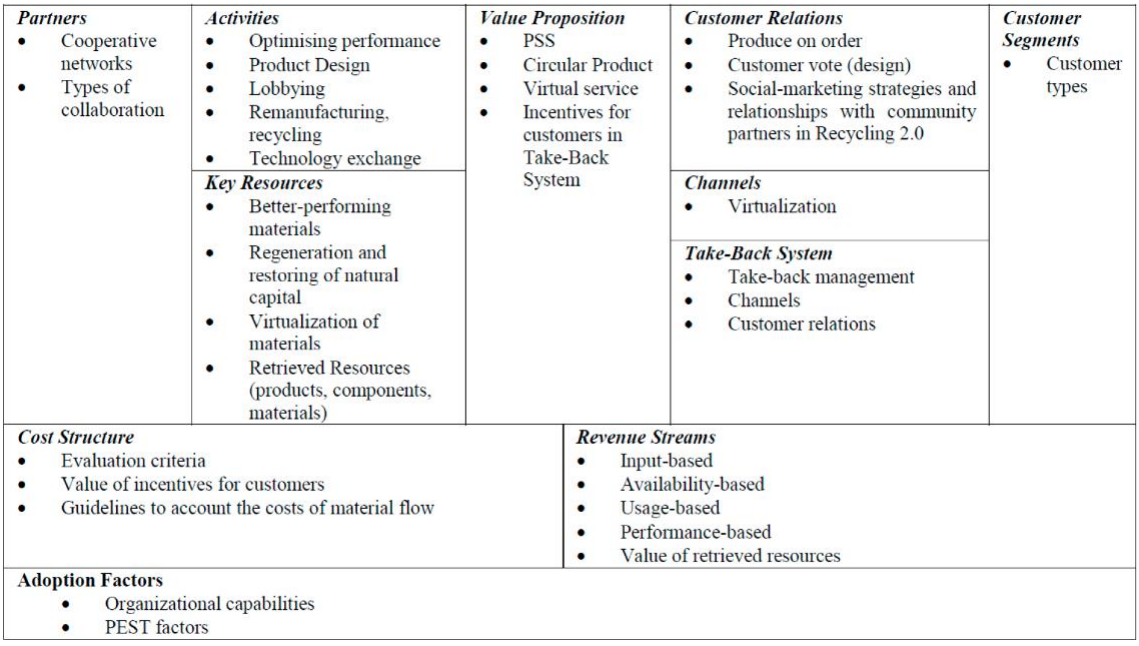

Figure 15-Modified framework of the CBM canvas (Lewandowski, 2016)

By adding these dimensions to the own canvas, it will be possible to create a company model that supports both financial and circular economy objectives, guaranteeing long-term value creation and material use.

(Braun, Schöllhammer, & Rosenkranz, 2021) highlight another major framework for CBM. The Business Model Canvas template has been modified, to include circular value generating methods. By incorporating five circularity modules, each of which affects a different part of the traditional canvas, this innovative strategy disentangles sales from raw material use, which is essential in a linear economy. Cross-integration is used to use industry symbioses for successful implementation, whereas horizontal integration is taken into consideration for synergistic collaboration across traditional business lines. Designing income streams for direct reuse, modifying value propositions for refurbishment and remanufacturing, and rethinking cost structures and partnerships to include secondary raw materials for recycling are all prioritised. (Braun et al., 2021) This canvas embodies an all-encompassing, integrated system that embraces the circular economy, surpasses industry boundaries, and promotes cooperative value networks.

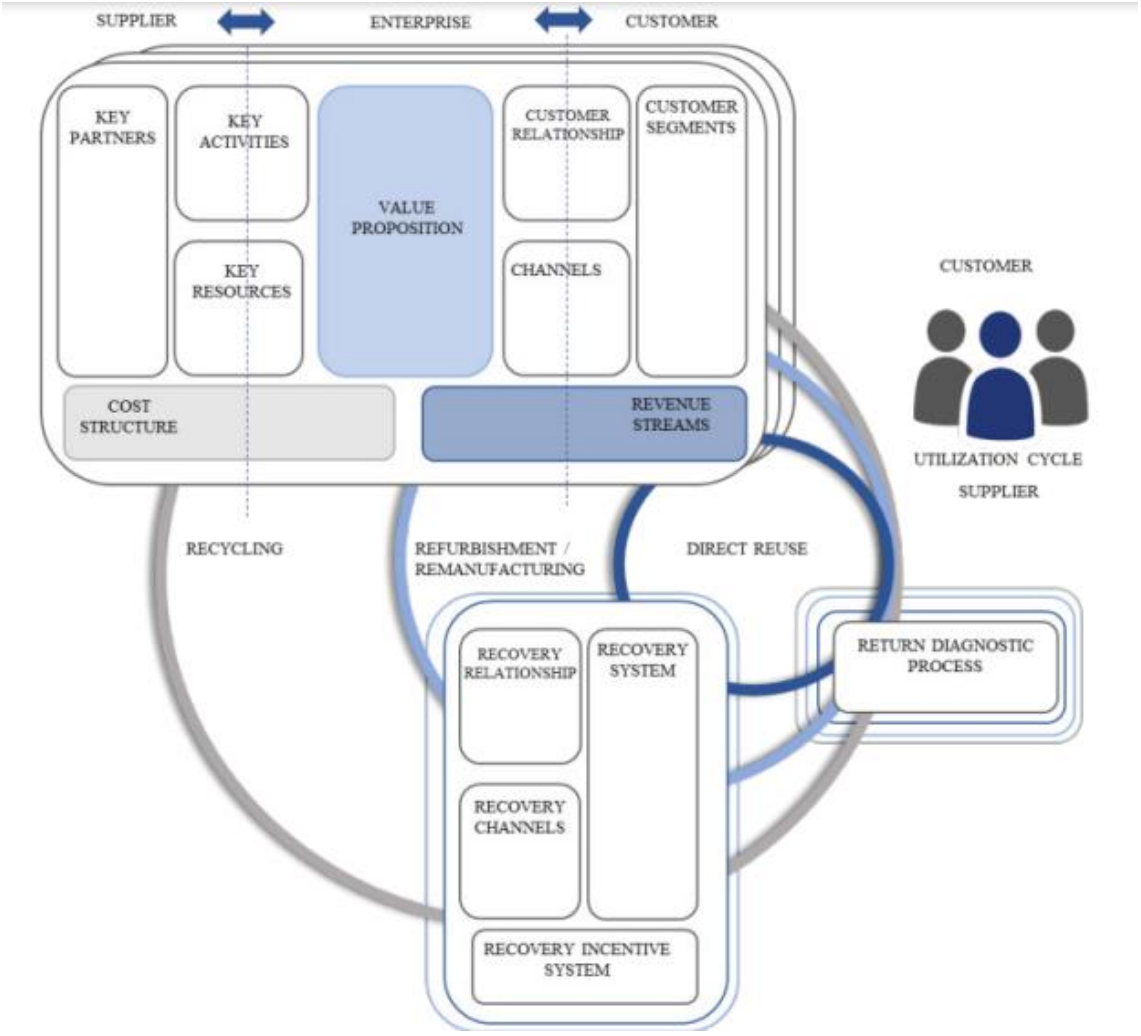

Figure 16-Template to develop CBM (Braun et al., 2021)

Five essential elements extend the traditional Business Model Canvas to encompass circular economy principles in the modular structure for circular business models:

- Return Diagnostic Process: This includes determining if materials or products will be recycled, remanufactured, reconditioned, or reused, as well as determining when they can be re-inserted into the supply chain. (Braun et al., 2021)
- Recovery System: Describes the added value that recovery systems bring to the circular economy and transparently demonstrates the links across systems. (Braun et al., 2021)
- Recovery Relationship: Modifies customer relationships to take into consideration the circular nature of circular commerce, in which supplier-customer interactions revert at the conclusion of a product's life cycle. (Braun et al., 2021)
- Recovery Channels: Focuses on effective reverse logistics and after-recovery services, this section discusses communication strategies with consumers who turn into suppliers at the conclusion of product use. (Braun et al., 2021)
- The Recovery Incentive System: This system seeks out creative ways to profit from the recovery of used goods, promotes consumer returns with incentives, and divides expenses and rewards among partners fairly. (Braun et al., 2021)

Including these elements in the development of a thorough circular business model will be beneficial.

The conceptual framework to be developed in this study has implications that could be clarified by using an actor-network method. The framework by (Hina et al., 2022) focuses on how corporate functions—such as strategy, processes, knowledge, and frameworks—align with circularity principles, which include preservation, optimisation, system effectiveness, and the minimization of negative externalities.

CBM strategies are centred on recycling, enhancing product longevity through design, promoting repair and upkeep, and maximizing utilization via sharing models. Simultaneously, the application of these strategies necessitates adherence to circular economy principles which focus on resource decoupling, efficiency maximization, and the reduction of negative external impacts. Knowledge management is crucial in this

context as it drives sustainable competitive advantages by underpinning the strategic implementation of these circular principles. (Hina et al., 2022)

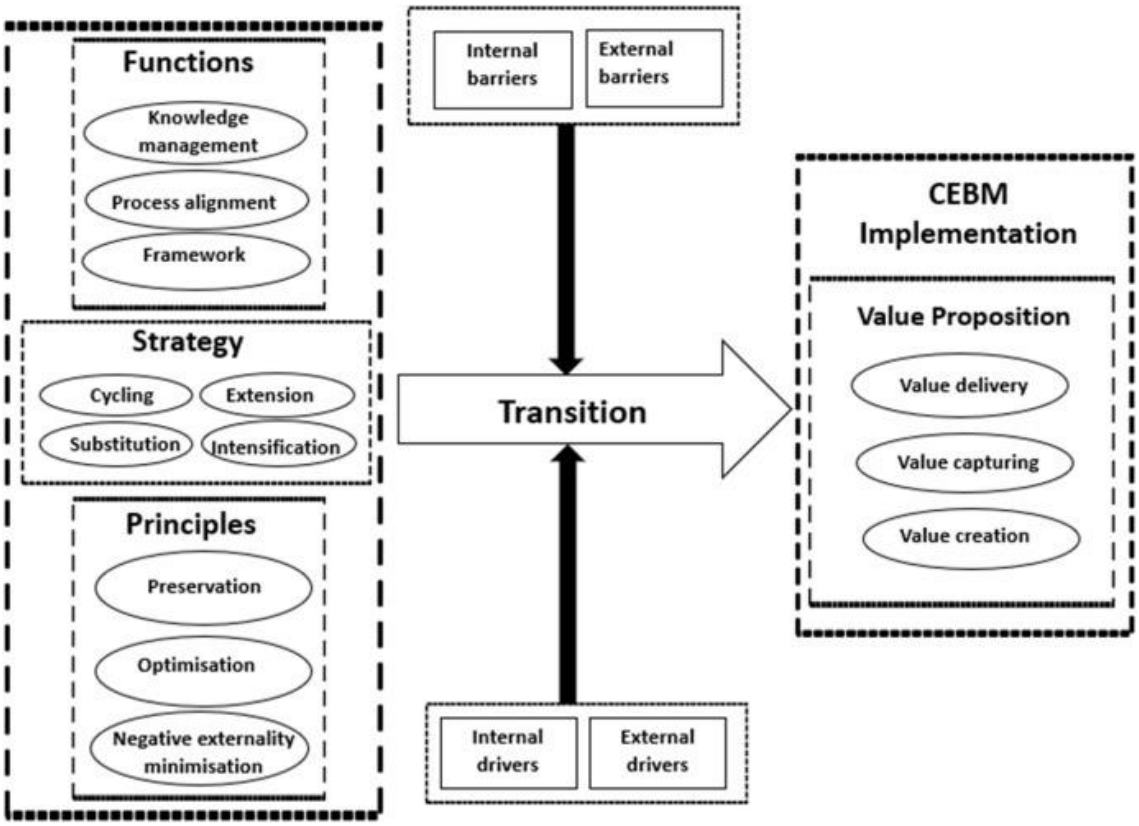

Figure 17-Actor-network theory-based framework for CBM implementation (Hina et al., 2022)

The present business model can be created, acquired, transformed, or diversified in order to apply CBM (Geissdoerfer et al., 2017). Nonetheless, the cornerstone for the effective implementation of the CBM attempt must be significant characteristics that were extracted from the assessment of the drivers and barriers.

It has been proposed that the systemic context of a CBM cannot be sufficiently met by the organization-centric structure of a standard BMC (Geissdoerfer et al., 2017). Despite its shortcomings, a number of scholars have proposed modifications to the BMC framework and its constituent parts, resulting in a variety of representations of the CBMC.

Lewandowski expanded it by adding the "adoption factor" and the "take-back system" in addition to adapting its constituent parts (Lewandowski, 2016). Hina et al. created a framework that emphasises value propositions in order to advance towards CBM

implementation (Hina et al., 2022). The framework is based on actor-network theory. In a similar vein, Braun et al. added new elements pertaining to value and recovery to the CEBMC and investigated the idea of value creation from a cascading hierarchy of resource cycles (Braun et al., 2021).

Through a comparative analysis of the conceptual CBMC produced in the three previous studies, this study has mapped a conceptual CBMC, encompassing various building blocks, for construction organisations, as shown in Figure 10. The legend in Figure 10 shows the new additions, updated building blocks, and unaltered building blocks in comparison to the traditional BMC.

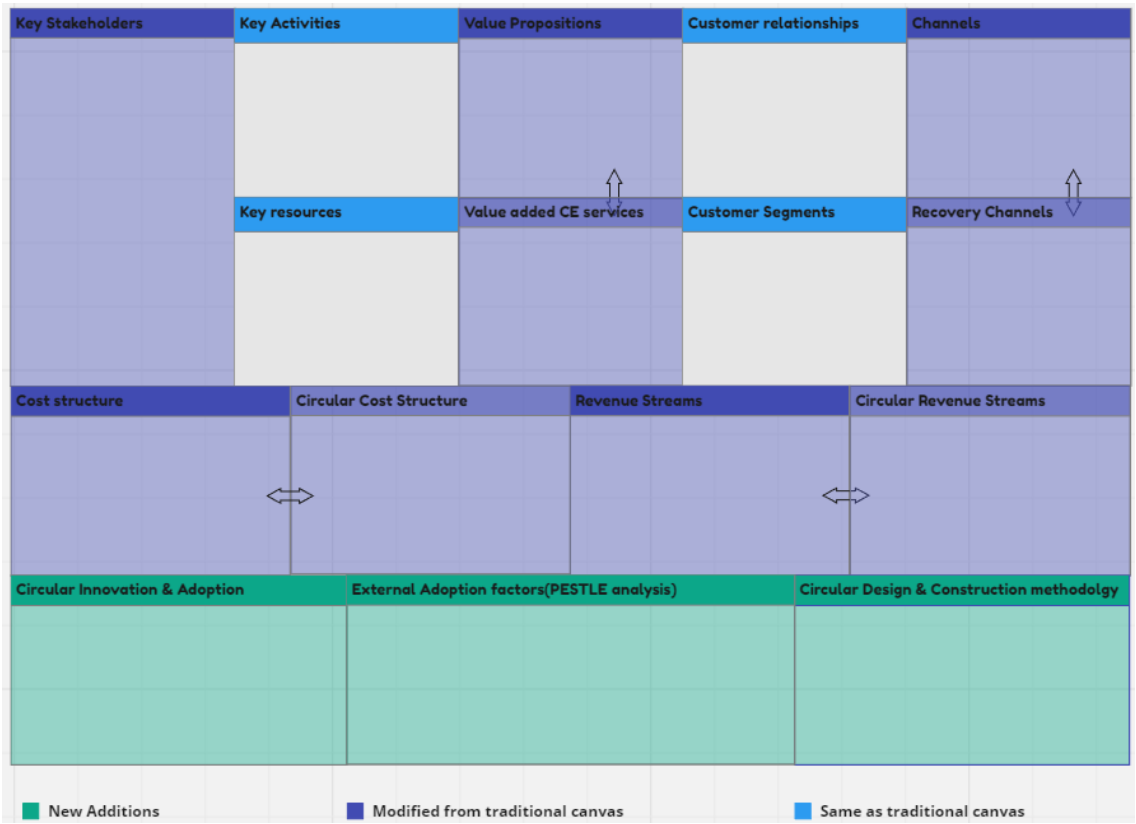

Figure 18- Proposed Circular Business Model Canvas for Construction (Adapted from Braun et al., 2021; Ellen Macarthur Foundation, 2015; Hina et al., 2022; Lewandowski, 2016; Osterwalder & Pigneur, 2010)

Below is a description of each notional CBMC building block for construction organisations.

- Key Stakeholders: Key stakeholders are those who work together to achieve circularity among the various parties involved in the construction process. Because principal contractor organisations participate in one or more phases of

construction projects and work closely with important stakeholders, their implementation of the CE can have a substantial impact on the industry's overall implementation of the CE in the context of construction. Developing extensive networks including all parties involved in the supply chain—from suppliers of design and raw materials to consumers, such as service providers, recyclers, and associated information flows—is necessary to shift the construction sector towards circularity. The adoption and development of circular innovations, circular-oriented decision making, circular value capture models, co-creation, and the spread of sustainability culture via marketing can all be facilitated by stakeholder engagement in the CE context through relationship-building, communication, and learning practices. (Osterwalder & Pigneur, 2010) Educational activities are also essential.

- Key activities: The organization's primary, auxiliary, and management operations pertaining to the CE are included in the value chain processes that are covered by key activities. For construction organisations, identifying the core, auxiliary, and managerial activities within CEBM is essential. (Osterwalder & Pigneur, 2010)
- Key Resources: Key resources address every step of the supply chain process, from choosing environmentally friendly suppliers and materials to using them during construction. The goal of the CE is to create a closed material flow across the whole economy. However, a construction company only works on a single or small portion of a project's phases. As a result, it is necessary to consider how it will affect the other lifespan stages, particularly the phases of usage and maintenance and demolition. According to Huovila and Westerholm, building material reuse done right can have a big positive impact on the environment. (Osterwalder & Pigneur, 2010) The magnitude of these advantageous outcomes, however, differs according on the selected materials and goods.
- Value proposition: This building block outlines the unique advantage the company delivers, focusing on environmentally friendly and long-term profitable building solutions for clients. (Osterwalder & Pigneur, 2010)
- Value added CE services: Value added services like product as a service, sharing economy, dematerialization, reverse logistics, and product life extension are examples of CE services that are provided by organisations. Organisational markers of CE include, for example, reverse logistics and

advertising/providing shared facilities or equipment. This factor enables an external body to assess a company's intent for CE. (Hina et al., 2022)

- Customer Relationship: Explains how to handle client interactions to guarantee their happiness and allegiance by providing superior service, being open and honest, and being involved all the way through the building process. (Hina et al., 2022)
- Customer segments: Customers have varying expectations about an organization's values. As a result, segmentation must be done correctly to deliver value. (Osterwalder & Pigneur, 2010)
- Channels: Describes the diverse ways the business interacts with customers directly, digitally, or through third-party agencies in order to convey and deliver its value proposition. (Osterwalder & Pigneur, 2010)
- Recovery channels: In addition to discussing communication tactics with customers who become suppliers after a product is used, this part concentrates on successful reverse logistics and after-recovery services. (Lewandowski, 2016)
- Cost structure: examines the financial implications of putting a circular business model into effect, including the costs of implementing sustainable practices as well as the possible benefits from lower energy and material waste. (Osterwalder & Pigneur, 2010)
- Revenue streams: Examines the various revenue streams that the company can achieve, such as direct sales, service agreements, or creative methods like leasing building components. (Osterwalder & Pigneur, 2010)
- Circular cost structure/Circular Revenue streams: An organization's economic, social, and economic costs and revenues are covered by its circularity cost and revenue. It is therefore advised to use suitable financial analysis methodologies because the cost does not stop at the initial direct cost. These methods include lifecycle costing, cost-benefit analysis, and net present value investment appraisals. (Braun et al., 2021; Hina et al., 2022; Lewandowski, 2016) In addition, assessments must be made of circular revenues, the secondary material market, supply chain risks. and material price estimations.
- Circular Design and Construction methodologies: Using innovative architectural and infrastructure design strategies to attain greater circularity is referred to as

circular design and construction. In addition, compared to linear construction, more personnel and a wider range of knowledge must be included in the design stage. Lewandowski went on to discuss the design for circularity using a variety of related concepts, including remanufacturing, maintenance, design for deconstruction, and design for product life extension (Lewandowski, 2016). To attain circularity, it is also necessary to use prefabricated components, modular construction, open building, and other innovative architectural techniques. (Braun et al., 2021; Hina et al., 2022)

- Circular Innovation and Adoption: Research and development are essential means of determining a methodical strategy for implementing CE in building projects and organisations to attain increased circularity. Adoption of technology includes the use of technologies to accomplish organisational circularity. One viable approach to moving the building sector closer to sustainability is to develop and implement new CE-friendly technology. Technology considerations include staff access to new and smart devices, building information modelling-based construction, augmented reality techniques for recycling and reuse, advanced robotics, additive manufacturing (such as 3D printing), IoT-based construction site control, and material passports.
- External Adoption Factors: Any element influencing an organization's adoption of CE that is not internal to the organisation is considered an external adoption factor. Several studies have stressed the need to properly determine external processes utilising the Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) viewpoint that effect the CE in an organisational environment (Lewandowski, 2016).

3.3 Case Studies

Several businesses and organisations that have effectively implemented circular strategies serve as examples of how circular concepts are applied in the construction and associated industries.

This section includes detailed case studies of Bouygues Construction and Rebel Group. The case studies should provide practical insights into the adoption and financial implications and risks of circular practices in the construction sector. The first

case study, Bouygues Construction, is assessed using both traditional and modified CCBM canvases to demonstrate the practical application and effects of the new conceptual model. The CCBMC is validated using this business case study. The Rebel Group case study focuses on comparative economic analysis of linear and circular initiatives and the long-term financial gains of circular construction practices, particularly in projects like circular viaducts. The outputs will be synthesized to obtain results and conclusions which can be further used for policy recommendations.

3.3.1 Bouygues Construction: A Business case

The Bouygues Group is a multifaceted French industrial conglomerate that holds substantial market share in media, telecommunications, and construction. The corporation was founded in 1952 and is run by a number of companies, including TF1, Bouygues Construction, and Bouygues Telecom. Bouygues Construction is known for its proficiency in sustainable construction and specializes in building, civil works, energy, and services. One of the top mobile network providers in France, Bouygues Telecom offers a wide range of telecommunications services. The company also oversees data centres, which add to its strong infrastructure network by storing and exchanging data and applications. (Bouygues Construction, 2024a; Bouygues Construction, 2024b; Bouygues Construction, 2024c)

Bouygues concentrates on energy, services, and building and civil works within the construction industry. Important tasks like project management, civil engineering, and infrastructure deployment help this sector function. The organization upholds enduring agreements and connections with an array of stakeholders, encompassing equipment providers, regulatory bodies, and property developers. (Bouygues Construction, 2024c; Vizologi, 20024) The building industry is distinguished by its dedication to innovation and sustainability, which enables Bouygues to find new growth opportunities and keep a competitive advantage.

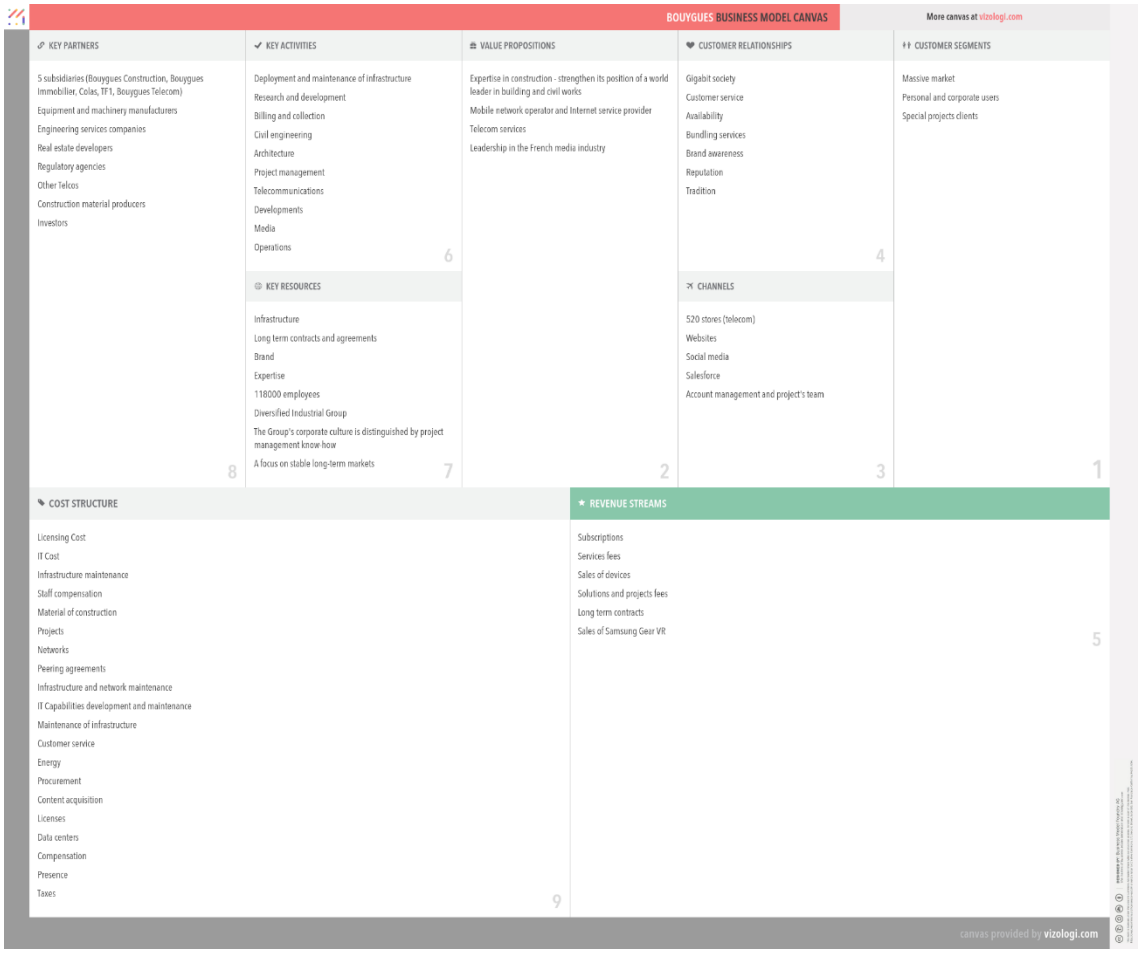

Figure 19-Buoygues Business Model Canvas (Vizologi, 20024)

Bouygues Construction has a comprehensive strategy focused on resource efficiency, sustainability, and creative construction techniques to integrate circularity into their economic model. This strategy promotes recyclable waste, reduces waste, and makes use of renewable resources. (Bouygues Construction, 2024b) The organisation places a strong emphasis on disregarding conventional methods to promote a variety of creative construction alternatives.

3.3.1.1 Reason for Study

By encouraging resource efficiency, sustainability, and innovative construction methods, Bouygues Construction aimed to incorporate circularity into their business model. This case study attempts to examine how Bouygues Construction applies the concepts of the circular economy. The company's attempts to reduce waste, reuse materials, and minimize its carbon impact are among the main goals to be understood. Later, the author also tries to analyse the company using the Business Model Canvas

to understand the essential aspects of the company and how circularity can be integrated into the Business Model.

3.3.1.2 Circular Integration in Operations

One of the principal initiatives demonstrating Bouygues Construction's dedication to circularity is the 'Maillerie' project, which emphasises the selective demolition of existing structures to reuse existing resources. 30,000 tonnes of concrete and 8,000 square metres of solid oak wooden flooring were salvaged for reuse in this project, demonstrating the company's commitment to a waste-free building site and the useful implementation of circular economy principles. The collaboration formed with manufacturers, startups in the circular economy, and interdependent associations has made it possible to recycle and reuse different components that were removed during the demolition of an old logistics facility. (Bouygues Construction, 2024b)

Throughout the whole value chain, from project design and material procurement to project implementation and operation, Bouygues Construction is aggressively lowering its carbon footprint. The Science Based aims project (SBTi) has certified the company's aims for decreasing greenhouse gas emissions by 2030. Furthermore, through initiatives like Cynéo, Bouygues Construction is leading the way in promoting the circular economy by concentrating on low-carbon concrete solutions to reduce its carbon footprint and striving for the mass reuse of resources.

Bouygues Construction has demonstrated a resolute commitment to mitigating environmental impact, optimising resource efficiency, and promoting sustainable growth in the construction sector through its circularity strategy, which is an all-encompassing and inventive endeavour in line with sustainability objectives (Bouygues Construction, 2024c).

Figure 20-3D Visualisation of Maillerie project (Bouygues Construction, 2024b)

Bouygues Construction has achieved notable progress in **incorporating the ideas of the circular economy** into its operational framework. This is a thorough synopsis derived from data collected from multiple sources:

- Bouygues Construction's Commitment to the Circular Economy: By emphasising the use of renewable resources, lowering waste output, and guaranteeing waste recyclability, the company is dedicated to more effective and sustainable resource management. (Bouygues Construction, 2020)Their broader environmental and corporate social responsibility (CSR) goals align with this commitment (Ellen Macarthur Foundation, 2024a).
- Project Highlight: 'Maillerie': Led by Bouygues Bâtiment Nord-Est and Link City, the 'Maillerie' project in Lille is a noteworthy example of their dedication to circularity. This project, which repurposes 30,000 tonnes of concrete and 8,000 square metres of solid oak timber flooring from a former logistics facility, is an excellent example of selective demolition and material reuse. (Bouygues Construction, 2024b)
- Reduction of Carbon Footprint: The Science Based Targets programme (SBTi) has confirmed the company's ambitious targets to cut greenhouse gas

emissions by 2030. During construction, these include a 40% reduction in direct emissions and a 30% reduction in indirect emissions. (Bouygues Construction, 2024c)

- Creative Solutions: Bouygues Construction prioritises creative solutions through research and development, such as low-carbon concrete and the recycling of building materials. For instance, the Cyneo initiative seeks to reuse materials in large quantities, greatly lowering the carbon footprint of concrete used in building. (Bouygues Construction, 2024c)
- Circular Design Experience Project: The goal of this project was to provide Bouygues Construction teams with decision-support tools by bringing together professionals to investigate circular economy ideas in the construction industry. A catalogue of reusable interior-finish materials, an indication grid for evaluating building and product performance, and a guide for design teams are some of these tools. (Bouygues Construction, 2024b)
- BIM and Circular Economy: It is emphasised that one of the main factors facilitating the circular economy in construction is the use of Building Information Modelling, or BIM (Bouygues Construction, 2020). Building Information Modelling (BIM) streamlines the management of a building's lifecycle, encourages effective decision-making, (Smith, 2014) and helps to adopt circular economy principles.

3.3.1.3 External Validation

1. Ellen MacArthur Foundation: This foundation highlights creative methods from a variety of industries and offers case studies and perspectives on the circular economy. Although there are no explicit references to Bouygues Construction, the foundation's resources can provide a more comprehensive knowledge of circular economy concepts in practice. (Ellen Macarthur Foundation, 2024a)
2. MDPI Journal: BIM's potential to get over obstacles to the circular economy is covered in an academic article on the technology's involvement in circular construction models. This source offers a theoretical foundation for analysing Bouygues Construction's circularity strategy. (AlJaber, Alasmari, Martinez-Vazquez, & Baniotopoulos, 2023)

Bouygues Construction has demonstrated a holistic approach to sustainable construction through the incorporation of circular economy principles into its business strategy.

3.3.1.4 Analysis using BMC parameters.

Bouygues Construction Model has been analysed using various parameters in Business Model Canvas to understand the business initiatives and adaptability of circularity or sustainability in the business. Bouygues Construction's strategy is based on a foundation that is highlighted by the traditional Business Model Canvas, which looks at important alliances, activities, resources, and cost structures (SlideShare, 2015; Vizologi, 20024). this analysis lays the groundwork for a further investigation of their circular building methodology and its wider industry ramifications.

- Key Partners: Bouygues Construction works with a range of partners to make sure that its projects are successful. These include waste management companies, subcontractors for specialized work, and material suppliers. They also collaborate with R&D centres for innovation, local government agencies for regulatory compliance, real estate developers, architects and engineers for project design, and NGOs and government organizations for cooperative sustainability projects. (SlideShare, 2015; Vizologi, 20024)
- Key Activities: R&D, project design and management, building and refurbishment, and maintenance and operations are among Bouygues Construction's primary business activities. They also include measures to reduce waste on sites, sales and marketing campaigns, and quality assurance and control. Key initiatives also centre on sustainability, including lifespan assessment, material recovery, design for disassembly, and educating and training stakeholders. (Bouygues Construction, 2024c; SlideShare, 2015; Vizologi, 20024)
- Key Resources: Advanced technology and equipment, skilled personnel, and material resources are some of Bouygues Construction's most important resources. They have a competitive advantage since they own technology patents. Their projects and R&D endeavours require financial capital, and they depend on networks for circular economy projects. (SlideShare, 2015; Vizologi, 20024)

- Value Propositions: Bouygues Construction provides a number of value propositions, such as innovative building techniques, superior construction, and customized solutions catered to the specific requirements of the client. Their methods, which also guarantee adherence to environmental laws, demonstrate their dedication to sustainability and safety. They place a heavy emphasis on cost reductions through effective procedures and cultivate a solid reputation as pioneers in environmentally friendly building. (SlideShare, 2015; Vizologi, 20024)
- Customer relationships: The organization cultivates enduring and intimate connections with customers by means of individual support and cooperative project planning. They collaborate with customers and interact with communities to make sure initiatives fulfil their needs and advance circularity. Their customer ties are strengthened by long-term support, maintenance, and material recovery collaborations. (SlideShare, 2015; Vizologi, 20024)
- Customer Segments: Bouygues Construction caters to a wide spectrum of clientele, including governments, urban developers, and the public and private sectors for public works projects. They serve both domestic and foreign customers, including those that value sustainability and are concerned about the environment. Long-term public-private partnerships (PPPs) are another important clientele. (SlideShare, 2015; Vizologi, 20024)
- Cost Structure: Bouygues Construction's cost structure consists of fixed expenditures for personnel, materials, and machinery as well as marketing and research and development costs. Subcontractor fees and logistics are examples of variable expenses. In addition, they have to pay for overhead, operations, lifecycle costs, and training and development. A sizeable portion of the cost structure of circular projects also consists of initial investments. (SlideShare, 2015; Vizologi, 20024)
- Revenue Streams: Bouygues Construction generates revenue in a number of ways. These consist of project revenue, construction practice consulting fees, and licensing. They charge a premium for their services, obtain grants and subsidies for sustainable practices, and provide maintenance services and

service contracts. Their revenue streams also include material recovery. (SlideShare, 2015; Vizologi, 20024)

- Channels: Bouygues Construction reaches out to its clients through a variety of ways. These consist of collaborations, industry conferences, seminars, direct sales, and project contracts. In addition, they keep up an online presence via publications, case studies, and digital platforms to highlight their work and draw in new customers. (Bouygues Construction, 2024a; SlideShare, 2015; Vizologi, 20024)

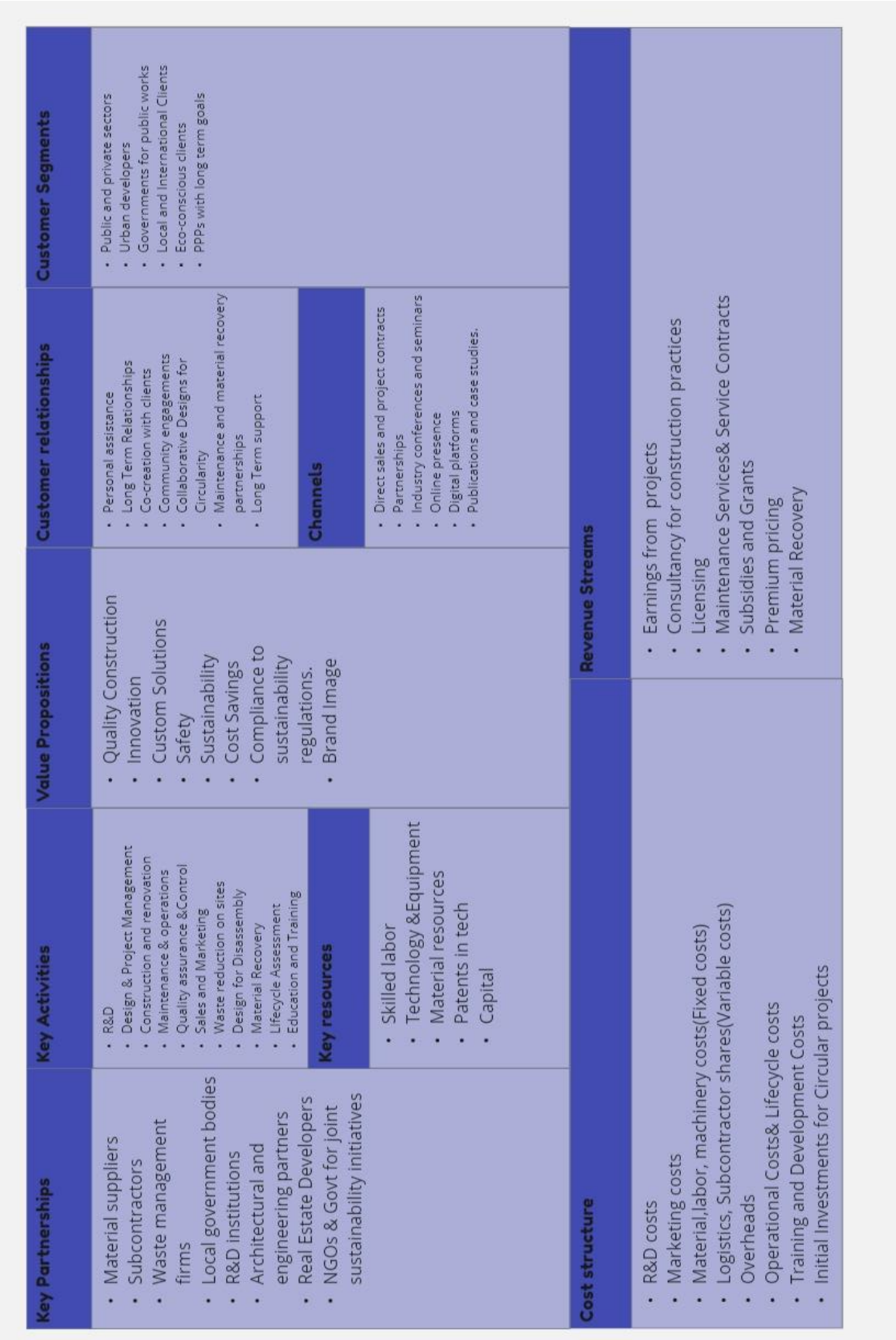

Figure 21-Bouygues Construction Business Model Canvas (Adapted from Bouygues Construction, 2024c; SlideShare, 2015; Vizologi, 20024)

The conventional Business Model Canvas offers an extensive framework for examining the several components that make Bouygues Construction successful. The company's dedication to incorporating sustainability into its core operations is highlighted by this analysis, which is essential to its long-term performance and adherence to environmental rules. However, the same case study will be examined utilizing the modified Circular Business Model Canvas for Construction in order to completely grasp the subtleties of their circular economy initiatives and comprehend their influence on the company. This strategy will give a more thorough evaluation of Bouygues Construction's tactics and their efficacy in promoting sustainable and circular practices by highlighting the distinctions and extra insights offered by the circular canvas.

3.3.2 Rebel Group_ Circular viaducts.

The Rebel Group is a multinational consulting and investment organisation with its headquarters located in the Netherlands. They work in a variety of fields, such as social work, urban development, transportation, sustainability, and healthcare. In their capacity as financiers and strategists, they provide counsel, carry out initiatives, and make investments in cutting-edge solutions that support their dedication to advancing society. Rebel's strategy is centred on thorough partnership with partners, prioritising the creation of tangible tools to assist in making strategic decisions as well as advise based on facts. Increasing sustainability and quickening the shift to a circular economy are frequent focuses of their initiatives, especially for the business community. (Rebelgroup, 2023; Rebelgroup, 2024a)

The Rebel Group bases its participation in the circular economy on three key tenets: providing advice on partnerships, policy, and strategy; measuring environmental effect; and implementing circular contracts and procurement. These pillars demonstrate their strategy for promoting a circular economy and support their objective of easing a transition with the least possible negative impact on the environment. The team's emphasis on research and practical tools for strategic decision-making enables them to work well with industry stakeholders, including rivals and supply chains, to promote the adoption of circular processes. (Rebelgroup, 2024b; World Economic Forum, 2024)

A study and pilot project analysis has been conducted by Rebel group for **Riijkwaterstaat**(Authority for Public Works and Water supply) in Netherlands to understand and compare the differences in linear and circular construction of water supply ducts in Kampen, The Netherlands. (Consolis, 2019) The study took into account the time value of money, all direct and indirect costs, social and environmental cost and other aspects of sustainability.

3.3.2.1 Reason for Study

Nearly 90% of Rijkswaterstaat (RWS) viaducts and bridges are demolished before they reach the end of their technical lives, according to research into the reasons behind their removal. Although these structures are predicted to last for about 80 years, the average realized lifespan according to a study dataset is much lower-46 years, on average. The main justifications for its functional demolition are **expansions required for railway infrastructure, enhancements to the road network to improve traffic flow, and changes in legislation and regulatory standards**, (Rebel, 2018)such as those affecting waterway width.

Figure 22-Viaduct model project (Rebel, 2018)

3.3.2.2 Traditional Alternative vs Circular Alternative

A comparison of conventional and modular viaducts is part of Rijkswaterstaat's (RWS) analysis of the societal costs and benefits of circular construction. The zero option, which stands for the conventional method, entails building and designing a typical viaduct in compliance with modern specifications.
Key Specifications of the viaduct are explained in Table 1.

Table 1-Specifications of Traditional Alternative (Adapted from Rebel, 2018)

Key specifications	
Length	20 m
Width	7.5 m (standard 7.5 m pavement width)
Main elements	-New viaduct -2x1 lanes (no emergency lanes)
Design elements	-Concrete girders -2 elevated abutments -No intermediate support joints
Materials	Standard Concrete process
Technical lifespan	One hundred years

Standard concrete processes are used to build the traditional viaduct. This means that a regular concrete mix is used, which is then usually processed into mixed granulate once the viaduct is demolished. Although this viaduct is designed to last one hundred years, the study indicates that it will likely need to be **replaced after 40 years** because of functional requirements like the need to improve traffic flow or comply with new laws. The modular viaduct designed and built as part of the Circular Project Alternative places a strong emphasis on component standardization and simplicity of dismantling. The viaduct is made up of discrete, prefabricated parts that are simple to disassemble and repurpose in various settings. The key specifications of the project are given in Table 2.

Table 2-Specifications of Circular Alternative (Adapted from Rebel, 2018)

Key specifications	
Length of the viaduct	20 m
Size of modular components for deck	1.25 m X 1.25 m
Thickness	1m (for span of 15-25 m)
Main elements	-Viaduct with modular components -2x1 lanes (no emergency lanes)
Design elements	-Concrete girders -modular deck
Material	-Sustainable high-grade concrete
Technical lifespan	Two hundred years

When the modular viaduct in the Circular Project Alternative needs to be replaced, that is, after 40 years, it is completely disassembled and rebuilt at a new location rather than being demolished. The old viaduct's location will thereafter be replaced, if no new raw materials are required for the replacement project, by a new viaduct made using elements released from other sites. The environmental impact and material costs connected with conventional demolition and reconstruction are significantly reduced by using this method.

3.3.2.3 Effects

The modular viaduct's full reuse as opposed to the regular viaduct's demolition and minimal reuse is the main distinction between the circular project option (modular viaduct) and the zero alternative (standard viaduct). This lessens the impact on the environment and results in significant raw material savings. But as the table below illustrates, the modular viaduct has more design and investment expenses.

Table 3- Initial Investment costs comparison- Linear vs Circular (Adapted from Rebel, 2018)

Cost Category	**Zero Alternative (Standard Viaduct)**	**Circular Alternative (Modular Viaduct)**	**Difference**
Construction: Abutments	245	245	0
Construction: Bridge Decks	58	408	+350
Construction: Finishing	44	44	0
Subtotal	347	697	+350
Additional Detailing (10%)	35	70	+35
Direct Costs	382	767	+385
Indirect Costs (38%)	145	291	+146
Construction Costs Subtotal	527	1,058	+531
Internal RWS Costs (12%)	63	140	+77
External Costs: Engineering (8%)	42	82	+40
Total Engineering Costs	105	222	+117
Additional Costs (10%)	53	106	+53

Risk Reserves (20%)	137	277	+140
Total Investment Costs	822	1,663	+841

It is clear that the modular viaduct comes with extra expenditures, especially for the bridge deck. Due to the modular bridge deck's construction and design, which is six times more expensive than the non-modular version, the modular viaduct's initial investment costs are roughly twice as high as those of a normal viaduct. The modular blocks need to be precisely measured and finished because they are high-quality, standardized parts with a minimum 200-year lifespan. In addition, compared to a typical viaduct, building the modular blocks requires more time and tools. But over an optimistic two hundred years, all the components can be reused, reducing production expenses. Because it uses fewer raw materials and has a smaller negative impact on the environment and air quality, this reuse is also good for the environment.

With a 2% and 1% discount rate, **the net present value of the investment and replacement costs** for the two options are displayed in the following tables for terms of 100 and 200 years.

Table 4-Investment Cost Comparison (in € millions) (Adapted from Rebel, 2018)

Discount Rate	Period	Zero Alternative Costs	Circular Alternative	Difference (Zero Alternative-Circular)	Other Differences
2%	100 years	€1.4 million	€1.7 million	€ 0.3 million (+22%)	Transport/storage costs, development costs, disruption, raw materials, +/- CO2, +/- employment, aesthetics
	200 years	€1.5 million	€1.7 million	€ 0.2 million (+13%)	
1%	100 years	€1.7 million	€1.7 million	€ -0.1 million (-5%)	
	200 years	€2.2 million	€1.7 million	€ -0.5 million (-23%)	

The difference over a **100-year** period between the project and the zero option, assuming a **2% discount rate**, is €300,000. Therefore, if one looks only at the investment costs (design, engineering, and building), the circular viaduct is 22% more

expensive. The gap becomes 13% during a **200-year** period when the viaducts need to be replaced four times. Transport and storage expenses, as well as the cost of demolition and deconstruction, are not included in this comparison. On the other hand, the environmental advantages of preserving materials for four viaducts are probably substantial but have not been measured or valued.

3.3.2.4 Detailed Economic Analysis

The below discussed factors are the **direct costs** involved in the project while comparing the linear and project alternative.

- **Initial Investment Costs:**
  - The modular viaduct's initial costs are roughly twice as high as those of the traditional viaduct.
  - The inflated costs are attributed to the advanced design and construction techniques required for modularity.
- **Lifecycle Costs:**
  - Based solely on initial costs, the modular viaduct is financially more expensive over a 100-year period.
  - Over a 200-year period, the cost difference decreases to 13% as savings from raw materials and reduced environmental impact accumulate.
  - Taking into account a 1% discount rate, the modular viaduct can become 5% cheaper over 100 years and 23% cheaper over 200 years due to savings in demolition, transport, and new material production.

Apart from the above discussed costs, few factors that have an **indirect impact on the finances** are development costs, transport and storage costs and costs for demolition and deconstruction.

- **Development Costs:** Until modular viaducts are standardized and extensively used, a sizable investment is needed for development, testing, research, and monitoring.
- **Transport and Storage Costs**: A sizeable number of projects must ensure enough demand and supply for the usage of modular elements to be justified. Up to their next usage, elements must be stored, which results in storage

expenses. Transport expenses could be greater than for completely new projects, depending on the locations.

Non-Financial Effects are something to be highlighted in this case. There are several factors that puts Circular projects on a better perspective that the linear one.

- **Resource Savings:** The modular viaduct's components can all be recycled or left in the wild. Two replacement viaducts' worth of materials can be saved over a century, and over two centuries, even more can be saved.
- **Environmental Impact:** Because of the circular viaduct's less carbon footprint and decreased material waste, the environment benefits greatly from it. When modular components are reused instead of being destroyed, the environmental impact is reduced.
- **Construction Disruption:** Compared to conventional viaduct construction, prefabrication of modular viaduct elements results in less time spent on-site and less disturbance of traffic.
- **Aesthetics:** The modular viaduct lacks decorative features unless they are useful, which may detract from its overall attractiveness. Because prefabricated components are standardized, they are inappropriate for historic projects.
- **Flexibility and Adaptability:** Greater flexibility is provided by the modular design, which enables the viaduct to be modified to meet changing needs without requiring total destruction. This flexibility lowers the frequency of significant operations and increases the structure's useful lifespan.

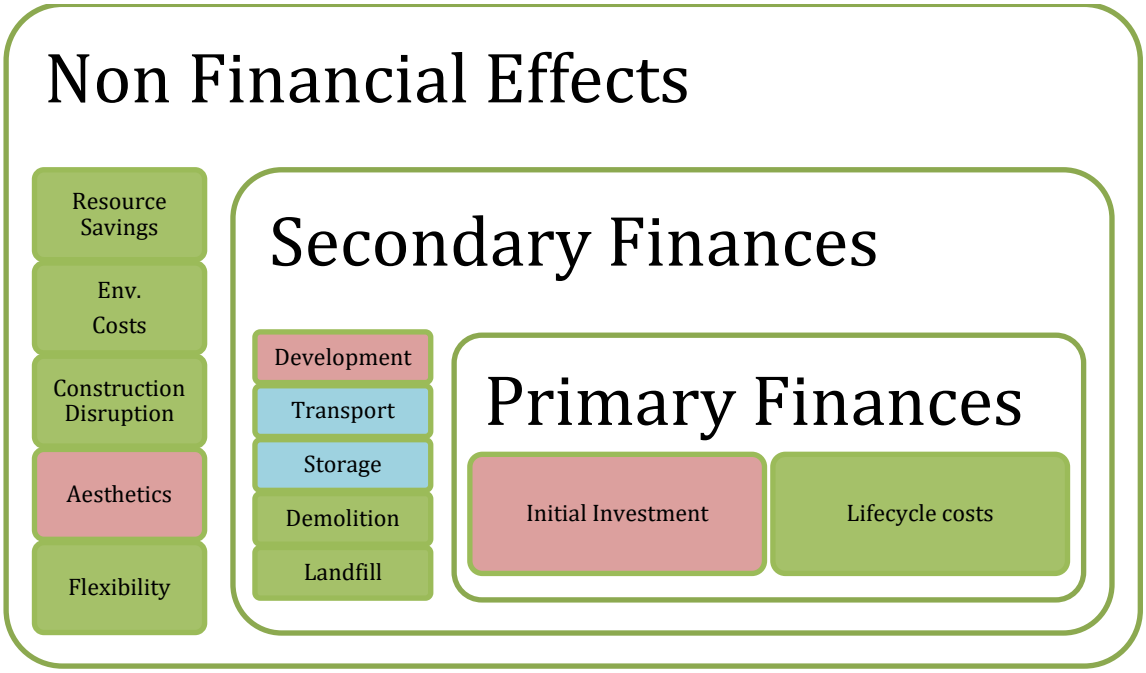

Figure 23-Economic Analysis of Circular Viaducts compared to Linear.

Negative impact (High Expense)

Positive impact (Low expense)

Uncertain impact (most likely to be negative)

3.3.2.5 Conclusion

The modular viaduct, a circular variation of the viaduct, is currently undergoing complete development. An initial examination of the expenses and advantages of a hypothetical model project reveals that while there are many benefits, the primary ones are the prevention of raw material consumption, the reuse of all components, and the reduction of related environmental effects. The initial investment costs are higher. When replacement costs are taken into account, the difference decreases significantly and may even go the other way: for a low discount rate of 1%, the investment and replacement costs of the modular viaduct are less than those of the standard viaduct. While the financial impacts of all factors are understood, the prices in transport and storage for circular projects are still uncertain.

Chapter 4. Analysis and Results

In this chapter, the author examines the economic, operational, and strategic factors influencing the adoption of CCBMs. This investigation begins with a thorough study of the major economic constraints and challenges to growing these models to a viable level. Following that, the thesis investigates the use of CCBMC, evaluating its usefulness in incorporating circular economy ideas into company processes and contrasting it with traditional models. We look at Bouygues Construction to see how this canvas helps with strategic decision-making and sustainable integration. The chapter then switches to policy implications, demonstrating how the CCBMC can drive corporate and governmental policymaking to promote wider adoption of circular ideas. Furthermore, the chapter addresses the possibility for scaling via collaborative networks and public-private partnerships, highlighting the importance of a unified ecosystem to support CCBM. Finally, it discusses the long-term financial benefits of using circular models, pushing for a paradigm shift that recognizes the larger economic, social, and environmental benefits of construction sustainability.

4.1 Analysing the key barriers of CCBM implementation: Economic perspective

The primary determinants of the economic barriers to the implementation of Circular Construction Business Models (CCBM) are evidently the following: lack of financial incentives, uncertain ROI, initial implementation costs, and obtaining economies of scale (Hina et al., 2022). Due of the unpredictability of material costs, labour costs, refurbishing charges, and logistics, unclear ROI is the most significant hurdle among them.

Making the switch to circular building methods necessitates large upfront investments in recent technology, employee retraining, and process reform. These large upfront expenditures are a major barrier, especially for small and medium-sized businesses (SMEs), (Hina et al., 2022) who might not have the funding available to make these investments.

The problem of high beginning expenses is made worse by the lack of strong financial incentives, such as grants, subsidies, and tax breaks. Businesses are left to shoulder

the entire financial burden of implementing circular processes since governments and financial institutions frequently fail to offer the support required to offset these expenses. (Technopolis Group et al., 2016) The dearth of outside funding deters many businesses from adopting circular business models.

The majority of circular construction projects start out small and need substantial funding as well as market development to grow to a size where they become profitable. Because the cost benefits of circular practices cannot be completely realised without reaching a significant scale, establishing economies of scale is a critical hurdle. (Technopolis Group et al., 2016) This scaling problem prevents CCBM from being widely used.

Uncertain ROI is the most important of the economic obstacles. Circular construction entails extremely variable and frequently unpredictable costs for materials, labour, renovation, and logistics (Technopolis Group et al., 2016). The cost of sustainable substitutes and recycled materials might vary, and the cost of specialised labour needed for circular operations is typically higher. The circular model's foundational refurbishment procedures have variable costs based on the availability and state of recycled materials. Furthermore, logistics increase costs and complexity since handling and transportation of recovered resources might be more complicated and expensive than in standard supply chains. (Hina et al., 2022)

(Pomponi & Moncaster, 2017) also noted that other significant obstacles to CCBM implementation in the construction industry include high initial costs, longer payback periods, uncertain financial returns, a lack of financial incentives, restricted access to financing, the viability of recycled materials economically, and regulatory and market uncertainties. Longer payback periods, which increase financial uncertainty, hamper the adoption of circular models even more, according to the study.

Additional impediments were noted in the Rebel group's Circular Viaduct case study. These included high starting expenses, R&D development costs, and uncertainty surrounding the costs associated with transporting and storing circular materials. These obstacles draw attention to the difficulty and expense of putting circular construction methods into practice.

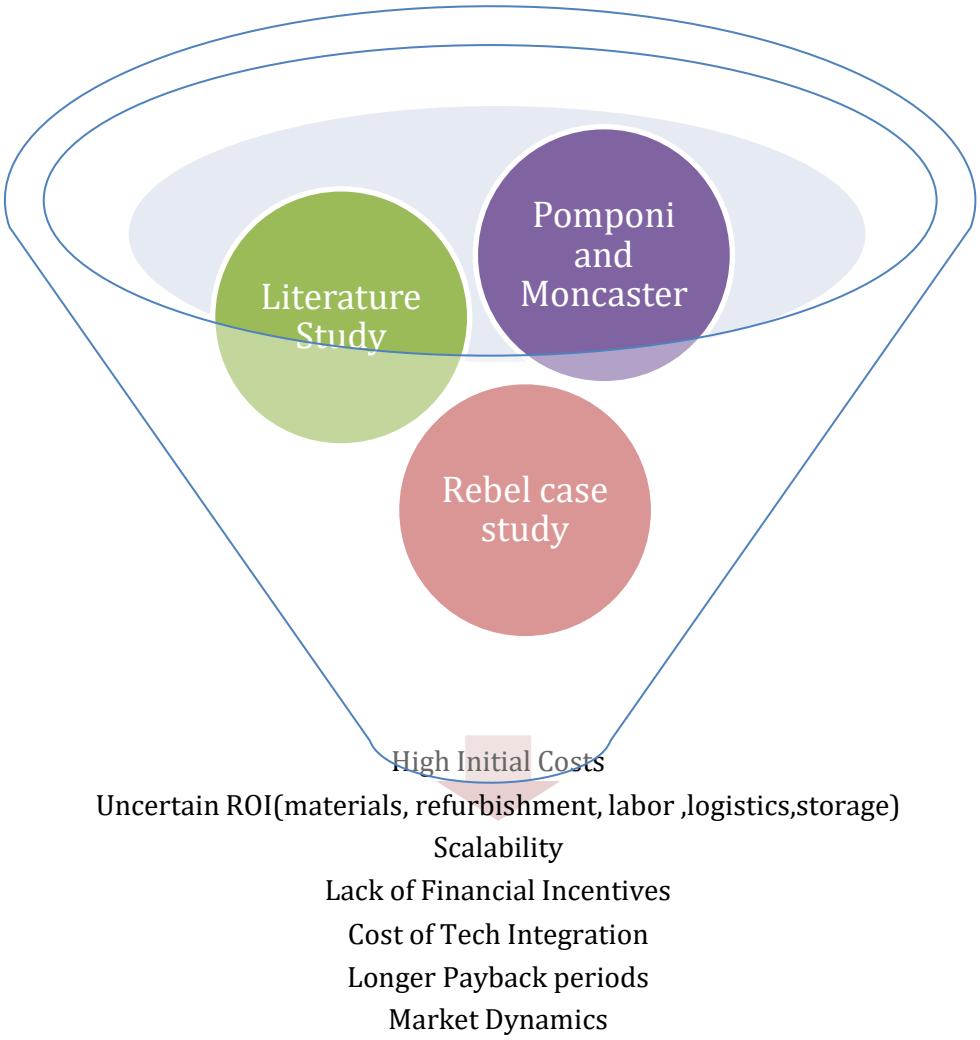

Figure 24-Financial Barriers of CCBM implementation (Hina et al., 2022; Pomponi & Moncaster, 2017; Rebel, 2018; Technopolis Group et al., 2016)

To create a climate that is conducive to the adoption of circular construction techniques, it is imperative to address this uncertainty as well as the other economic obstacles. Future work should concentrate on creating plans to lessen these ambiguities and give companies more transparent financial routes to adopt and profit from circular models.

4.2 CCBM canvas for Circularity Assessment of Businesses

Recognizing the benefits of the Circular Construction Business Model (CCBM) canvas over the traditional business model canvas requires an understanding of how the canvas is used during the assessment process. The circular economy concepts are integrated with typical business parameters in the CCBM canvas, resulting in a more

thorough assessment of sustainability practices. By using the CCBM canvas, companies may improve their strategic decision-making and align with global sustainability goals by gaining insights into long-term economic and environmental advantages. This section will examine the particular adjustments and extra criteria added to the CCBM canvas to show how it provides a more comprehensive framework for evaluating circular construction companies such as Bouygues Construction.

4.2.1 Utilising CCBMC to assess Buoygues Construction

Bouygues Construction, which was previously reviewed using the standard business model canvas, will be reevaluated using the CCBM canvas in order to better understand the influence of the CCBM canvas on decision-making. In order to give firms who are committed to incorporating circular economy practices into their core operations a clearer route, this comparative research intends to demonstrate how the adoption of circular principles might influence strategic choices, operational efficiencies, and sustainability outcomes.

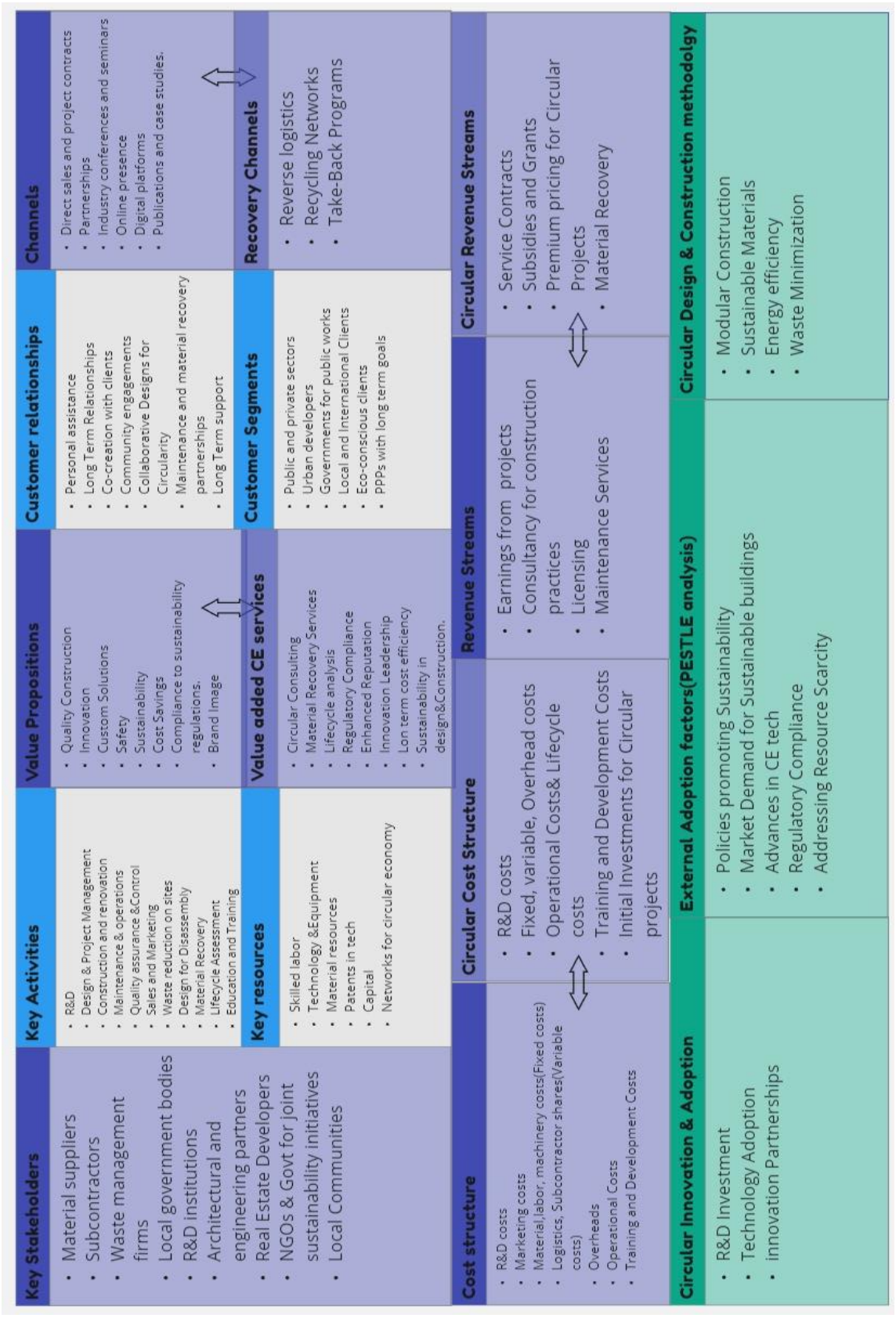

Figure 25-Bouygues Circular Construction Business Model Canvas (Adapted from Bouygues, 2021; SlideShare, 2015; Vizologi, 20024)

The various parameters of CCBM canvas have to be discussed again to analyse the key differences between the outputs of traditional and modified canvas.

- Key Stakeholders: Bouygues Construction works with a variety of stakeholders who are necessary to put circular economy principles into practice. These include waste management companies for effective waste treatment, subcontractors with expertise in circular processes, and material suppliers offering recyclable and sustainable products. Bouygues collaborates with NGOs and local government agencies to advance collaborative sustainability projects, and it partners with R&D centres and architects to develop cutting-edge design and construction techniques. (Bouygues, 2021; Bouygues Construction, 2024b) By including the community, initiatives are guaranteed to adhere to local requirements and standards.
- Key Activities: Important activities for Bouygues in the circular economy, research, and development (R&D) pertaining to sustainable building methods and materials is part of construction. Modular construction and disassembly design ideas are incorporated throughout design and project management, facilitating faster material recovery. To reduce their negative effects on the environment, lifecycle evaluations guide maintenance and operations. (Bouygues, 2021; Vizologi, 20024) Programs for education and training make sure that everyone involved is aware of circular processes, which promotes a sustainable culture inside the business.
- Key Resources: The business uses a number of important resources to help with its circular economy ambitions. The use of innovative technology and skilled workers are essential for putting sustainable construction techniques into action. Green technology patents give a company a competitive edge, and sustainable and recyclable material resources are selected. (Bouygues, 2021; SlideShare, 2015; Vizologi, 20024) Funding circular projects requires financial resources, and networks supporting the circular economy enable Bouygues to stay in touch with partners and market developments.
- Value Propositions: Bouygues Construction provides innovative, sustainable, and high-quality construction solutions as well as value propositions that are in line with the principles of the circular economy. They offer specialised solutions that are customised to meet the demands of their clients, prioritising cost effectiveness, safety, and adherence to sustainability laws. Their reputation and

leadership in sustainable building are further enhanced by additional circular economy services such as lifecycle analysis, material recovery services, circular practice consultancy, and regulatory compliance assurance (Bouygues Construction, 2024b; SlideShare, 2015).

- Customer Relationship: Strong client ties are sustained by the business through one-on-one support, enduring alliances, and cooperative design initiatives. They work together with communities and clients to co-create sustainable solutions, making sure that initiatives both advance circularity and satisfy client expectations. (Bouygues Construction, 2024b) Partnerships for material collection and maintenance, as well as long-term assistance, further solidify these bonds by providing value that continues long after the project is over.
- Customer Segments: Bouygues Construction provides services to a broad spectrum of clients, including governments engaged in public works projects, the public and private sectors, and urban developers. (Bouygues, 2021; Bouygues Construction, 2024b) They serve both domestic and foreign customers, but they concentrate especially on environmentally sensitive customers and public-private partnerships (PPPs) with long-term sustainability objectives.
- Channels: The business uses a variety of methods to connect with its clientele, such as partnerships, industry conferences, seminars, and direct sales. An online presence via publications, case studies, and digital platforms enables them to exhibit their work and draw in new customers. (Bouygues, 2021; SlideShare, 2015; Vizologi, 20024) Reverse logistics and recycling networks are examples of recovery pathways that are essential for effectively managing end-of-life materials.
- Cost Structure: R&D expenditures, marketing charges, and fixed costs for supplies, personnel, and equipment are all included in the cost structure. Subcontractor fees and logistics are examples of variable expenses. (Vizologi, 20024) The management of operational and lifespan costs guarantees sustainability, whilst the adoption of circular processes is aided by training and development expenditures (Bouygues Construction, 2024b). Making the shift to a circular economy model requires making initial investments in circular ventures.

- Circular Cost Structure: The same R&D expenses fixed and variable costs, and operational costs are included in circular cost structures, but lifecycle costs are given more attention. Investing in training and development is important because it guarantees that all parties involved can apply circular practices. (Bouygues, 2021; Bouygues Construction, 2024b)Setting up sustainable systems and procedures requires initial investments in circular projects.
- Revenue Streams: Bouygues Construction generates revenue through project earnings, licensing, and consulting fees related to construction processes (Vizologi, 20024). Service contracts and maintenance services are another source of income for them. Their sustainable initiatives are supported by grants and subsidies; (Bouygues, 2021) also, premium pricing for circular projects and material recovery yields financial benefits.
- Circular Revenue Streams: Circular income streams include service contracts, grants and subsidies allocated to circular initiatives, and premium pricing for sustainable projects, in addition to regular revenue streams. (Bouygues, 2021; Bouygues Construction, 2024b) By recycling and repurposing building materials, material recovery also increases revenue and adheres to the circular economy principles.
- Circular Innovation & Adoption: To develop innovative circular building techniques and technologies, the company makes R&D investments. Maintaining an industry lead requires establishing innovation collaborations and using cutting edge technologies. (Bouygues, 2021; Bouygues Construction, 2024b) These initiatives guarantee ongoing development and the implementation of sustainable best practices.
- External Adoption Factors (PESTLE Analysis): Circular economy technological advancements, market demand for sustainable buildings, and sustainability-promoting policies are examples of external forces affecting the development of circular practices. In order to maintain long-term profitability, regulatory compliance and resource scarcity management are crucial. (Bouygues, 2021; Bouygues Construction, 2024b; Bouygues Construction, 2024c) PESTLE analysis is used to evaluate these variables in order to determine how they may affect the company's circular activities more broadly.

- Circular Design and Construction Methodologies: Bouygues building utilizes circular design and building techniques, including energy saving measures, modular construction, and the use of sustainable materials. (Bouygues, 2021; Bouygues Construction, 2024b)Throughout the building process, waste is minimized, and resources are employed effectively thanks to this primary focus. Bouygues leads the circular construction business and meets its sustainability targets with the aid of these approaches.

A thorough framework for evaluating the circularity of construction companies is provided by the updated Circular Construction Business Model Canvas. It offers a thorough assessment of Bouygues Construction's tactics and procedures by adding more sustainability-focused criteria. The company's adherence to circular economy concepts is highlighted in this reassessment, which employs the CCBMC to show how these practices impact decision-making. The impacts and benefits of utilizing the modified CCBMC over the conventional Business Model Canvas are examined in the section that follows, offering information on the advantages of implementing a circular strategy in the construction sector.

4.2.2 Effect of modified CCBMC

The Circular Construction Business Canvas offers significant benefits over the conventional approach from the standpoint of the business owner. First off, the CCBM canvas clearly **integrates the principles of sustainability and the circular economy**, making sure that every facet of the company operates in harmony with environmental objectives. The **growing focus on sustainability** is essential for contemporary construction firms looking to lessen their environmental impact. A comprehensive lifecycle perspective is also included in the CCBM canvas, taking into account the **full lifecycle of products** and materials. This encourages procedures like material recovery and design for disassembly, which are crucial for reaching complete circularity but are frequently disregarded in conventional models.

Furthermore, by emphasizing the significance of resource conservation and waste reduction, the CCBM canvas promotes **increased resource efficiency**. This emphasis aids in finding ways to cut costs and maximize the use of resources, which

improves operational effectiveness. By highlighting the adoption of innovative technology and continual improvement, the canvas also promotes **strategic innovation and research and development**. This strengthens the company's innovative culture and gives it a competitive advantage.

Broader stakeholder engagement is an additional significant benefit of the CCBM canvas. By engaging a broader spectrum of stakeholders, such as nearby communities and regulatory agencies, the business can promote cooperation and enhance its standing. The CCBM canvas also guarantees **regulatory compliance** and **efficient risk management**, assisting the business in managing risks associated with resource shortages and waste management as well as navigating changing environmental requirements.

Lastly, by emphasizing sustainability, the CCBM canvas helps achieve **long-term economic benefits**. This entails getting grants and subsidies for environmentally friendly initiatives as well as paying more for environmentally friendly products.

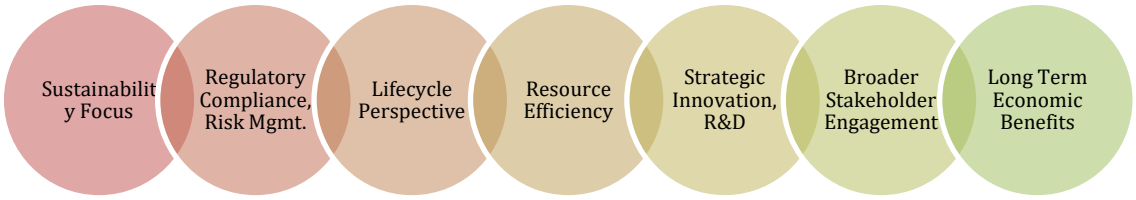

Figure 26-Effects of CCBMC

All factors considered, the CCBM canvas offers a strong framework for incorporating circular economy ideas into the fundamental activities of construction companies, resulting in positive effects on the environment and the economy.

4.3 Introduction of CCBMC for Effective Policy making

The Circular Construction Business Model Canvas (CCBMC) is a vital tool for evaluating and improving circular practices in construction companies. This paradigm incorporates circular economy concepts including material recovery, lifespan assessments, and sustainable design in addition to evaluating conventional business components. Companies can use this canvas to design complete internal policies that support sustainability goals, and governments can use it to create rules that encourage the adoption of circular business models in a variety of industries.

4.3.1 Internal Policy Making within the company.

The introduction of the new modified Circular Construction Business Model Canvas provides a methodical framework for evaluating sustainability and incorporating circular economy ideas into the fundamental activities of construction companies. Using this canvas can have a significant impact on policy making for Bouygues Construction and other similar companies in a number of key areas. This method can assist in creating efficient company policies in several ways which is discussed along this section. Various documents by Ellen Macarthur Foundation supports the various statements and suggestions in this section. (Ellen Macarthur Foundation, 2021b; Ellen Macarthur Foundation, 2021c; Ellen Macarthur Foundation, 2021d)

Figure 27-Effect of CCBMC on Company Policy making (Adapted from Ellen Macarthur Foundation, 2021b; Ellen Macarthur Foundation, 2021c; Ellen Macarthur Foundation, 2021d)

The circular economy and sustainability are integrated into the company's strategic vision, which is ensured by the canvas. Policies **that organize the entire firm towards shared sustainability** goals can be formed by clearly defining important areas such as value propositions, core activities, and customer interactions with an emphasis on circular practices (Ellen Macarthur Foundation, 2021c). The canvas helps with **better decision-making** by offering a thorough understanding of how circular processes affect every facet of the company, from revenue streams to critical resources. (Ellen Macarthur Foundation, 2021b) Investments in ecologically and financially advantageous sustainable technology and processes might be given priority in policymaking.

The canvas draws attention to the significance of particular resources for material recovery and lifetime evaluations, such as cutting-edge technologies and environmentally friendly materials. Thus, policies can be created to guarantee that **sufficient resources are allocated** to these critical areas, guaranteeing that the business can continue its circular activities. **Identifying potential risks**, including supply chain interruptions or regulatory non-compliance, is made easier by evaluating

the company through the lens of circular economy concepts. (Ellen Macarthur Foundation, 2021c; Ellen Macarthur Foundation, 2021d) By guaranteeing sustainable supply chains and strict respect to environmental laws, policies may be created to reduce these risks.

Continuous innovation and improvement are encouraged by the canvas's emphasis on circular innovation and adoption. It is possible to create policies that **encourage continuous research and development**, which will maintain the business at the forefront of sustainable construction methods and cultivate an innovative culture (Ellen Macarthur Foundation, 2021b). A greater understanding of the roles played by different stakeholders, like as partners, suppliers, customers, and the community, **facilitates improved stakeholder management**. Policies that guarantee open communication and cooperation with all parties involved can be developed (Ellen Macarthur Foundation, 2021b), which will increase confidence and cooperation when putting circular practices into practice.

The canvas offers a structure for establishing precise objectives and measurements associated with circular economy methodologies. Policies might require consistent tracking and reporting of key indicators, guaranteeing that the **business's performance is continually evaluated** and enhanced (Ellen Macarthur Foundation, 2021b). The canvas assists in identifying opportunities for waste reduction and process optimization by emphasizing sustainable construction methods and effective resource utilization. Standardizing these procedures across all projects through the introduction of policies can increase **efficiency in operation** and reduce costs (Ellen Macarthur Foundation, 2021b).

The canvas assists in identifying necessary policy revisions to comply with legal obligations, with a greater emphasis on exceeding environmental standards and complying with regulatory requirements. It is possible to create policies that guarantee all **activities comply with the regulation** as it stands and are ready for any modifications in the road (Ellen Macarthur Foundation, 2021d). Using the circular business model in the company's activities is in line with the larger goals of **corporate social responsibility** (Ellen Macarthur Foundation, 2021d). To formally commit the company to sustainability, policies can be created to make sure that all corporate operations benefit society and the environment.

Construction businesses may include sustainability into its business model in a holistic manner by utilizing the Circular Construction Business Model Canvas. Strong policies that support the company's strategic goals, enhance decision-making, optimize resource allocation, manage risks, promote innovation, involve stakeholders, measure performance, improve CSR, increase operational efficiency, and guarantee regulatory compliance are made possible by this integration. By implementing these principles, the company may preserve its competitive advantage in the construction industry and achieve long-term sustainability.

4.3.2 Government Policy making for Circular Businesses

Government regulations pertaining to circular enterprises might be significantly influenced by the launch of the updated Circular Construction Business Model Canvas (CCBMC) and its application in evaluating companies such as Bouygues Construction. Through the provision of an organized and thorough framework, the CCBMC assists policymakers in comprehending the essential elements and advantages of circular business practices, enabling the development of successful public policies. The impact of this method on the formulation of government policy is discussed in this section. The suggestions put forward in this section is based on various articles by Ellen Macarthur Foundation and European Commission , in which they have given extensive framework for policy making based on circular initiatives. (Ellen Macarthur Foundation, 2022; Ellen Macarthur Foundation, 2024b; European Commission, 2016)

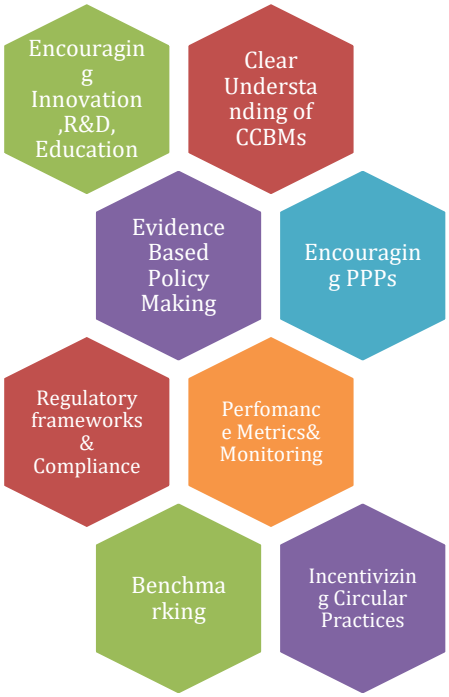

Figure 28-Effect of CCBMC on Governmental Policy making (Adapted from Ellen Macarthur Foundation, 2022; Ellen Macarthur Foundation, 2024b; European Commission, 2016)

A comprehensive overview of how companies might incorporate the concepts of the circular economy into their daily operations is given by the CCBMC. Governments can learn more about the essential components of a successful circular economy, such as resource efficiency, waste reduction, and sustainable innovation, by using this canvas to evaluate enterprises. This knowledge can help shape the creation of regulations that uphold and encourage good practices in a variety of sectors.

By using the canvas, comprehensive information about how companies apply the principles of the circular economy may be gathered. Governments can create **evidence-based policies** that specifically address the demands and issues faced by the construction industry by using this data-driven approach. (European Commission, 2016) For instance, based on tested business models, rules might be created to encourage material recovery and recycling activities.

The canvas offers a structure for establishing precise objectives and measurements associated with circular economy methodologies. To ensure accountability and transparency, governments might create regulations that require certain indicators to be monitored and reported on a regular basis. (Ellen Macarthur Foundation, 2024b;

European Commission, 2016) It is possible to create **performance metrics to track advancement** and promote ongoing improvement.
Governments can identify and **benchmark best practices** in the adoption of the circular economy by using the CCBMC to assess industry leaders such as Bouygues Construction. By creating norms and recommendations for other companies, these benchmarks can promote the wider adoption of circular practices (Ellen Macarthur Foundation, 2024b). Policies that encourage businesses to meet or beyond these criteria might be created to foster an innovative and continuous improvement culture.

Governments can establish **tailored incentives** for companies that implement circular economy concepts (Ellen Macarthur Foundation, 2022) by utilizing the insights gathered from the CCBMC. Investments in sustainable materials, technologies, and procedures can be encouraged by the creation of policies such as **tax breaks, grants, and subsidies** (European Commission, 2016). These incentives can hasten the shift to a circular economy by reducing the financial obstacles to implementing circular practices.

The significance of **regulatory compliance** in circular business models is emphasized by the CCBMC. Using this approach, governments can determine which regulations need to be changed and create new ones that promote circular activities. (Ellen Macarthur Foundation, 2024b; European Commission, 2016) Policies can be created to guarantee that companies follow environmental regulations, encourage the sustainable use of resources, and reduce waste. Governments can also set up enforcement systems to keep an eye on and guarantee compliance.

The necessity of circular practice **education and training** is emphasized by the CCBMC. Governments can create regulations that encourage educational projects and programs that try to raise knowledge of the circular economy among consumers, workers, and enterprises. Governments have the capacity to cultivate a sustainable culture and stimulate the adoption of circular practices at all societal levels through the promotion of education and awareness. (Ellen Macarthur Foundation, 2022)

The CCBMC emphasizes how crucial it is for different stakeholders—such as companies, governmental organizations, and academic institutions—to work together. Governments have the power to enact laws that support and **foster public-private**

partnerships aimed at creating and executing circular economy solutions. (Ellen Macarthur Foundation, 2022; Ellen Macarthur Foundation, 2024b) These collaborations can stimulate creativity, facilitate knowledge exchange, and pool resources to accomplish shared sustainability objectives.

Governments can develop policies that encourage research and development (R&D) in circular economy technologies and practices (Ellen Macarthur Foundation, 2024b) by following the CCBMC's emphasis on innovation and research. Governments can incentivize companies and academic institutions to create fresh approaches that strengthen the circular economy by establishing funding programs, innovation hubs, and research grants.

With the introduction of the updated Circular Construction Business Model Canvas, policymakers now have access to a useful tool. Governments can use this framework to create targeted policies that facilitate the building industry's shift to a circular economy. Strategic alignment, resource allocation, risk management, innovation, stakeholder participation, performance monitoring, corporate social responsibility, operational efficiency, and regulatory compliance can all be aided by these policies.

4.4 Ecosystem of Companies & Government: Future Scalability

The effective execution of Circular Construction Business Models (CCBMs) is contingent upon sustained cooperation between a heterogeneous network of businesses and governmental organizations. A smooth coordination of several tasks, such as construction, waste management, logistics, storage, and material supply, is necessary for the integration of circular concepts. This section examines how cooperative efforts may lead to future scalability, using case studies and current research as a source of information.

Effective Stakeholder Collaboration is essential to integrating circular principles into the building process. To enable the effective adoption of circular models, collaboration among architects, engineers, contractors, and waste management organizations is necessary, as highlighted by (Pomponi & Moncaster, 2017) and (Ghisellini et al., 2018).Involving other important parties, such as material suppliers, logistics

companies, storage facilities, and governmental organizations, can improve this cooperative approach even further, which helps in upscaling.

The key **functional collaborations** that is important for upscaling a Circular Construction Business are discussed below.

- **Construction companies:**

Role: Put circular design concepts into practice by making sure buildings are made to be disassembled and reused.

Collaboration: Create modular construction components that are simple to disassemble and repurpose by collaborating with engineers and architects.

- **Material Suppliers:**

Role: To supply recyclable and sustainable materials.

Collaboration: Establish close ties with building companies to provide materials that satisfy circular criteria and enable recycling and reuse of materials.

- **Logistics Providers:**

Role: Manage the transportation of materials and modular components. *Collaboration:* Create effective logistics plans to reduce the expense and environmental effect of shipping reusable parts and materials. The Rebel group's Circular Viaducts case study brought attention to the importance of logistics in terms of cost in circular construction.

- **Storage Facilities:**

Role: Store onto components and resources that can be reused until needed for new projects.

Collaboration: To assist local circular construction initiatives, create networks of storage facilities in key locations. The financial effects noted in the Circular Viaducts case study can be lessened with the aid of efficient storage solutions.

- **Waste Management Companies:**

Role: Take charge of the recycling and disposal of building waste.

Collaboration: Reorient the emphasis to maximize material recovery and recycling rather than landfill discharge. It is anticipated that the use of CCBMs would increase the demand for sophisticated recycling capabilities while decreasing the requirement for traditional waste management services.

- **Governmental Entities:**

Role: Provide financial incentives and regulatory support.

Collaboration: Create policies that support circular construction methods through grants, tax breaks, and other financial aid. In order to remove the financial obstacles to CCBM implementation, government assistance is essential.

In order to bring these different functional collaborations, a strong collaborative strategy has to be adopted. The functional collaboration with different stakeholders over a longer period of time can be challenging too. The following paragraph discusses **the potential collaborative models** that can be adopted for the same.

- **Integrated Circular Construction Companies:**

In this model, every function required for circular building is integrated under a single organizational structure by one organization or consortia. (Pomponi & Moncaster, 2017) This covers planning, building, obtaining supplies, transportation, warehousing, and managing waste.

Operations can be better controlled and coordinated by combining all functions into a single entity **(streamlined operations).** By doing this, the delays and misunderstandings that frequently arise when several separate businesses are engaged are reduced. By centralizing all operations, quality standards can be consistently implemented and upheld, guaranteeing that all building materials and techniques adhere to the principles of the circular economy. This ensures a **consistent quality control** of the operations. Integrated businesses can minimize the environmental impact of construction by maximizing resource utilization at every stage, from waste management to the acquisition of building materials. This ensures an **effective resource management.**

There are few challenges to be taken into consideration while adopting this model. Setting up an integrated model like this calls for a large investment in infrastructure, training, and technology. Therefore, the **initial capital requirements are high**. One other challenge would be the **complex management** involved. It can be challenging to manage a variety of tasks inside a single organization, and it calls for strong organizational structures and procedures.

- **Collaborative Networks:**

In this concept, a network of specialized businesses is involved, each of which focuses on a different facet of the cyclical construction process. (Pomponi

& Moncaster, 2017) These businesses collaborate to complete circular construction projects inside a single framework.

By concentrating on its core skills, each business may increase productivity and creativity. It is simple to integrate new partners and technologies using this strategy, therefore offering **great flexibility**. By utilizing the abilities and skills of multiple partners, collaborative networks are able to grow more readily without requiring a single organization to make all of the investments, therefore it offers **great scalability**. **Shared risk and cost** are another advantage offered in this collaboration. By dividing up the financial and operational risks among several partners, the strain on any one business is lessened.

To guarantee that all parties collaborate effectively, **robust coordination and communication** systems are needed. **Alignment of goals** could be challenging. When partners work individually, it can be difficult to make sure that their standards and goals are in line.

- **Public Private Partnerships (PPPs):**

Under this model, private businesses and government agencies work together. Private businesses contribute knowledge, creativity, and efficiency, while government agencies offer financing, incentives, and regulatory support. (Ghisellini et al., 2018; Pomponi & Moncaster, 2017)

One of the main advantages is **access to public funds**. Financial hurdles for private enterprises can be reduced by government support, which can offer crucial money for R&D and initial implementation expenditures. Construction processes can be encouraged by government laws and regulations. The **regulatory support** offers a great advantage. **Public good and social impact** is an add on. PPPs have the potential to bring together the objectives of the public and private sectors in order to achieve wider societal advantages including environmental protection and sustainability.

Following rules and processes set forth by the government can be difficult and time-consuming. The **bureaucratic processes** are a hurdle to deal with. It can also be difficult to **align the interests** of public and private organizations since they frequently have distinct goals and schedules.

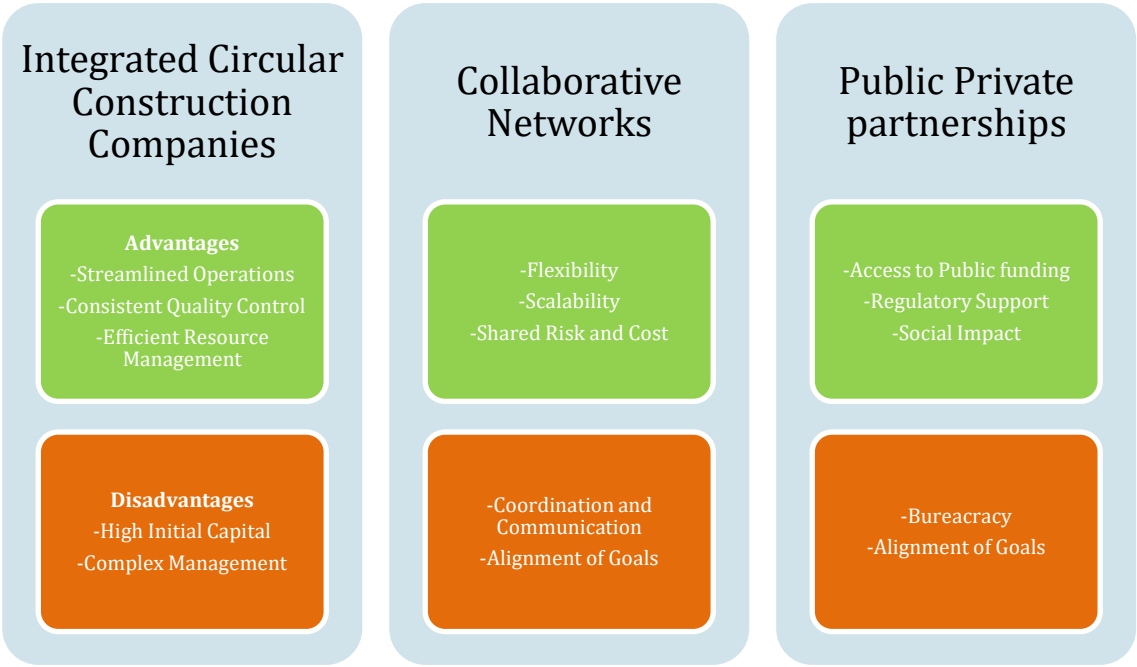

Figure 29-Collaborative Models for CCBMs(Adapted by author)

The cooperation of multiple stakeholders is necessary for the scalability of circular construction business models. Public-Private Partnerships, Collaborative Networks, and Integrated Circular Construction Companies all have their own advantages and disadvantages. Through the utilization of these cooperative models' advantages, the construction sector can surmount financial obstacles and attain long-term expansion. Subsequent endeavours ought to concentrate on cultivating these partnerships, offering monetary rewards, and establishing legislative structures that endorse circular building methodologies. The idea of a circular and sustainable building sector can happen with these united efforts.

The **financial implications**, mostly gains, as a result of these collaborations, are pretty straightforward. Reusing materials and cutting waste can result in **long-term savings** that can **balance the high upfront expenses** of CCBMs. By distributing these expenses across stakeholders more fairly, collaborative models can help make the transformation financially feasible. Reaching **economies of scale** is crucial to CCBMs being widely used. Working together can assist in creating the supply chains and market demand needed to operate at profitable scales. The case study of Circular Viaducts underscored the significance of scaling in order to fully achieve cost benefits. By **distributing financial risks** among several organizations, collaboration can lessen

the load on individual businesses. Regulatory assistance and government incentives can help reduce hazards even more and promote investment in circular building.

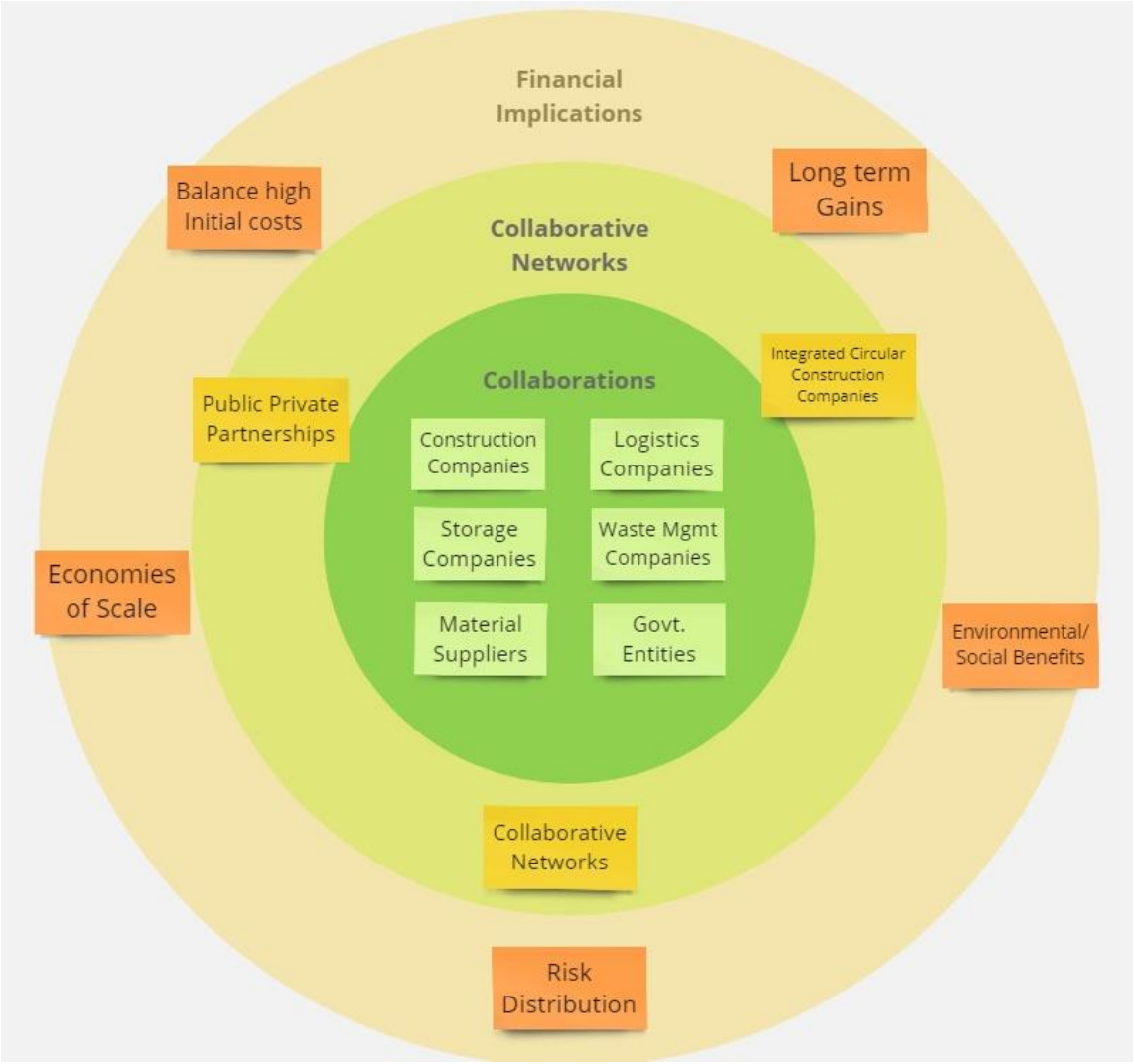

Figure 30-The ecosystem of companies for scalability(Adapted by author).

Businesses that implement circular processes support more general social and environmental objectives like environmental stewardship and sustainable development. Companies can strengthen their bonds with stakeholders and improve their company's reputation as a result.

4.5 Long Term Financial Gains

The belief that circular construction business models (CCBM) are less profitable than traditional linear construction models is one of the key obstacles to their implementation. There are various tactics involved in addressing this perception.
Companies' willingness to participate in CCBMs is essential to their implementation's success. The long-term advantages of circular processes, including improved corporate reputation, cost savings on materials, and resource efficiency, are being recognised by an increasing number of construction organisations. (Bouygues Construction, 2024c) Businesses who are prepared to invest in circular construction techniques show innovation and leadership, establishing benchmarks for the sector and inspiring others to do the same. Early adoption also helps them by giving them knowledge and market share in a sector that is changing.

Businesses can seamlessly switch from linear to circular models by integrating circular ideas gradually. This strategy calls for the gradual adoption of more sophisticated tactics like designing for disassembly and using recycled materials, after beginning with more basic ones like recycling and waste reduction. (Technopolis Group et al., 2016) The transition is made more bearable and less financially taxing by gradual integration, which lowers upfront costs and enables businesses to gradually develop the infrastructure and capabilities they need.

Although it might not seem as profitable at first as standard construction techniques, circular construction has substantial long-term financial advantages. As a result of increased resource efficiency, lower waste disposal costs, and cheaper material costs because of the utilisation of recycled components, circular processes can eventually result in significant cost savings (Technopolis Group et al., 2016). Additionally, by selling repurposed parts and materials, circular construction can create new sources of income. Eventually, circular construction can be a worthwhile endeavour since these long-term financial advantages can balance out the initial higher expenses.

Justifying the switch to circular construction requires an understanding of the more extensive social and environmental costs associated with traditional linear construction techniques, as mentioned in the detailed (Rebel, 2018), (Technopolis Group et al., 2016). Linear construction frequently results in waste production, resource depletion,

and severe environmental deterioration, all of which have long-term detrimental effects on the environment and human society. Businesses may lessen these negative consequences and promote social justice and environmental sustainability by implementing circular processes. Understanding these additional expenses emphasises the significance of sustainable building techniques and the real benefit of circular construction, which goes beyond short-term financial gains.

Chapter 5. Conclusion

The expected outcome of this thesis includes robust analysis of CCBMs, a comprehensive understanding of its economic viability and practical implementation of CCBMs in the construction industry. Synthesis of findings provides actionable insights on economic profitability and business model viability for construction companies aiming to transition to circular business model.

This thesis thoroughly looked at the economic viability and strategic implementation of Circular Construction Business Models (CCBMs) in the context of Central European construction industries, with a special emphasis on case studies from the Netherlands and France. The findings show that CCBMs not only promote sustainable development, but also provide a road to increased economic resilience and competitiveness in the construction sector.

The study found that integrating circularity into construction methods is hampered by significant constraints such as high initial costs, uncertain return on investment, and the difficulty of obtaining economies of scale. However, these problems are countered by the long-term financial and environmental benefits of circular processes, such as reduced waste, lower resource consumption, and increased material efficiency. This balancing emphasizes the importance of strategic planning and the implementation of creative business models that prioritize both sustainability and profitability.

The Circular Construction Business Model Canvas (CCBMC) was efficient in offering a structured way to implementing circular practices. This tool not only aided strategic decision-making within companies such as Bouygues Construction, but it also revealed the potential for policymaking to promote the wider adoption of circular models in the industry. Businesses that link their internal corporate strategies with broader regulatory frameworks can improve their operational efficiencies and market competitiveness.

Furthermore, the thesis emphasizes the need of collaborative networks and public-private partnerships for upscaling CCBMs. This cooperation is critical for overcoming financial and logistical hurdles and creating an ecosystem that promotes sustainable practices throughout the building industry.

To summarize, while shifting to circular construction business models presents considerable hurdles, the strategic use of CCBMs, accompanied by suitable regulatory measures and creative business practices, can result in enormous economic, environmental, and social advantages. Future research should concentrate on improving the tools for assessing circularity, developing new collaboration models, and incorporating circular economy ideas into global construction processes. This would strengthen the economic case for circular models while also advancing the building industry's commitment to sustainable development.

5.1 Limitations

While there were several generic limitations like geographical constraints, temporal limitations and resource limitations, the key constraints specific to this research are as follows.

- **Data Constraints:**

  The case studies that are entirely entitled to CCBMs are difficult to find; and hence, in the current scenario, the case always required a cross analysis of CBMs with Circular pilot projects.

  The dependence on case studies, even though insightful, limits the capacity to generalize findings to the larger construction industry. Case studies are usually unique in terms of setting and the methods they involve.

- **Methodological Constraints:**

  While a mixed-methods approach provides a comprehensive view, it also adds complexity when integrating qualitative and quantitative data. The subjective aspect of qualitative analysis may influence how the results are interpreted.

5.2 Suggestion for Future Research

The author suggests few directions to look further in details to carry out the future research.

- **Policy impact Studies**: Analysing the influence of certain government policies on the adoption and success of CCBMs would aid in determining the regulatory circumstances that best promote circular economy practices in construction.
- **Scale and Scope of Implementation:** Investigating various scales of implementation, from small-scale projects to large-scale developments, to determine the scalability of CCBMs and identify critical elements influencing them.

Declaration of Authorship

I hereby declare that the attached master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

Berlin, 05.07.2024

Location, Date

Signature of the student

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