BECOMING *Entrepreneurial*

A STRATEGY FOR A CIRCULAR BUILT ENVIRONMENT

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Faculty: Architecture, Urbanism and Building Sciences

MSc: Management in the Built Environment

Course: AR3R010-Graduation Laboratory

Graduation lab: Construction Management and Entrepreneurship

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Acknowledgements

This fruition of this research project marks the completion of the Master of Science in Management in the Built Environment at Delft University of Technology. The research is a collective effort of individuals who believed in my vision and contributed towards it in every capacity. First, I would like to extend my gratitude to the thesis supervisors Hans Wamelink and Catherine De Wolf. Their timely mentorship and guidance has played a crucial role in shaping the research project. Hans Wamelink, my first mentor, instilled confidence in me with words of wisdom and adept perspectives on all things relating to life and work. My second mentor, Catherine De Wolf, was a source of constant inspiration and was always proactive in helping me cultivate my thoughts. The research project stands for the indisputably encouraging and supportive environment that both mentors created collaboratively.

Furthermore, my experience of working with Yvette Govaart, Partner at COUP, has greatly facilitated the research enquiry. I would like to thank her and everyone at COUP for giving me the opportunity to work in an entrepreneurial and dynamic environment. Yvette's mentorship and personal experiences of being a developer in the circular built environment provided a deep understanding of the practical implications of this research.

This research builds on information about the case projects from Ditte Gerding's exemplary master thesis titled 'Talking circularity - the influence of actors on the building process'.

I am indebted to her generous and invaluable assistance in providing me with relevant contacts and sharing her experiences.

This research could not have been possible without the enthusiastic participation of the interviewed stakeholders of the chosen case studies. I would thus like to extend my gratitude to Constantijn Berning (EDGE technologies), Eric Van Noord (Architekten CIE), Axel Hendricks (Beelen), Oscar Vrijzelaar (J.P Van Eesteren), Thomas Metz (Rijksvastgoedbedrijf), Mike Van Vliet (AlbaConcepts), Yvette Govaart (COUP & BlueCity), Jan Jongert (Superuse) and Jeroen Zandboer (BAM) for sharing their experiences for the sake of this research.

I am grateful for family and friends who joined me on this journey and made every second worth it.

Akshit Suraj Parmar

The interviews that were conducted during this thesis are available upon request. Excerpts from the interviews have been chosen to outline information relevant to the inquiry initiated in this thesis. The responsibility of the translation and interpretation of the excerpts fully lies with the author.

“We cannot solve our problems with the same thinking we used to create them”

– Albert Einstein

Abstract

This research investigates the role of Entrepreneurial Behaviour in stimulating the transition of the Built Environment from a take-make-waste linear model to a circular model that focuses on closing the resources' loops. Entrepreneurial behaviour (EB) has historically steered new and disruptive innovations across all industries owing to its strong inclination towards new and unexplored ideas. EB is critical for performance in an uncertain or unstable business environment because it can explain as *taking action* to change the system environment. There are regulatory, cultural, financial, and sector-specific barriers that pose difficulties in implementing CE in construction practices. However, these barriers are seen as potential opportunities by 'entrepreneurs' or 'actors that show EB' because they can capture value out of highly uncertain situations. Therefore, this research investigates the possibility of a correlation between EB and the transition to a CE. A conceptual framework is developed to show that new and incumbent organisations in the built environment are entrepreneurial at three levels: the organisational level, the business model level, and the network level. The framework is applied to a case study analysis of three circular economy pilot projects in the Netherlands, concluding that actors who are key decision-makers for circular construction projects show entrepreneurial behaviour. The patterns of entrepreneurial behaviour have been identified as (i) developing a circular ambition, (ii) experimentation, (iii) taking risks, (iv) innovative organisation management, (v) re-thinking roles, (vi) new business models and (vii) taking the lead. The study contributes to the intersection of the fields of Circular Economy and Construction Management by outlining patterns of Entrepreneurial Behaviour and identifying them as an enabler in the transition of the Built Environment to a Circular Economy.

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Report Structure

Chapter 1 introduces the two main concepts addressed in this research, Circular Economy (CE) and Entrepreneurial Behaviour (EB), by highlighting the academic origins of both subjects, the selected definitions, and their societal relevance. The section concludes by identifying a literature gap as a starting point for the empirical explorations.

Chapter 2 details the research design and methodology, including the selected research tools deployed in the process. Additionally, this section defines the main research question and supporting sub-questions. It also introduces the conceptual framework that forms the basis of this investigation to understand EB in the actors involved in construction practices based on CE

Chapter 3 focuses on the literature review, which presents fundamental theoretical concepts and existing literature surrounding the main areas of the research, namely entrepreneurship and CE implementation in building projects. The learnings from the literature review culminate into an analytical framework that forms the basis of the empirical investigation that is carried out to answer the main research question.

Chapter 4 describes the methodology and relevance of the expert survey that is conducted to validate the findings from the literature review.

Chapter 5 and 6 introduce the cases by outlining the processes chosen for the case study methodology. This section also introduces the cases and relevant background information that serves as a starting point for the empirical research proceedings.

Chapter 7 uses the analytical framework to elaborate the findings from the selected cases. These findings are based on semi-structured interviews.

Chapter 8 discusses the findings from the case studies with reference to the learnings from literary concepts. This section also points out the limitations and implications of the findings that form the basis of the research.

Chapter 9 concludes the research by answering the main research questions and the sub-questions and provides recommendations for further research.

Chapter 10 provides recommendations for future research.

1. Introduction

'Without the strength to endure the crisis, one will not see the opportunity within. It is in the process of endurance that opportunity reveals itself.'

-Chin-Ning Chun

1.1 A Societal Challenge

Development activities in the BE have put a significant burden on our planet and its environmental capacity, resulting in the introduction of the CE designed to change the present patterns of production and consumption. The BE is a significant consumer of natural resources due to the linear production process, which embraces the 'take, make, waste' model (Mcdonough & Braungart, 2009). This model does not consider the current scarcity of resources and the impact of waste. According to the IPCC (Lucon, et al., 2014), 32% of the global final energy use in 2010 was accredited to the construction and operation of buildings. A material-intensive sector, the construction industry consumed 110.6 billion tonnes of material, mainly based on non-renewable fossil fuels (Lacy & Rutqvist, 2015; Sanchez & Haas, 2018).
Building practices are greatly dependent on virgin materials that face resource scarcity in the future (Arcadis, CIRCLE & WBCSD, 2018). Extracting these virgin materials creates a degenerative impact on the environment and destroys the livelihood of communities that exist off the ecological landscape. For example, the 30 billion tonnes of sand extraction per year (UN , 2014) makes the coastlines, where human populations are located, more vulnerable (UNEP, 2014). 40% of the materials from the global economy are consumed by the construction industry (Khasreen, Banfill, & Menzies, 2009). Only 20-30% of materials are recycled or re-used at the end-of-life of a building (EMF, 2014). Thus, the linearity of the building process must be reshaped to deal with resources more consciously and to utilize waste as a resource (Mcdonough & Braungart, 2009).

Additionally, economic challenges such as supply risk, complicated ownership models, de-regulated markets, and unclear regulatory environments are a cause of financial insecurities across organisations and economies alike (Sachs, 2015). Societal expectations regarding issues like poverty, unemployment, poor working conditions, widening equality gap, and social vulnerability are not being fulfilled or degrading in the current economic system (Bannerjee & Duflo, 2011). To make this paradigm shift, businesses and practitioners within the various industries must focus considerable attention on attaining a more environmentally and socially sustainable approach to standard practices (Geissdoerfer, Sandra Naomi Morioka, Monteiro de Carvalho, & Evans, 2018). The principles and values that made up the linear economy's support system for value creation have become increasingly scrutinized, presenting a new wave of active involvement of organisations to accelerate the transition towards a sustainable economy (Visser, 2018). The building industry must respond to this dire societal need to find new ways to reduce pressure on the ecological resources by deploying CE principles in its decision-making and day-to-day activities.

1.2 A Transitional State

CE has been defined by the Ellen McArthur Foundation (2013) as "an economic and industrial system where material loops are closed and slowed, and value creation is aimed at every chain in the system". This research would adhere to and build upon this definition. Bocken et al. (2017) point out that the concept of CE has gained momentum across industry, politics, and academia, but the knowledge and tools to implement it in practice are yet to be developed. Furthermore, this holds true for the building sector which is known to diffuse innovation rather slowly (BIS, 2013).

CE has many conceptualisations in literature (Allwood, 2014; Bakker, den Hollander, van Hinte, & Zljlstra, 2014) that undervalue the social impact, emphasise the economic benefits, and simplify environmental aspect (Geissdoerfer, Savaget, Bocken, & Hultink, 2017). Thus, CE as a concept offers to be more attractive for policymakers and actors in the private sector when compared to competing approaches like *sustainability.* Although circularity presents itself as a promising concept, its implementation has not been utilized to its full potential. The difficulties are expected in relation to the process when compared to the technicalities of the product.

Furthermore, the collaboration between the stakeholders in the process (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019), and how their roles change is important to ensure the implementation of circularity in the BE. Adams, Osmani, Thorpe & Thornback (2017) indicated that the designers and clients lack awareness and knowledge about circular building processes. They also add that a fragmented supply chain and unclear incentives and regulations throughout the project lifecycle are some of the several barriers that inhibit CE in the construction industry. According to Eberhardt et al. (2020), most building projects are not yet moving towards a CE despite an increase in development and implementation of CE building design and construction strategies. Incoherent building processes without commonly acknowledged directions is one of the reasons for the lack of implementation of the CE concept in the BE (Eberhardt, Charlotte, Birkved, & Birgisdottir, 2020).

Among researchers and experts, the sustainability discussion in the BE has pivoted itself around energy-efficient buildings for a long time (Woolthuis, 2010). The introduction of CE has brought about a shift in focus to material efficiency in building products and processes along with social and economic value capture. Nevertheless, the latter has not yet attained support from the policy and finance sector that other mature sustainability concepts have over the past years. Figure 1 represents the maturity curve of any given industry (Sabol, Šander, & Fučkan, 2013). The construction industry is still in the *introduction stage* (Figure 1) in its implementation of CE. Implementing a CE in the BE needs a transition new business models that are different from traditional models of a linear economy based on an extractive take-make-waste cycle (Nunez-Cacho, J., Molina-Moreno, & Corpas-Iglesias, 2018). On comparing a new business production model to the introduction stage of Figure 1, it can be found that the transition to CE is one that is characterised by high prices and high risks for the participating actors, who can also be identified as early adapters.

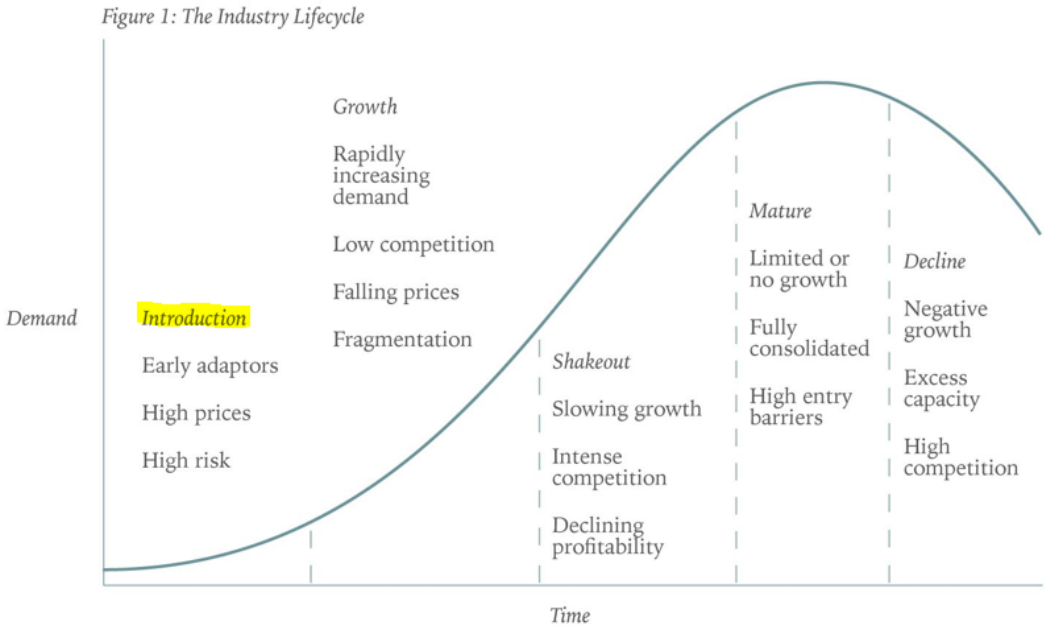


Figure 1: Industry Life Cycle curve for CE (Sabol, Šander, & Fučkan, 2013)

Meadowcroft (2009) indicates that the market actors who are established (regime actors) have a greater tendency to be reluctant to adopt newer alternatives that would affect their existing business systems, than the newcomers (niche actors). This finding encourages further research into assessing the regime actors for drivers and barriers faced in adopting the CE in the BE.

1.3 Steering the Transition

Society continually imposes the need for change in every economic sector. This long-term, structural re-orientation and transformation of economic activities are termed transitions (Kemp, 1994). The transition from a linear model to a circular model is being demonstrated on multiple levels such as material flows and cash-flow based business models. Nevertheless, this is an intermediary phase (Arcadis, CIRCLE & WBCSD, 2018). The transition to CE often brings along new strategies, challenges, and new patterns of functioning, which are perceived as increased risks (Bocken, Short, Rana, & Evans, 2013). When designing buildings or products that implement CE principles, financial and economic uncertainty and a lack of collective

knowledge, tools and guidelines are some of the biggest challenges (Adams, Osmani, Thorpe, & Thornback, 2017). The conceptual model of the life cycle curve (Figure 1) supports the previous statement by Adams et. al (2017). In the research *From Principles to Practices* (Acharya, Boyd, & Finch, 2018), the five key themes that were identified as potential enablers to help overcome common barriers in the transition to CE were: collaboration, knowledge, policy, leadership, and finance. For the industry, this means that there is a need for change that goes beyond incremental innovations based on technical progress only (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007).

According to Acharya, Boyd, & Finch (2018), the responsibility to lead the transition initially lies with the actors who have high decision-making influence in the value chain. Thus, it is suggested that policymakers, investors, and clients are regarded as the most influential actors in the supply chain because of their control over the business models and contractual frameworks (Acharya, Boyd, & Finch, 2018). However, generalizing the role of these actors based on their influence within the supply-chain network can prove to be inaccurate because actors may or may not adopt the expected, leading role. Kraaijenhagen et al. (2018) describe 'transformation agents' as important actors for implementing circularity. They primarily answer the 'who' question regarding the implementation of a necessary internal transformation for the organisation. According to Kraaijenhagen et al. (2018), these agents work as role models and ambassadors to inspire and motivate their contemporaries to join the circular transition. Identifying the 'transformation agent' from the network of involved stakeholders in the construction must be supplemented by investigating their competencies and impacts on the organisation. However, it is essential to note that Kraaijenhaagen et al. (2018) refer to agents who bring about soft transformations, which means internal transformations within a singular organisation. To capture the full potential of the circular supply chain, the partners external to the organisation must also undergo similar soft transformations. If only one of the partners in the supply-chain transformed, the circular project will difficult to implement (Kraaijenhagen, van Oppen, & Bocken, 2018).

1.4 Understanding the Value chain

The application of CE in the construction industry is focused on gaining knowledge about the whole building lifecycle, which involves various actors of the construction value chain. This

demands a systems-thinking approach that understands the required changes across a broader context (Arcadis, CIRCLE & WBCSD, 2018). Multiple stakeholders or actors are involved in building process and they each have their individual objectives and roles which may be interlinked but are not necessarily aligned. In the linear development system, the respective actors have limited accountability as their roles are restricted to specific phases of the project's life cycle. For example, the architects, advisors, and engineers are responsible for planning, designing, and reviewing the building's construction process based on the developer/client's brief. This restricts their involvement in the design and construction phase as shown in Figure 2. The linear process also creates a loss of value at every stage. Waste is designed into the building in the design phase.

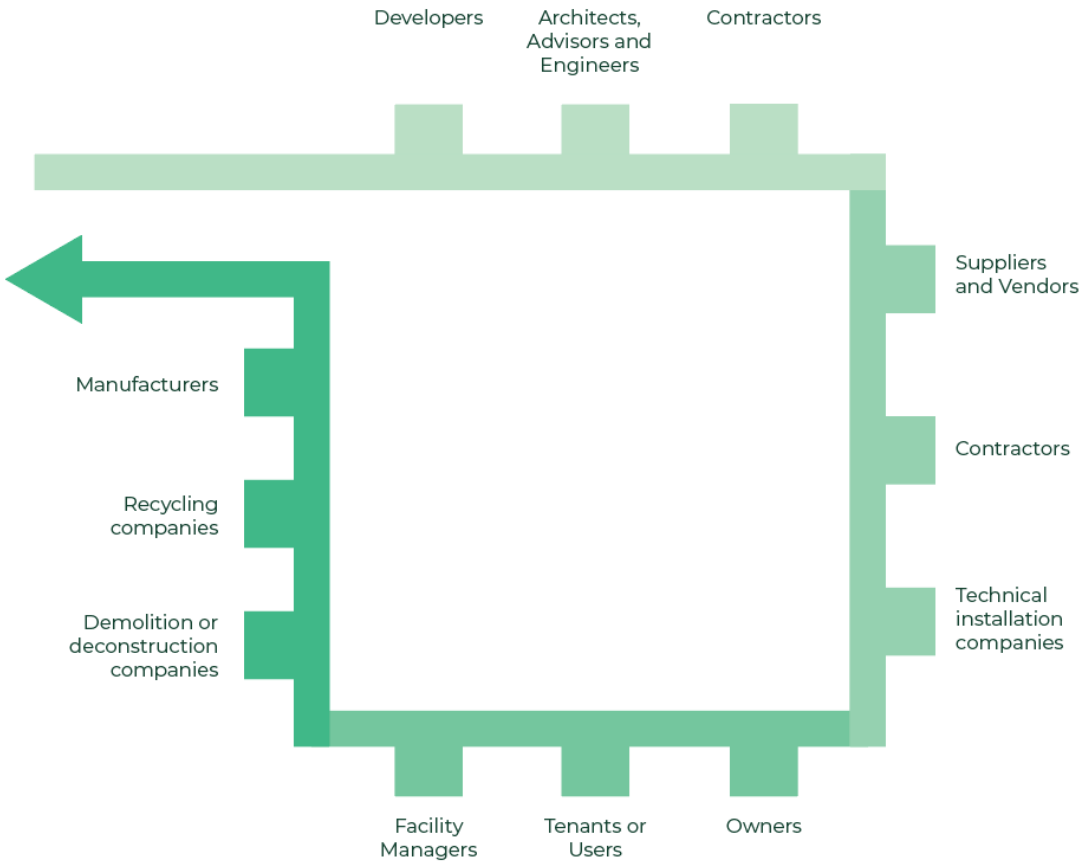


Figure 2: Linear value chain (own image)

Some stakeholder groups such as institutions and unions (Table 1) play an influential role in the value chain without being a direct part of it (Leising, Quist, & Bocken, 2018). Table 1 provides an extensive but not definitive list of the various types of actors involved in construction projects in the different phases of the life cycle. CE requires a change in the value chain around the design, construction, operation, maintenance, renewal and repurposing of buildings (EMF, 2013a). Therefore, implying that actors like designers and investors need to adopt a longer term vision by designing not just the building but the past, present and future of the materials and components of the buildings into the broader ecosystem (ARUP, BAM, 2017).

Table 1: Stakeholders in the Value chain (adapted from Noordhuis & Vrijhoef, 2011)

Stakeholder Group	**Types of Actors**
Principals, Initiators	Developers, Housing associations, Government (local or national), other principals
Investors	Private equity, Investment funds, Banks, crowdfunding
Designers	Architects, urbanists, place-makers, engineers, consultants
Contractors	General contractor, maintenance contractor, services contractor, demolition contractor, sub-contractors
Suppliers	Direct suppliers, distributors, manufacturers, retailers, service providers
Users	Residents, organizations, government, individuals, others
Government	EU (European Union), National Government, Local government
Organisations	Trade unions, Trade organisations

1.5 Entrepreneurship and Entrepreneurs

Hisrich and Peters (1998) define entrepreneurship as 'a process of creating something new'. According to Eric Ries (2011, p. 8), the concept of entrepreneurship is focused on "creating new products and services under conditions of extreme certainty". Ries (2011), also points out that entrepreneurs are can be found in establishments across any sector or industry, ranging from a small-sized company to a large enterprise. Entrepreneurship does not limit itself to ownership, but it can also be observed both within and outside organisations (Stevenson & Jarillo, 1990). Kuratko and Hodgetts (1998) define entrepreneurship "as a process of innovation and new venture creation through four major dimensions – individual, organisational, environmental, process – that is aided by collaborative networks in government, education, and institutions. All of the macro and micro positions of entrepreneurial thought must be considered while recognising and seizing opportunities that can be converted into marketable ideas capable of competing for implementation for today's economy". Chell (2008), brings together different definitions of entrepreneurship and observes the emphasis on the conception of a business from an idea.

Entrepreneurial actors compensate for their limited resources by their ability to create strategic partnerships with new and incumbent actors who have a shared vision of leading industry transformations (Hockerts & Wustenhagen, 2010). The transition to a CE requires the creation of new systems, procedures and collaborations between actors across the value-chain (Veleva & Bodkin, 2018). To start a new building project which uses an exact clone of the existing linear methods of building, all the way down to the pricing, customers and business model could be attractive for investors and incumbent firms because its success depends on the execution of a proven business model. However, entrepreneurs have the ability in shaping new landscapes (Geels, 2004) because of their willingness and capacity to experiment with innovations that culminates in a venturesome behaviour. They often host the persistence and initiation to make a change happen (Woolthuis, 2010). However, it is important to understand EB to answer why some individuals or firms display transformational qualities. EB is not restricted to the activities of certain entrepreneurs or start-ups but can be attributed to all kinds of organizations including incumbent firms.

1.6 Why Entrepreneurial Behaviour (EB)?

The definitions of EB revolve around entrepreneurial events like the creation of new ventures (Gartner, 1988), new organisations (Vesper, 1985), new entry or new product development (Lumpkin & Dess, 1996). However, the definition which suits the nature of this research the best is provided by (Mair, 2005), she defines EB as: "a set of activities and practices by which individuals at multiple levels autonomously generate and use innovative resource combinations to identify and pursue opportunities." According to Luca (2017), the analysis of EB depends on the approach with which is it analysed. For example, an economic approach to EB explains EB in terms of a company's performance in economic factors. In contrast, a psychological approach may identify the dispositional factors between individuals from the same backgrounds (Luca, 2017). Thus, substantiating that EB cannot be defined and categorised unless viewed within a particular context or a defined perspective.

Before determining the relevance of EB for this research, other concepts that surround entrepreneurial research were identified and assessed. Some of these include, Entrepreneurial Orientation (Andrea, Cesar, Guimar, & Vasconcelos, 2018), Entrepreneurial intention (Gieure, Benavides-espinosa, & Roig-dobón, 2020), Entrepreneurial beliefs and attitudes (Scheiner, 2009). Fishbein and Ajzen (1975) described the correlation between these different entrepreneurial concepts as a sequential evolution from belief to attitude to intention to behaviour. Authors like Moruku (2013) classify the qualitative aspects of an entrepreneur as: being proactive, competitive, innovative, risk-taking, and independent. Any entrepreneurial disposition must be converted into identifiable actions so that its performance benefits are realised. Thus, EB, an action-based understanding of entrepreneurship, focuses on understanding what are the actions after investigating the motivation behind 'why' (Sinek, 2009). Pirela (2007) suggests that EB is critical to performance in hostile, unstable, and uncertain business environments. Therefore, EB is not a disposition or personality but the resulting action (Moruku, 2013).

Wiklund (1998) suggested that EB contains nine indicators: (i) establishing of new enterprises or growing the existing firms, (ii) making new market entry, (iii) developing a new market or marketing to new customers, (iv) developing a new product, (vi) producing a new product ahead of competitors, (vii) investing in new product development which is fraught with uncertainty and

failure, (viii) introducing new operating procedures, and (ix) reorganizing the firm. It can be seen from this list that ‘newness’ pervades the EB landscape (Moruku, 2013).

1.7 Literature Gap

Research identifies the increasing frequency of CE literature in the last decade (Cramer, 2020; Merli, Preziosi, & Acampora, 2018; Ghisellini, Cialani, & Ulgiati, 2016). However, there are scarce studies on implementing the transition to a CE (Ghisellini, Cialani, & Ulgiati, 2016; Franco, 2017; Cramer, 2020). This knowledge gap becomes wider when one looks at the studies on CE implementation based explicitly in the BE or the construction industry. According to Luca (2017) entrepreneurial actors are characterised by limited resources, uncertainty in the market and decision-making in uncertain environments. The research identifies similar challenges that are presented in the CE based construction processes.

Andrea et al. (2018) recognize the concept of entrepreneurial orientation as one of the strategic drivers to attain a competitive advantage in cleaner production. Observing the considerable interest in current innovations in CE in the construction sector, it can be hypothesized that EB is a critical strategic driver in the transition. It has not been established yet whether EB has a role in the transition of the BE to a CE. The literature identifies EB as a precursor to transformational activities or actions; thus, this research pivots around actors who show EB in the circular building process to stimulate the transition to a CE.

2. Research Design

2.1 Research Goals

Circular entrepreneurship in the BE is not a widely researched topic. Therefore this research aims to broaden current knowledge for entrepreneurship research related to CE, specifically in the BE. The previous sections summarised the history, definitions, and relevance of CE and EB. Both concepts have been researched extensively in independence, with different contexts and purposes. Moreover, they both stress the importance of unexplored competitive advantage that can improve environmental, social, and economic progress and bring system-level changes. However, the relationship between both notions has not been studied extensively, and their mutual dependency remains unexplored. Knowledge about their relationship is relevant for practical implications as well as conceptual clarity. The research goals derived from the literature gap guide the formulation of the leading research question:

"How does entrepreneurial behaviour in the value-chain actors of the built-environment contribute to its transition to a circular economy?"

The following sub-questions are articulated as stepping stones to answer the main research question:

a) *How is entrepreneurial behaviour identified in the circular economy?*
b) *Which actors show patterns of entrepreneurial behaviour in the selected cases?*
c) *How are patterns of entrepreneurial behaviour deployed in circular building projects?*
d) *What is the contribution of entrepreneurial behaviour in the selected circular cases for the built environment?*

Figure 3 represents the conceptual framework that forms the basis for the hypothesis of the research. The framework suggests the hypothesis that within the context of building projects in the BE, CE principles are carried out by value chain actors who utilise EB as an enabler to the

transition. The conceptual framework considers EB of value chain actors in the building projects as an independent variable that may or may not positively influence the dependent variable, implementation of CE principles.

The framework addresses the first subquestion by investigating how EB can be defined and comprehended in the given context. The second subquestion aims to identify the actors who display EB in the value chain of the given context. The entrepreneurial actors play a central role in developing the thesis because after their identification, the third subquestion analyses the entrepreneurial approaches adopted in the building project. The final subquestion reflects on the contribution made by the actor's EB to the implementation of circular principles in the building project.

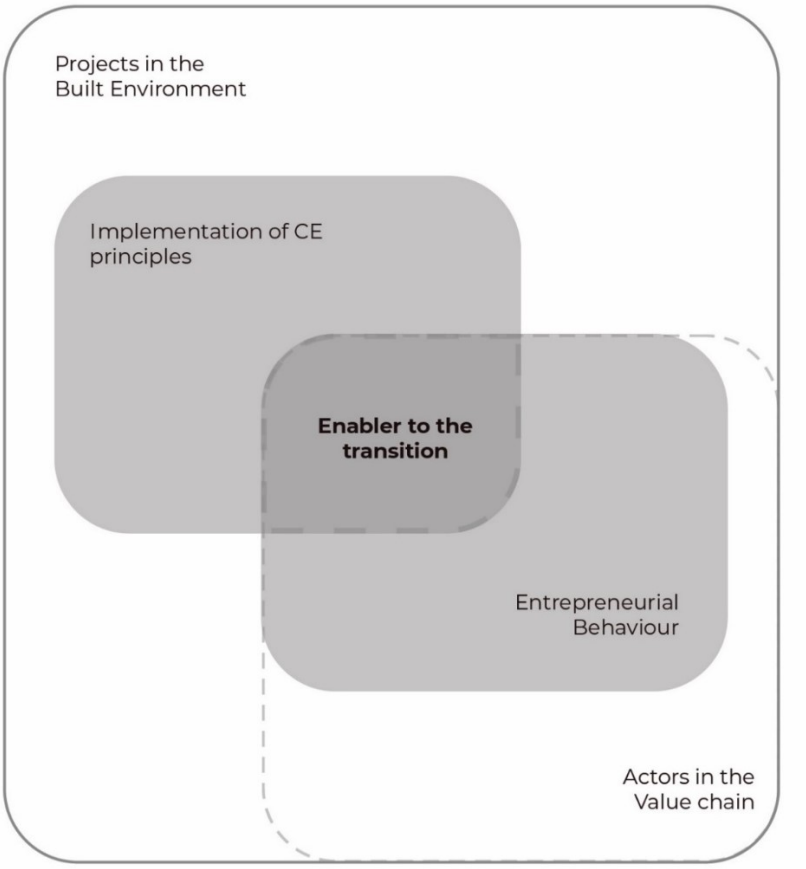


Figure 3: Conceptual framework

2.2 Research Methods

A qualitative research methodology is adopted for this research because it aims to explain the role of EB in the transition. Such research demands flexibility to appropriately examine the EB and the causal reasons underlying them (Yin, 2003). The research has an exploratory and explanatory nature. There is little data available about the role of EB in the implementation of circularity in the BE. Therefore, a qualitative study is appropriate for the collection and assessment of empirical data. The research design strategy that is developed to operationalize the conceptual framework is not a standard approach but heavily borrows from
A step-by-step approach is adopted to design the research strategy. As visually represented in Figure 4, the first step of literature research helps to address the practical gap that points towards the need for research in CE implementation in the BE. The literature research explores theoretical concepts about EB and CE that leads to the identification of several patterns of EB researched by entrepreneurship authors over time. An expert survey is the next research method (input) that is deployed to substantiate the relevance of the entrepreneurial patterns that were identified in the literature review. On analysing the opinion of practitioners of circular principles in the BE, an analytical framework that integrates the two domains is developed (output). The analytical framework is used as a guidance tool to assess the case studies for patterns of EB. The result of the case study is discussed in relation to the literature research findings to test the hypothesis.

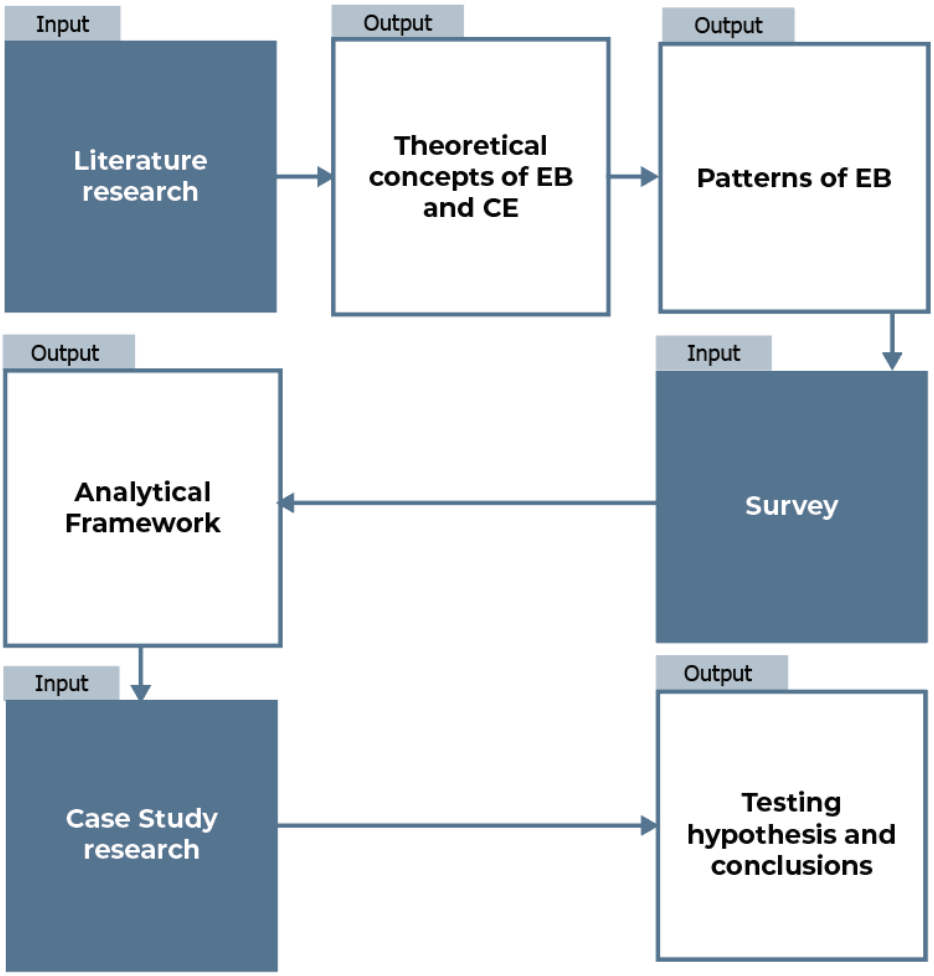


Figure 4: Research design strategy

The case study analyses and literature research are to be conducted simultaneously to facilitate information exchange between the two methods. Case study research will mainly be carried out to analyse existing circular construction projects through both an external supply-chain perspective and an internal organisational point of view. The case study research will be used to identify specific actors involved in steering the circularity initiative in the BE. Participating actors in the value chain will be assessed for patterns of EB that are displayed through their actions or activities. Moreover, case studies are instrumental in identifying the entrepreneurial

actors who steer the transition. Table 2 demonstrates how the research subquestions would be answered with the help of the corresponding research methods as explained above.

Table 2: Research questions and corresponding methods

Sub-questions	Methodology
How is entrepreneurial behaviour identified in the circular economy?	Literature Review + Survey
How are patterns of entrepreneurial behaviour deployed in circular building projects?	Literature review + Case studies
Which actors show patterns of entrepreneurial behaviour in the selected cases?	Case study
What is the contribution of entrepreneurial behaviour in the selected circular cases for the built environment?	Case study + Literature review

2.2.1. Literature Review

A literature review is conducted to provide a foundation for the research approach and findings as a first step. The literature review aims to find theoretical linkages between EB and circular principles in construction projects in the BE. Concepts like circular principles, circular business models and circular strategies are explored in the context of the BE. A systematic literature search is conducted using the keywords: 'circular economy' AND (entrepreneurship or entrepreneurial or entrepreneur) AND ('built environment' OR construction OR building) on journal search engines like Elsevier and Google scholar that allow the use of advanced search tools for targeted searches. The sources of information were the academic databases ScienceDirect, and Scopus of Elsevier. The first search result yielded 1,390 documents (Figure 5), while the second query yielded 267 documents (Figure 6) and the final search query resulted in 33 documents (Figure 7). This decreasing trend resulted from the fact that the search terms were made more specific and narrow to reduce the ambiguity in search terms. The documents

that were assessed from the final search query were cross-checked against the previous two searches to observe if those documents were a subset of the larger outcomes. The most relevant papers for this research turned out to be a part of all three search outcomes, these papers are listed in

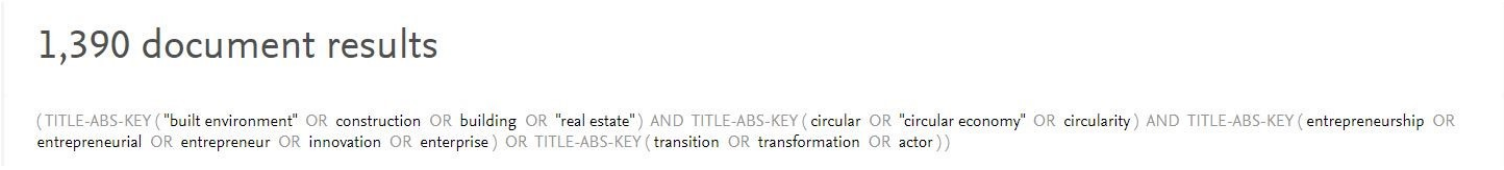


Figure 5: Search result No.1

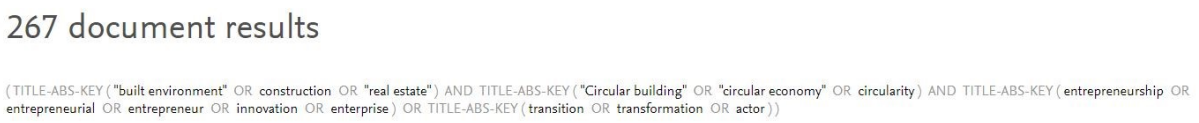


Figure 6: Search result No.2

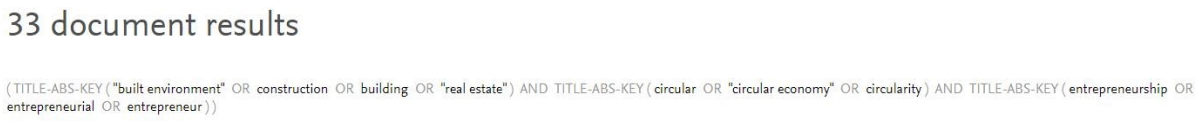


Figure 7: Search result No.3

Table 3: Search result No.3 selected papers

Authors	Title	Year
Leising, E., Quist, J., & Bocken, N.	Circular economy in the building sector: Three cases and a collaboration tool	2018
Veleva, V., & Bodkin, G	Corporate-entrepreneur collaborations to advance a circular economy	2018
Woolthuis, R	Sustainable Entrepreneurship in the Dutch Construction Industry	2010
Hart, J., Adams, K., Giesekam, J., Tingley, D., & Pomponi, F.	Barriers and drivers in a circular economy: the case of the built environment	2019

Although a systematic literature review is a good starting point for a research, it was not possible to find literature related toboth EB and CE (in the BE) in the same search query because academicians have independently addressed them. Thus, a snowballing literature review technique (
Figure 8) was used simultaneously to identify key literature first and then use the references of the primary literature to expand the scope of the literature review.

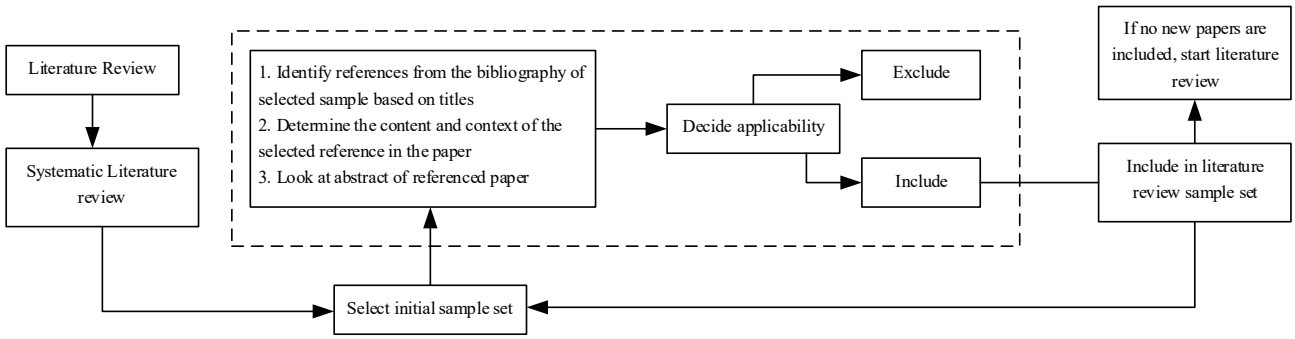


Figure 8: Snowballing research design

The snowballing technique also helped the research focus on certain themes that may not have been directly related to CE and EB but had a major role in tying the concepts together. The snowballing approach (
Figure 8) started by defining a few initial papers which arose from search queries that targeted 'Entrepreneurial Behaviour' and 'Circular Economy' independently. This resulted in different outcomes from the combined results stated earlier in the chapter. These papers have been identified in Table 4, along with the theme that their primary focus lies in. The sample set represents the first set that was achieved as a result of one iteration of the snowballing technique Figure 8); however, the literature review is a culmination of multiple such iterations.

Table 4: Selected sample set for snowballing

Core Theme	Topic	Author
Circular Economy in the Built Environment	Status Quo of the BE	Adams, Osmani, Thorpe and Thornback (2017)
		Debacker et al. (2017)
		Kanters (2020)
Entrepreneurial Behaviour	Patterns	Scheiner (2009)
		Middleton (2010)
	Entrepreneurial processes	Kuratko (2010)
	Organisational characteristics	Kuratko (2010)
		Gartner et al. (2010)
		Elfring (2005)
Circular Business models	Transformation of business models	Frishammar & Parida (2019)
		Alapsahin & Angelis (2020)

2.2.2. Expert survey

In addition to the literature review, the research collects data from existing actors who have experience with circularity in the BE. The main objective of this survey would be to validate the information that was gathered in the literature review using a practical perspective. Entrepreneurship literature mentions that concepts surrounding entrepreneurship are contextual and may vary based on the perspective that they are studied from (Luca, 2017). In that case, holding a survey amongst circularity experts of the BE in the Dutch context improves the possibility of having an accurate image of the entrepreneurial culture of the actors in the Dutch BE. The survey can also contribute to the conclusions by confirming whether EB can be used as universal entrepreneurship indicators in the BE. The survey participants have a diverse range of roles in the BE, leading to a more holistic understanding of EB.

2.2.3. Case study

Thereafter, a qualitative case study methodology is considered by creating selection criteria to select construction projects (built or unbuilt) that have achieved circularity when compared to their initial ambition. The case studies would provide an in-depth empirical understanding by revealing how circular building processes were implemented through the collective action of the value chain. Data collection techniques like analysis of company documentation and interviews (semi-structured) with involved actors will carry out this case study research. The case study research design for this investigation can be broken down into three significant steps (Figure 9). The first step of project analysis is carried out after the selection criteria are determined, and the cases are identified. It involves collecting general data about the case, such as the client's circular ambition, the context, the type of project coalition, type of circular principles implemented, and other such aspects about the project. The next step of network analysis is directed towards identifying and analysing the actors involved across the value-chain of the project. A step that documents the varying role played by the actors in the implementation of the circular aspects of the project is necessary to identify the entrepreneurial patterns. The actors are a part of a network that makes the value-chain, thus it is also essential to understand their role and position in relation to this network. The last step of the case study research process is to

identify the actors who can be called '*steering actors'* because they display EB in the process of building. Using the information gathered about EB from the literature review, the actors' profiles from the cases are assessed to check whether EB plays a role in successfully implementing CE principles in the cases.

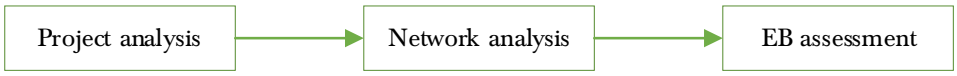


Figure 9: Case study research design

This research would build on Gerding's (2019) case study analysis, using her thesis as a basis for the selection criteria of the cases, preliminary case analysis, and actor-network analysis. This research would serve as an extended investigation that is focused primarily on the role of EB in the transition process. Gerding's (2019) work proves to be a helpful starting point for the research because it provides a robust background for investigating the EB of specific actors in the value chain. This research will add value to the existing pool of knowledge by taking the research forward in a new direction and retaining its primary focus on the correlation between entrepreneurship and CE principles.

2.3 Research Outcome

This research will contribute to CE research in the BE by exploring the role of EB in the transition because CE is set to become a vital factor in the future landscape of the BE. This research also takes a new look at assessing the current state of the transition and suggests the possibility of stimulating it with the findings of the investigation. If the correlation holds true, then the research can be used to influence the actions of future actors in the BE to assume EB for the interests of the society, environment, and economic well-being of organisations. The results could also point to the likelihood that EB displayed by value chain actors cannot solely carry out the transition to CE. The research output also aims to springboard the importance of behavioural studies to understand the actors' motivations. By identifying and operationalising EB, the strength of the research lies in a practice-based approach to the application of the CE in the BE.

Recommending entrepreneurial strategies and methods to actors in the BE is one of the expected practical outcomes of this research.

From a scientific standpoint, most of the current literature tried to document the current status of CE implementation in the BE by understanding the challenges and enablers. This paper explores a new dimension for CE in the BE because it analyses the implementation of CE principles from the perspective of the value-chain actors, by understanding the actions that they take in order to accomplish their goals.

3. Literature Review

This section introduces fundamental theoretical concepts in the fields of CE and Entrepreneurship. While section 1 focuses on the implementation of CE in the BE, section 3.2 and 3.3 describe the relevant theoretical concepts found in the entrepreneurship literature. Section 3.3 and 3.3 bridge the two fields by introducing concepts that explain the importance of EB in the CE implementation. The literature review concludes with the development of an analytical framework that is based on the learnings from the theoretical confluence of Entrepreneurship and CE practices in the BE. The framework forms a foundation for further empirical research in the form of an expert survey and case study.

3.1 Circular Economy in the Built Environment

3.1.1 Background

Recent thinking on CE has mainly been focused on short and medium-lived consumer products (Benton, Coats, & Hazell, 2015; Pollard, Turney, Charley, & Webster, 2016). shows various principles for CE in the BE derived from several often interlinked schools of thought. It is observed that eliminating the concept of waste and maximising the value of materials is a common element. The common elements obtained from this table are directed towards eliminating the concept of waste and maximising the value of materials (EMF, 2013a). It must be noted that the extent of circularity is not measured based on whether all of the related principles are followed or not. The principles present concepts which on application, bring the desired product or process closer to achieving a CE model.

Table 5: Circular economy principles (Adams et. al, 2017)

Principle	Source
Increase productivity of materials by doing the same or more with less	Fuller (1973), Hawken et al. (1999), Lund (1955), Stahel (2010), Womack et al. (1990)
Eliminating waste by defining materials as either technical or biological nutrients enabling them to be within closed material loops	EMF (2013a; 2013b), McDonough and Braungart (2009)
Thinking in systems by studying the flows of materials and energy through industrialized systems, understanding the links, how they influence each other and the consequences	Meadows and Wright (2008), Pauli (2010)

CE in the BE cannot be determined without identifying the nature of the building process and the final output that is generated. CE principles that have been mentioned in . require the application of CE aspects across the building's life cycle. All the processes, activities and components that must be organised for development in the built environment have the potential to become more circular on individual levels. Traditional design, construction and operation activities and processes are made more circular by transforming them or introducing their circular counterparts in the development process. However, the CE aspects (Table 6) are not integrated throughout the project lifecycle because they are applied in isolation within the building process.

The design strategies (Table 6) usually have a pervading impact across the different phases of a project, from the conceptualisation to repurposing or deconstruction. It is so because design strategies are preventive strategies that are deployed early in the early project stages, for example the planning or design phase (Ghisellini, Ji, Liu, & Ulgiati, 2018). Designing a building in accordance with circular principles may have far-reaching implications such as changes in the ownership structure or end-of-life scenario (Leising, 2016). Additionally, the manufacturing and supply stage is focused on the active role played by supply-side actors such as contractors, manufacturers and service providers who must adapt the circular principles independently or in collaboration for the building project. There are possibilities of overlapping CE aspects for

multiple lifecycle stages, such as using recycled materials (in the manufacturing stage) and procurement of recycled materials (in the construction stage). This proves that circularity is successfully achieved when circular principles are followed across the connected lifecycles.

Table 6: CE aspects across building's life cycle stage (Adams et. al 2017)

Life Cycle stages	CE aspect
Design	DfD (Design for Disassembly) Design for adaptability and flexibility Design for standardisation Design out waste Design in modularity Specify reclaimed materials Specify recycled materials
Manufacture and Supply	Eco-design principles Use less materials/optimise material use Use less hazardous materials Increase the lifespan Design for product disassembly Design for product standardisation Use secondary materials Take-back schemes Reverse logistics
Construction	Minimise waste Procure re-used materials Procure recycled materials Off-site construction
In use and refurbishment	Minimise waste Minimal maintenance Easy repair and upgrade Adaptability

	Flexibility
End-of-life	Deconstruction Selective demolition Re-use of products and components Closed-loop recycling Open-loop recycling

Lemmens and Leubkeman (2016) add that circular economy practices maintain or enhance the value of building materials and components to the maximum extent by means of re-use or recycling. Additionally, in a CE, buildings are viewed as temporary banks that utilise and store useful materials and products (Ghaffar, Burman, & Braimah, 2020). To exploit the potential provided by BAMB (Buildings as Material Banks), various circular strategies like deconstruction, selective dismantling, material and component re-use and closed-loop recycling can be applied in the end-of-life phase of the building (Adams, Osmani, Thorpe, & Thornback, 2017). When salvaged materials substitute the virgin materials for the desired characteristics, high value re-use and recycling is achieved (Ruiz, Ramón, & Domingo, 2020). Building materials are used throughout the life cycle of a building in different material flows that relate to construction, deconstruction and material production. Thus, creating market for high value re-use and recycling requires collaboration between multiple construction and demolition partners across the value chain of a building (Ruiz, Ramón, & Domingo, 2020).

3.1.2 Principles of CE in the BE

This sub-chapter provides further insight into CE principles' different classifications and how they can be applied in the building process.

One of the definitions of CE is "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops" (Ludeke-Freund, Gold, & Bocken, 2018). According to Geissdoerfer et al. (2017) this can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling. These principles are also referred to as major reverse cycles as seen

in Figure 10 (EMF, 2012). Literature that focuses on the classification of CE principles applies different terminology and rules for the classification. **Error! Reference source not found.** provides a juxtaposition of the different kinds of categorizations that have been made regarding CE principles over the years. They differ in level of detail and in their definitions but operate within the same general principles of narrowing, slowing down, or closing material and energy loops.

Table 7: Circular Principles

Ludekefreund et al. 2018	Circular Strategy	Maximize material and energy efficiency Dematerialisation	Product service system (PSS) Extending product value Classic long life model (Bakker et. al, 2014) Encourage sufficiency			Extending resource value Industrial symbiosis		
EMF, 2013	Resource strategy	Narrowing	Slowing down			Closing		
Ludekefreund et al. 2018	Value strategy	Reduce component & material input and output	Retain component value			Retain material value		
Lansink 1979	3 Rs	Reduce	Reuse			Recycle		
Bocken et al. 2016	Patterns (main Circular results - results of activities)	Prevention & Reduction	Repair & Maintenance	Reuse and redistribution	Refurbishment & remanufacturing	Recycling	Cascading and repurposing	Organic feedstock

This research will consider Figure 10 as the reference framework for further empirical research because it provides insights into the different patterns resulting from strategies like reduce, reuse, and recycle.

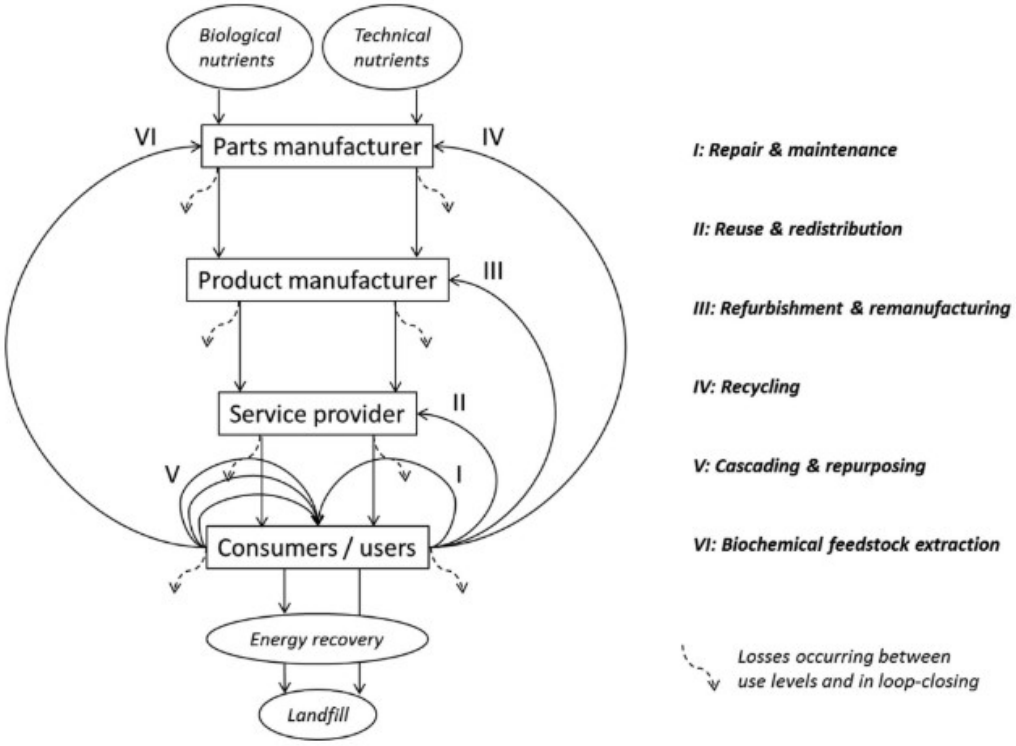


Figure 10: Major reverse cycles for the CE (EMF,2012)

Prevention and Reduction

Prevention and reduction serve as the first action towards managing waste as it evaluates the need for new buildings, materials or products (Lansink, 1979). Reduction can be achieved by conscious decision-making in terms of choosing material and energy efficient manufacturing processes and construction techniques. Hutner et al. (2017) suggest that prevention can be adopted in three ways; pre-use, use and post-use, depending on the project phase. The pre-use phase focuses on designing products that have a minimal waste stream, minimal toxic impact, or designed for disassembly or repair. By applying these principles also mentioned as circular principles in the design phase by Adams et al. (2010), waste can be prevented and reduced by changing the production design (Esmaeilian, et al., 2018). Intense utilisation of space, energy and

materials in the use phase by means of business models and technology can reduce waste. Hutner et al. (2017) propose that re-use and repurposing buildings, materials and components is a way to prevent the birth of a new waste cycle.

Repair and Maintenance

Repair and maintenance operations are focused on the life span extension of materials, products, components, or buildings through periodic monitoring and upkeep to retain or restore its functionalities (Linton & Jayaraman, 2005). This principle facilitates the reduction and prevention of waste streams by improving the serviceability and desirability for re-use. Repair and maintenance preserve the original functionality of the material, product, or building, thus preventing downcycling or recycling, resulting in a change of quality, properties, and environmental value.

Reuse and Redistribution

Reuse and redistribution are focused on retaining the purpose a product, material, component, or building was designed and produced for, with minor enhancement or no change. The commercialisation of this model implies that the ownership may be transferred from one owner to another. The reuse process requires redistribution if on-site reuse is not possible. Reuse and redistribution usually demand a market place that can assist the actors in identifying the market value and the opportunity for trading it using the market infrastructure (Ludeke-Freund, Gold, & Bocken, 2018). Renovation projects use this principle to reuse existing structures over reusing building components or materials because it is resource-effective. The energy and resources required to reuse and redistribute materials and components are used as decision-making variables by actors in the BE.

Refurbishment and remanufacturing

The refurbishment and remanufacturing pattern is similar to reuse and redistribution but it requires enhancement to improve the component's quality or upgrade it to an appropriate physical condition (Ludeke-Freund, Gold, & Bocken, 2018).

This process requires a reverse logistics infrastructure that facilitates take-back systems so that actors like suppliers and manufacturers can refurbish the products using industrial processes. The

additional energy required to refurbish is added to the product's life cycle analysis, thus helping actors select the appropriate circular principles.

Recycling

Recycling is described as the process of converting used or waste products into new products thus providing a new lifecycle to a waste stream (Cruz Rios & Grau, 2020). The recycling process requires a supply chain that facilitates the collection of material at the source, transportation to an actor capable of recycling, separation, and processing and finally, redistribution of the new product (Ludeke-Freund, Gold, & Bocken, 2018). Thus, although recycling conserves raw materials, it can have a negative impact on the environment.

Cascading and repurposing

Cascading and repurposing primarily focus on the value-retention of biological materials (Ludeke-Freund, Gold, & Bocken, 2018) by recovering the biological nutrients from waste streams. This pattern is mostly applicable for products and components used in the stuff and space layers of the building (Brand, 1994) because of their composition.

3.1.3 The Status Quo

This sub-chapter discusses and understands the current building practices by highlighting processes that have been adopted and perfected over decades of business as usual. It is essential to understand the current practices so that the required changes can be identified.

The building process is categorised into 4 main phases (Debacker, Manshoven, Peters, Ribeiro, & Weerdt, 2017):

a) Conceptualisation & design
b) Construction
c) Usage & Operation
d) Repurposing & demolition/deconstruction

These phases are made up of intermediate stages and milestones which involve a wide variety of actors. In the context of the current building practices, Debacker et al. (2017) find that most

actors are only involved in one or two main phases. They also observe that actors who participate in the design and construction phase have well-established connections and relationships that seem to decline once the building is commissioned. The actors lose connections and project specific knowledge and are rarely actively involved again during the later phases. Most of the valuable information which is created and managed by these actors is related to the construction, operation, materials, and re-use/recycling/recovery options of the building, and is therefore not available for the actors at the end of life phases such as repurposing and demolition/deconstruction activities (Debacker, Manshoven, Peters, Ribeiro, & Weerdt, 2017). This gap in the transfer of knowledge also means that the actors in the design and construction stages seldom account for the end-of-use or end-of-life scenarios when making critical design decisions and choices. If these decisions were based on potential end-of-life scenarios, the waste streams of the building could be predicted to facilitate reuse or disassembly of building components. Circular and reversible building solutions are perceived as too expensive compared to the linear 'take-make-waste' models, which has been optimised throughout the value chain for decades (Debacker, Manshoven, Peters, Ribeiro, & Weerdt, 2017). As a result, most renovation, refurbishment, and renewal strategies end up in linear solutions. The current value chain is highly dependent on traditional business and financing models, which advocate the ownership of products more than performance-based product-service systems, posing a challenge for resources/products to be taken back by their manufacturers (Debacker, Manshoven, Peters, Ribeiro, & Weerdt, 2017).

3.1.4 Current Challenges

This sub-chapter builds on current practices in the BE by highlighting specific challenges that CE implementation faces in the construction industry. This research defines the challenges as a first step towards finding a solution to the transition.

The literature discusses the difficulty in implementing CE principles and strategies in the construction industry (Kanters, 2020). This research compiles the different types of challenges that are encountered by actors who wish to implement circular principles in their building projects. Hart et al. (2019) classified these challenges in four categories: (i) Cultural challenges,

(ii) Regulatory challenges, (iii) Financial challenges and (iv) Sectoral challenges. These challenges are categorized and outlined in Table 8.

Table 8: Challenges in the BE (adapted from Hart J. , Adams, Giesekam, Tingley, & Pomponi, 2019)

	Code	Challenge
Cultural	C1	Lack of interest, skills/knowledge and engagement
	C2	Lack of collaboration between business functions
	C3	Risk Aversion
Regulatory	R1	Lack of a consistent regulatory framework
	R2	Obstructing laws and regulations
	R3	Lack of incentives for CE
Financial	F1	CAPEX prioritised over OPEX
	F2	Greater investment costs
	F3	Low prices for virgin materials
	F4	Limited funding
	F5	Unclear business case
Sectoral	S1	Lack of coherent vision
	S2	Lack of standardization
	S3	Split incentives
	S4	Long product lifecycles (buildings and materials)
	S5	Technical challenges
	S6	Insufficient use or development of CE-focused design and collaboration tools, information, and metrics

Cultural Challenges

The challenges in this category concern the current status of the BE, which is dominated by management practices and mindsets deeply entrenched in the linear economic model. These challenges address the social, behavioural and managerial aspects that need to be changed to transition to a CE (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019).
Hart et. al (2019) describe the lack of interest, knowledge/skills and engagement (C1) as an overarching challenge that impedes the circularity efforts. The lack of interest is observed on the supply side and demand side of the value chain. A lack of intrinsic motivation across value chain actors results in the absence of the infrastructure that is required to carry out circular processes. CE implementation has been limited to isolated projects and does not have a widespread reach when compared to the pervasive linear model. This has caused a limited understanding and lack of awareness surrounding the CE amongst important actors within the value chain (Adams, Osmani, Thorpe, & Thornback, 2017). The limited awareness gives rise to process-based challenges like a lack of end-of-life planning during the commissioning and design phase by involved actors like the client/owner, architects, contractors, and consultants.

Hart et al. (2019) and Pomponi and Moncaster (2018) described the second cultural challenge as the lack of collaboration between business functions and businesses (C2). This challenge points towards the incompatibility of the traditional competitive mindset with the collaborative approach required to progress the CE. Collaboration is required within one's organisation as well as between organisations so that the focus is shifted from increasing the market share from a business opportunity to increasing the market size collaboratively (Kraaijenhagen, van Oppen, & Bocken, 2018). The construction industry which is mainly responsible for the BE is tightly connected with other sectors, mainly the financial sector (Adams, Osmani, Thorpe, & Thornback, 2017). This means that the partner sectors must be synchronous in making the transition to CE so that the construction actors can carry out the circular strategies. For example, the financing of buildings is still carried out traditionally and does not consider value of materials at their EOL (Adams, Osmani, Thorpe, & Thornback, 2017).

Risk aversion (C3) is a cultural challenge that is common across the construction sector. Masi et al. (2017) suggest that implementing CE in value chains would result in higher risk exposure for

businesses. The absence of information and exemplary projects increases the perception of risk for actors who want to transition to CE.

Regulatory challenges

Regulatory challenges result from the regulatory environment and policy that surrounds circular practices in the construction industry. These challenges are context specific and may differ from city to city within the same country. The lack of consistency in the regulatory framework (R1) is mentioned in literature frequently (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019). This is a result of an unclear collective vision from policymakers across the world. Laws and regulations are often obstructing instead of facilitation (R2) (Pomponi & Moncaster, 2012).

A lack of incentives for adopting CE (R3) that match the expectations of the market parties create a barrier to entry. Incentives relating to public procurement, tax subsidies and producer responsibility are frequently mentioned in literature (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019).

Financial Challenges

Challenges that originate from financial concerns about the fiscal environment surrounding circular principles such as extended ownership, residual values, harvest values and multiple ownership structures are mentioned in literature (WBCSD & Circle Economy, 2018).

Financial institutions are integral to the building sector, however, they need to adapt longer term business models. Capital expenditure (CAPEX) is favoured over operational expenditure (OPEX) (F1), and the expected investment returns are transactional and not long-term (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019). Implementation of CE in building projects requires investment in interventions like reverse logistics, pilots, research and development and certification. This makes circular projects much more expensive than traditional construction projects (F2). Current financial valuation models do not associate the environmental and social costs with the financial costs of materials. Thus, the cost of virgin materials is low (F3) compared to re-used, repurposed, refurbished or recycled materials. The current valuation methods are not aligned with the resource value of materials at the end-of-life, thus creating a high barrier to entry for actors to be interested in circular material flow chains. Finally, circular business models such as material take-back systems and product-service systems have not been

proven yet in the BE. An unclear financial case (F5) pose a big challenge for CE implementation because of instances like the split-incentive where the initial investor may not benefit directly, because the benefits may fall to the final owner (Zuidema, 2016). A deeper understanding of how each party involved can apply CE principles in their individual financial contexts is required. All of the above financial challenges result in hesitancy from investors leading the challenge of limited funding (F4).

Sectoral Challenges

Sectoral challenges relate to the specific nature of the construction industry and the involved processes such as: design and engineering, construction, maintenance, ownership, supply and demand, dismantling, transformations and repurposing to name a few. There is limited research available for reuse of components and in the past research has emphasised the reduction of construction and demolition waste (Adams, Osmani, Thorpe, & Thornback, 2017). There is still a gap in literature about the systemic nature of the value chain, operation of circular value models and integration of processes across the supply-chain (Bragança & Regina, 2020).

Due to the vastness of the industry that includes actors dedicated to multitudes of disciplines and processes, a lack of a coherent vision (S1) is a prevalent challenge. This challenge is closely related to the cultural barriers because it refers to the need for an overarching vision that can guide decision-making across all the actors and stakeholders from policymakers to tenants (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019).

The lack of standardisation (S2) points towards the need for industry wide consensus on standar building practices and assessment criteria so that the circular efforts can be scaled (WBCSD & Circle Economy, 2018). The highly contextual nature of building projects and lack of information about existing building components and materials make it hard to apply the principle of re-use and redistribute.

Split or confused incentives (S3) addresses the complexity of the BE since assets involve multiple stakeholders who have misaligned objectives. The low accountability results in a highly competitive environment characterised by fragmented value chains and a lack of transparency between value chain actors (Acharya, Boyd, & Finch, 2018).

The extended product life cycles of building and materials (S4) are related to the complexity resulting from the long lifespan of assets in the BE. This challenge points out the difficulties in adopting innovative ownership structure, EOL scenarios, business cases and financial models due to long lead times and lack of control over the project's lifecycle (Acharya, Boyd, & Finch, 2018).
Technical challenges (S5) concern the limitations offered by circular processes such as material recovery, reuse, refurbishment and recycling. Hart et al. (2019) describe the difficulties in extracting materials like bricks and wood without damaging their structural properties.
CE-based design and collaboration tools, information and metrics (S6) are needed to overcome the sectoral challenges by contributing to the BE's collective knowledge. Kanters (2020) points out that Circular strategies like design for disassembly (DfD) do not have established standards and the process of its implementation is still very uncertain and contextual.

3.2 Discovering Entrepreneurial Behaviour

This chapter is devoted to defining the scope and boundaries of entrepreneurial behavior, as a topic area in the field of entrepreneurship.

3.2.1 An introduction to Entrepreneurship

One of the main problems of entrepreneurship research is the definition of entrepreneurship and the entrepreneur (Delmar, 1996). Delmar (1996) adds that entrepreneurship research is highly heterogeneous since research is conducted from different fields such as economics, history, policy, psychology, sociology and geography, to name a few. This results in a lot of context-specific definitions and approaches. Ries (2011) defines the concept of entrepreneurship as "creating new products and services under conditions of extreme certainty". Hisrich and Peters (1998) define entrepreneurship as the process of creating something new. They add that entrepreneurship requires the investment of time and effort along with the responsibility of financial, psychic, and social risks to achieve the outcome of personal satisfaction and monetary rewards. Stevenson and Jarillo (1990) further reveal that entrepreneurship is not just limited to ownership, but it can take place across all levels within or outside an organisation. Entrepreneurial initiatives can be organised within the firm through internal ventures or

externalised outside the boundaries of a firm using instruments like venture capital funding (Elfring, 2005). The locus of entrepreneurship ranges depending on the exploration/exploitation opportunities presented to the entrepreneur (the actors who displays entrepreneurial behaviour). Entrepreneurs are generally assumed to be individuals like business owners or founders. However, in the context of this research, entrepreneurs are individuals who display entrepreneurial behaviour regardless of their role in the organisation.

However, other authors like Low and Abrahamson (1997) argue that entrepreneurship illustrates the creation of an organisation. This view is different from the assumptions used in this research because it explains the creation of an organisation through entrepreneurship. This research intends to look at entrepreneurship as the manifestation of entrepreneurial behaviour, which can essentially be used in all kinds of scenarios, including creating new organisations. Furthermore, to support the widespread nature of entrepreneurship, the literature points out that entrepreneurship can also occur within incumbent organisations that operate in existing markets (Casson, 1982; Shane & Eckhardt, 2010).

Kuratko and Hodgetts (1998) define entrepreneurship as "a process of innovation and new venture creation through four major dimensions – individual, organisational, environmental, process – that is aided by collaborative networks in government, education, and institutions. All of the macro and micro positions of entrepreneurial thought must be considered while recognising and seizing opportunities that can be converted into marketable ideas capable of competing for implementation for today's economy". This definition by far is found to be the most appropriate and all-encompassing for investigating EB in the CE actors.

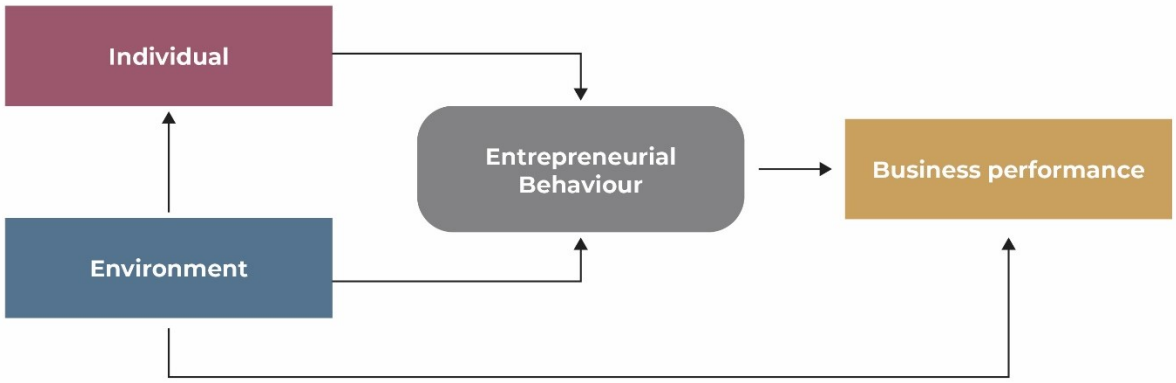
3.2.2 Definitions and background of Entrepreneurial Behaviour

According to Delmar (1996), the economic process of entrepreneurship is best understood from the perspective of EB since the psychological standpoint and experience forms the foundation of the entrepreneurial process. He concludes that entrepreneurial actors' motivations, ideas, objectives, and actions result in new business and innovations. Thus, EB helps to understand the entrepreneurial process better.

Most academic research concentrates on entrepreneurs during their professional activities, as a result, the efforts are directed towards analysing the entrepreneurial decision to start a business or the founding of an enterprise (Hisrich & O'Brien, 1981; Voigt et al., 2007; Man et al., 2008). This research will focus on the broader role of EB in innovative practices, which is aligned with Delmar's (1996) research. McMullen and Shepherd (2006) describe EB in terms of specific actions with the help of which actors or organisations can make decisions under uncertain circumstances. They also add that actors who utilise EB led decision making are able to achieve a competitive advantage. Smith & Gregorio (2017) add that EB represents the behaviour of actors or organisations by which they move new markets, create new customers, and/or combine (existing) resources in new ways. Some researchers regard innovativeness and ingenuity (solving problems with creative solutions), the propensity to take risks (willingness to pursue opportunities in uncertain environments), and proactiveness (doing what is needed) as three key dimensions that underlie EB (Covin & Slevin, 1991; Lumpkin & Dess, 1996; Morris, Kocak, & Schindehutte, 2008). Organisations are progressively committing to entrepreneurial behaviour as a vehicle to achieve competitive advantage in a constantly changing environment (Barringer & Bluedorn, 1999; Ireland et al., 2001; Lyon et al., 2000). Shane & Venkatraman (2000) suggest that discovering and exploiting value-creating entrepreneurial opportunities is based on two fundamental components: EB and willingness. The component of EB is further explained as the set of activities required to move a concept or idea through the key stages in the entrepreneurial process to implementation" (Morris & Kuratko, 2002).

Understanding the composition of EB is essential to understand how it can be operationalised in practice. Delmar (1996) suggests that the four main concepts of entrepreneurship: (i) individual, (ii) environment, (iii) Entrepreneurial performance/behaviour and (iv) business performance can be structured into a model (Figure 11) that represents the relationships between the concepts.

Figure 11: Model of entrepreneurial behaviour (adapted from Delmar, 1996)



The individual (i) level highlights the disposition of the entrepreneurial actor or organisation by gauging characteristics such as motivations and abilities. Entrepreneurial actions originate from these individual behaviours; thus, EB may vary from actor to actor.

The environment (ii) level indicates the configuration and characteristics of the internal organisation and context of the actor, project or organisation. The environment has an active impact on the interpretation of the goals and actions of the entrepreneurial actors. The actors create innovations or value that they think would have the most impact on the environment at a given point in time. Thus, the organisational structure and environment serve as the medium for the entrepreneurial actors to dispose of their goals.
Entrepreneurial behaviour (iii) is defined as the actions that must be taken to achieve the desired ambitions (Delmar, 1996). Entrepreneurial behaviour provides the link between the inherent motivations of the entrepreneurial actors and the resulting business performance. It serves as a

tool for reasoning because EB can be understood by understanding the various behaviours and decisions that are under the control of the entrepreneurial actors (Delmar, 1996).

Business performance is the outcome of the reaction of the environment (market) to the actions of the entrepreneur/ actor. It is determined by how the market or other actors in the environment respond to entrepreneurial behaviour. Therefore business performance indirectly depends on the concepts of individual and environment. In other words, even if an actor possesses the individual characteristics that lead to innovation and growth in the enterprise, the context of the environment may act as an enabler or barrier to the output of EB.

3.2.3 Identifying patterns of Entrepreneurial Behaviour needed in the CE

EB has been viewed in multiple, often contradictory ways by several scholars across varying academic literature that spans over 20 years. This subchapter lays down the different descriptions that have been made about EB in varying contexts.

As part of the literature review, research documents in the field of entrepreneurship were scanned to identify the characteristics of entrepreneurs. It was found that authors explain EB with the help of patterns or indicators that individual actors or their organisations show. The list of identified patterns is tabulated in Table 9. The literature review finds that patterns of EB have been documented extensively in various sectors and across different contexts. The studies range from gender-specific research (Buttner, 1993; Hisrich & Obrien, 1982) to analyse small scale enterprises (Davids, 1963). Thus, it is found that the terminology used is not homogeneous and often describes different events that take place in different periods. However, this research groups the documented patterns into common characteristics of EB. The column labelled *'pattern groups'* in Table 9 provides a classification of the different types of observed patterns in entrepreneurs in the researched literature.
However, it is essential to note that the frequency of occurrences of patterns of EB does not necessarily correlate with the prevalence in practice.

Table 9: Characteristics of Entrepreneurs

Patterns of EB	Pattern Groups	Authors of identified research
Ambition	Ambition	Davids (1963), Dunkelberg & Cooper (1982) , Sexton & Bowman-Upton (1990), Sutton (1954), Hisrich & Obrien (1982)
Goal orientation		
Achievement orientation		
Recognition		
Growth orientation		
Independence orientation	Leadership	Durand (1975), Gasse (1977), Hisrich & Obrien (1982)
Autonomy		
Leadership		
Self-reliance		
Proactiveness		
Taking initiative		
Risk taking	Risk-taking	Hornaday & Bunker (1970), Liles (1975), McClelland (1987)
Risk management		
Risk bearing		
Making decisions based on trust and competence of people		
Tolerance for ambiguity		
Tolerance of uncertainty		
Using past knowledge to identify opportunities	Opportunity identification	Alvarez et al. (2010), Casson (1982)
Spending resources to research opportunities		
Alertness to opportunities		

Creation of new combinations of resources (opportunities)	Learning through experimentation	Ries (2011), Alvarez et al. (2010)
Learning through experimentation		
Learning as you go		
Evaluating direct feedback		
Access to social capital	Access to social capital	Buttner (1993)
Innovative incentive models within the existing firm structure	Organisational changes	Shane & Eckhardt (2010), Gartner, Carter & Reynolds (2010), Kuratko (2010)
Rewards and reinforcements		
Strategic Renewal of firm		
Renewing routines over time		
Formation of new organizations		
Innovation activities in products or processes	Business model innovation	Gibbs (1987), Kuratko (2010), Murdoch (2005), Kraaijenhagen et al (2018)
Business model reconstruction		
Creation of a business plan		

The literature research aims to achieve a clear understanding of the need for EB in the context of CE in the BE. Thus, the grouped patterns from Table 9 were reviewed with relation to current literature that is more focused on CE.

Ambition

The first pattern identified in entrepreneurship literature is 'Ambition' that comprises entrepreneurial patterns like ambition, growth orientation, achievement orientation, recognition, and goal orientation. This indicator explains that for an entrepreneur, the prospect of achieving their goals is more important than any other benefits or securities (Delmar, 1996). In the context

of the BE, ambitions are linked to future visions that define the circular building process (Nevens, Frantzeskaki, Loorbach, & Gorissen, 2013). A guiding ambition is used to create a shared commitment from stakeholders to define and develop an ambition for the building process (Quist, 2007). Ambitions initiate the heuristic process of defining the problems that need to be resolved. Smith et. al (2005) identify that ambitions can be used as a tool to map the 'possibility space' of alternatives that align with the core motivation of the entrepreneurial actors. A clear ambition also facilitates the building of actor networks by binding together actors who share common visions and interests for the BE.

Developing a clear and robust ambition is thus identified as an essential trait of EB in the context of the BE as well as general entrepreneurship. It is also identified as the first step that must be adopted to initiate, lead or execute an entrepreneurial process (Kraaijenhagen, van Oppen, & Bocken, 2018).

Leadership

Leadership, taking initiative, proactiveness, self-reliance and autonomy as concepts have been increasingly repeated in recent literature (Kuratko. D, 2010). The umbrella term leadership is a heavily researched multidisciplinary topic that focuses on improving organisational performance. A study of CE projects by Rizos et al. (2016) regards leadership, an extension of the company's culture, as an essential enabler. Proactiveness is defined by Izaias (2013) as "anticipating and acting on future wants and needs in the marketplace. It is a forward-looking perspective characterized by the introduction of new products and services ahead of the competition and acting in anticipation of future demand". Proactiveness and leadership are observed as effective vehicles to champion the actors' ambition (Quist, 2007). According to Zucchella and Urban (2019), the leadership process to steer a paradigm change involves: (i) setting a direction for the organization, (ii) aligning people through effective communication and argumentation, (iii) motivating internal and external partners and (iv) managing complexities in the organization and its environment.

Risk-taking

Risk-taking or risk-taking propensity is hailed as one of the main indicators of EB because according to economic theory, one of the main roles of the entrepreneur is to bear risks (Delmar,

1996). Entrepreneurs have a greater tolerance to ambiguity which states that they expose themselves to greater risks without resulting in stress and unpleasantness (Delmar, 1996). Research indicates that risk taking propensity is a trait at the individual level and is a precursor to entrepreneurial decision making (Keh, Foo, & Lim, 2002). The risk-taking quality of entrepreneurial actors also relates to their tolerance to ambiguity (Table 9) which is an emotional reaction to uncertainty.Risk adversity is a dominant force in the traditional construction sector. Thus, businesses can maximise their profits by removing externality-lated risks from their own business models (Kraaijenhagen, van Oppen, & Bocken, 2018). CE business models require actors to take risks as an antecedent to establishing collaboration-based business models where the risks can be shared.

Opportunity Identification

The ability to identify opportunity is an EB pattern group. It is defined by Casson (1982) and Schumpeter (1934) as an opportunity that offers the chance to meet a market demand through a creative combination of resources to deliver value.

Learning through Experimentation

Through experimentation, the importance of learning is highlighted by Kraijenhaagen et al. (2018) as an important step in the entrepreneurial process. Bocken et al. (2018) suggests that experimentation can be used as a tool to explore value proposition, creation, delivery and capture using field experiments. Experimentation provides significant results that can accelerate the entrepreneurial processes; first, pilots and experiments lead to knowledge creation that reduces the uncertainty; second, pilots provide proof of concepts that can overcome internal and external resistance to transition efforts.

Access to social capital

The access to social capital is an indicator of credibility resulting from established relationships with other actors in the ecosystem. Social capital may also provide a competitive advantage to entrepreneurial actors (Shane & Eckhardt, 2010). Trusted networks play a significant role in partnerships in projects which include uncertainties without fear of opportunism (Gordon & McCann, 2000).

Organisational changes

Innovation in organizational mechanisms is an umbrella term for various indicators like renewal in routines, renewal of the firm, creation of new teams, formation of new organisations, rewards and reinforcements and more autonomy to employees. Fundamentally, it is directed at any change brought about to the existing organisational mechanisms to ensure an overall transition across the individual level (Delmar, 1996). These changes aim to renew the way interactions occur within the organisation and between organisations with other actors. An internal environment that supports innovation is a stronger antecedent of EB (Hornsby et al.,2002). Organisational changes must be adopted by incumbent organisations so an environment where EB flourishes can be created. In the context of the BE, organisational innovation is required to inhabit the open-ended, continuous and collaborative development processes needed for implementing CE principles. Thus, implying that changes must be made to the way a project team is organised on a project level.

Business model innovation

Business model innovation can be defined as the designed changes brought to the elements of a firm's business model (Foss & Saebi, 2017). The innovation process depends on the degree of changes that impact the business performance in the given context. Literature recognises that business model innovation can equip actors with a competitive advantage, profitability and improved organisational performance (Bock et al., 2012, Zott et al., 2007). Business models are used to describe the customer's demands and the organisation's strategy to deliver value to meet their demands in the best way; thus, business models are strongly linked to the ambition of entrepreneurial actors (Foss & Saebi, 2017). However, to understand what business models do, this topic will be further addressed in chapter **Error! Reference source not found.**.

The transition to a circular economy needs innovative business models which either replace existing ones or grab new opportunities (EMF,2016) and is considered as one of the main difficulties for successful implementation of circular economy (Kok et al., 2013)

By rethinking the three value dimensions, i.e. what value is proposed, how value is created, delivered and captured (Table 2), business model innovation provides a more holistic approach for aligning the value creation logic of the company with circular principles (Bocken et al. 2016).

3.3 Circular Entrepreneurship

This chapter introduces the concept of entrepreneurship related to the circular economy and discusses how they are related to each other and operate in the same domain.

There is a need for a holistic economic model (Brown, 2017) for the networked complexities of the world that we inhabit (Zucchella & Urban, 2019). According to Prahalad and Krishnan (2008),"The new source of competitive differentiation may lie in the internal capacity to reconfigure resources in real-time, driving co-created value through global networks". CE provokes us to develop a management revolution that requires a paradigm shift in the current economic and managerial systems (Auerswald, 2012). Capra (2015) clarifies that a collective effort is required to match the complexity of the challenges and create new knowledge. In the age of a digitally connected world, people with varying decision powers are able to participate in the creation of knowledge and its implementation in the real world (Zucchella & Urban, 2019). CE illustrates the advent of a new kind of web that requires collaboration between actors across the value chain; producers, consumers, governments, NGOs, and institutions to achieve success in its implementation (European Commission, 2018). Other key drivers are the personal motivations of entrepreneurial actors and overall business incentives in the institutional context of CE (Lenox & York, 2014).

Zucchela and Urban (2019) define circular entrepreneurship as an aspect of the complex socio-economic system that needs rethinking in terms of relationships, patterns and contexts (technical, political, legal, and cultural) by means of collaboration within and outside the organisation. Circular entrepreneurship has been described as the creation of a 'responsible' enterprise which is not only a legally registered enterprise but also an organisation with far reaching responsibilities like NGOs, territorial institutions, and political associations (Zucchella & Urban, 2019).

Zucchella and Urban (2019) have described the characteristics of circular entrepreneurship initiatives as follows: (i) creation of environmental, social, and economic value for the societal needs, (ii) investing resources for sustainability, (iii) utilising digitisation and technology, (iv) achieving sustainable competitive advantage through innovation and R&D, (v) promoting

circular principles to reduce waste generation, (vi) reducing the energy consumption of the business processes, (vii) communicating, training and advocating the implementation of circularity, (viii) adapting efficient organizational activities (agile, flexible, partly decentralized, rapidly reactive, competent) that enable the change, (ix) collaborating within and across value chains.

3.2.4 Circular Economy as an entrepreneurial opportunity

The circular economy presents an opportunity for a symbiotic, sustainable and economic growth. The circular economy (as a whole) is a USD $4.5 trillion opportunity (Rutqvist & Lacy, 2015). Entrepreneurial actors are aware of opportunities and explore/exploit them compared to other actors in the economy (Zoltan & Audretsch, 2010). Casson (1982) defines entrepreneurial opportunities as "those situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than their cost of production".
Drucker (1985) classifies entrepreneurial opportunities into three categories: "(i) the creation of new information, as occurs in the invention of new technologies; (ii) the exploitations of market inefficiencies that result from information asymmetry, as occurs across time and geography; and (iii) the reaction to shifts in the relative costs and benefits of alternative uses for resources, as occurs with political, regulatory, or demographic changes". Entrepreneurial opportunities are different from business opportunities because they discover new interactions in an uncertain and dynamic environment (Kirzner, 1997). Thus, CE is a promising endeavour for entrepreneurs to experiment with new business models and relationships with the value chain actors.

3.2.5 Learning from Born circular firms

This subchapter tries to understand the different types of actors who are involved in the transition to a CE. Understanding these actors is important for this research because they bring different skills, resources and expertise to the table with regards to implementation of CE principles in the BE.
Born circular firms are organisations that are founded to adhere to circular economy principles. These firms tend to operate in networks to compensate for their smaller scale in terms of

operations and resources compared to incumbent firms (Zucchella & Urban, 2019). Viewing the importance of collaboration and network in the successful implementation of CE, born circular firms embed themselves in circular ecosystems. These ecosystems not only include partners of the value chain but also regulatory and institutional actors. This makes the born circular firms a driving force in the transition towards sustainability because the nature of their organization is shaped by the needs of the circular economy. Although their response to localised problems and opportunities was geographically limited, the solutions were based on global issues like pollution, waste generation and global warming (Zucchella & Urban, 2019). It is also suggested that born circular firms hold the potential to gain the attention of policymakers and direct it towards their agenda through initiating dialogue regarding regulatory policies.

A distinction between born-circular firms and transitioning circular firms is essential to know how these actors of the circular value chain can cooperate and benefit from cooperation. The transitioning firms may be incumbent firms trying to reduce their environmental impact while improving the social impact. These organisations could be long-established and large, which poses a challenge to the transition because of managerial and organisational obstacles that have been established over time, making it a complex affair (Zucchella & Urban, 2019).

3.2.6 Corporate entrepreneurship

Firms that rely on entrepreneurship actions as the core of their commitments, decisions, and strategies are usually called entrepreneurial firms (Mintzberg, 1973). Covin, and Kuratko (2009) define a corporate entrepreneurial strategy as “a vision-directed, organization-wide reliance on entrepreneurial behaviour that purposefully and continuously rejuvenates the organization and shapes the scope of its operations through the recognition and exploitation of entrepreneurial opportunity”. Corporate entrepreneurship for a CE can be explained as the strategies that are taken by an organisation to accommodate CE principles in their processes or products. Guth and Ginsberg (1990) stress corporate entrepreneurship is carried out in two major ways: new venture creation within existing organizations and the transformation of ongoing organizations through strategic renewal.

It can be observed that strategic entrepreneurship involves activities that use the words renewal, regeneration, redefinition, and reconstruction, which are all indicative of the application of new

or innovative processes within the organisation. Such innovations have the possibility to result in the formation of new business entities. Corporate entrepreneurship approaches stimulate innovation across any of the five areas - strategy, value proposition, market positioning, internal organization , and business model (Morris et al., 2008). Current and future innovative competitive advantages can be developed using a set of actions that are framed around EB (Ireland, Kuratko, & Covin, 2003). Covin and Miles (1999) assert that corporate entrepreneurship is based on the need for innovation. Evidence indicates that corporate entrepreneurship is essential for organisations facing a dynamic environment, shifting customer needs and changing societal and technological values (Morris, Kocak, & Schindehutte, 2008).

3.2.7 Circular Business Models

Business models are used to describe the way business is done. Business models indicate the value that a business offers by the means of a product or service or both. The previous chapters point that the transition to CE requires entrepreneurial actors that develop new business models or innovate existing models to suit the collaborative nature of circular businesses (Zucchella & Urban, 2019). Circular business models are built to positively impact society, the environment, and economic competition (Kraaijenhagen, van Oppen, & Bocken, 2018). Kraaijenhagen et al. (2018) also point out that the current economic system can house micro-level circular economy ecosystems by means of stakeholder collaboration.

Such systems are unlike linear economy models where the benefits of one stakeholder cause detrimental effects to other stakeholders, such as society, environment, partners, suppliers, customers, to name a few.

Circular economy principles in the building sector are primarily focused on design strategies. However, for these principles to scale across the industry, equal focus must be placed on circular business models (Acharya, Boyd, & Finch, 2018). With the help of circular business models, the principles of CE defined in Figure 10 can be translated into viable business cases that add social and ecological value (Ludeke-Freund, Gold, & Bocken, 2018). Business models are typically a snapshot of the process of value creation for customers to create economic value. There is consensus among research that business models help in the management, design, communication, and analysis of value creation systems of organisations (Zott, R. Amit, &

Massa., 2011). Implementation of circular business models challenges the traditional models that emphasize financial value creation (Lewandowski, 2016). Circular business models help companies add value through the principles of CE like closing material loops and minimizing waste and consumption. Elimination of waste, creating changes in resource productivity and enhancing the customer value proposition on price, quality, and availability require a rethinking of products and services in their entirety (Accenture, 2015).

Business models are composed of core elements called (a) value proposition (what does the business offer to the customer), (b) value creation (how does the business create the value), (c) value exchange/delivery (how does the value reach the customer) and (d) value capture (how value is captured) in a coherent whole (Richardson, 2008). One of the definitions of business models provided by Osterwalder and Pigneur (2010) is "the rationale of how an organisation creates, delivers and captures value." One of the most recent definitions, conceptualises CBMs as "business models that are cycling, extending, intensifying, and/or dematerialising material and energy loops to reduce the resource inputs into and the waste and emission leakage out of an organisational system. This comprises recycling measures (cycling), use phase extensions (extending), a more intense use phase (intensifying), and the substitution of products by service and software solutions (dematerialising)" (Geissdoerfer, Savaget, Bocken, & Hultink, 2017).

There are various types of circular business models in the built environment that are based on principles of circularity that have different terminology that span different business processes. Thus for this research the following list of circular business models was identified because it relates to the application of circular principles in the BE from a process perspective that acts as a guideline for organisations to adopt circular processes in their building activities (WBCSD & Circle Economy, 2018):

1. Circular supplies

This business model emerges from the circular principles of prevention and reduction and re-use and redistribution—actors in the BE focus on renovating or refurbishing existing projects over new construction unless necessary. The buildings are also designed out with minimal material usage that can be easily maintained and re-used.

2. Product as service systems

This business model is developed on the premise that product suppliers provide the materials, products or components as a service instead of an upfront change in ownership. The users pay for the product's performance, whereby the ownership of the product is retained with the supplier or manufacturer. This results in the alignment of the incentives of the product providers and consumers.

3. Product lifetime extensions

The business model depends on the maintenance and lifespan extensions of existing products, components, materials or buildings. Actors invest resources in developing tools that can facilitate maintenance, repairs and upgrades. There is an opportunity for new business models to monitor and data analysis or develop products that can communicate their state and are easy to maintain and retain.

4. Sharing platforms

A sharing economy results in the reduction of waste and efficient use of resources. The waste streams of one supply chain can be the input for another. By harnessing the power of digitisation and technology, platforms can enable the sharing of waste, recycled, re-used and refurbished materials, components or products. This business model also applies to a sharing model for real estate where underutilised space can be optimised for maximum use and returns.

5. Resource recovery

Buildings can serve as material banks for recycled and repurposed materials. Value collaborations can help in creating downstream recycling processes that source waste material and convert them into building materials.

3.2.8 Transforming business models

In the linear economy line of thinking, the key focus often revolves around how organisations generate returns by satisfying customer demands (Kraaijenhagen, van Oppen, & Bocken, 2018). In the CE, value generation transcends beyond the individual organisation because the potential is maximised when value is created collaboratively with partners. Circular business models link the different components of a business, such as product design, finance, marketing, R&D, procurement, and manufacturing, in relation with external parties who are collaborators in the value creation (Beattie & Smith, 2013).

Business model innovation in new and existing businesses is required to seize the generated opportunities from CE thinking (Pieroni, McAloone, & Pigosso, 2019; Frishammar & Parida, 2019). This process is challenging because changes must be implemented across all the components of the business model (Lewandowski, 2016). Storbacka et. al (2013) add that a fundamental change is required in the business logic which entails new collaboration with both old and new actors in the firm's business ecosystems. Like corporate entrepreneurship, incumbernt firms are more likely to require innovation in their business models. Since business models transcend organisational boundaries (Zott, R. Amit, & Massa., 2011), partnerships in the value chain ecosystem are important for collaboration and innovation.

When incumbent organisations implement changes in their business model to close material loops, reduce energy consumption, retain product ownership, and optimiseheir processes, they transition towards becoming a circular firm (Lewandowski, 2016). Lewandowski (2006) adds that business models can be categorised by where they stand on a spectrum between linear and circular because every business model involves both economies.
Frishammar and Parida (2019) conclude that the process of transforming business models is experimentative rather than sequential and emergent rather than planned. Small scale trial and error is highly preferred over large-scale rollouts business decisions. The transition from a business model to a circular business model is a discovery-driven approach which requires entrepreneurial patterns of learning through experimentation (Ries, 2011) and rapid feedback loop processes integrated within the organisation's operations. Risks and uncertainties also accompany the transition process because of a lack of perception of the organisation's future business models compared to their core business models (Lamberg, Laukia, & Tikkanen, 2013).

3.4 Learnings

The literature review was carried out to understand what is already known about CE in the BE and identify the concepts and theories applied in the domain (Bryman, 2001). As per, Figure 4 the literature review is chronologically carried out before the case study analysis so that the

outcomes of the literature review provide a much more specific and targeted approach towards understanding EB in the actors of the value-chain of circular projects.

Chapter 1 introduces CE in the BE by classifying the circular principles that may be used in the building process to attain circular ambitions. This classification is useful because it identifies the different building processes and practices carried out across the complete life-cycle of a project. The chapter provides insights on the implementation challenges of CE in the BE. The challenges serve as an antecedent to analysing the case studies based on the role of EB in overcoming the challenges.
Chapter 3.2 investigates the concepts of entrepreneurship and EB. The chapter proposes that EB can be modelled on three conceptual levels: the individual, the environment, and the business performance (Figure 11). The chapter also contributes to developing the concept of EB by discovering different entrepreneurial patterns that form EB. Patterns of EB are qualitative indicators of actors or organisations who operate in highly uncertain circumstances.
Chapter 3.3 addresses the main objective of this paper by exploring the concept of 'Circular entrepreneurship'. This chapter lays the foundation by describing the need for entrepreneurial actors in the CE and their role in transitioning the BE. Different approaches to entrepreneurship are investigated in this chapter so that this information can be utilised to assess the actors of the empirical case study research. The chapter concludes by explaining the importance of circular business models as a critical component of EB and addresses types of circular business models applied in the BE.

3.2.9 Developing an analytical framework

Concerning the theoretical explorations about EB, two main conclusions can be drawn from the literature research. The first conclusion is based on Delmar's (1996) model of EB (Figure 11). The model asserts that EB is a multi-level phenomenon and is affected by variables on each level – the individual level, the environment level and the business performance level. However, the model does not clarify how EB can be recognised or detected on each level. As a result, the second conclusion of the literature research solves this gap by identifying how EB is recorded in literature with the help of noticeable patterns shown by entrepreneurial actors or organisations.

There is a possibility that there are more entrepreneurial patterns in practice than recorded in the literature review due to limitations of the nature of the research approach. However, this research assumes the entrepreneurial patterns identified in Table 9 as a starting point and classifies them according to the conceptual levels suggested in Delmar's (1996) model of EB.
Opportunity identification and access to *social capital* are entrepreneurial patterns that are excluded from this process because the survey results conducted simultaneously with the literature review indicated that they are not prevalent in practice.

Figure 12 explains the process of how the two conclusions about EB derived from literature are interrelated. *Ambition, risk-taking, learning through experimentation* and *organisational changes* are patterns of EB that indicate organisations' approaches on an organisational level. The observed patterns on the organisational level are labelled behavioural patterns since they differ from actor to actor. These patterns correspond to the organisational level because they reflect the internal functioning of the organisation.
Leadership is identified as a pattern of EB that is needed on an organisational, value chain and ecosystem level. The environment level mentioned by Delmar (1996) also includes external contextual factors of the market and regulatory context. These contextual factors are not under the influence of entrepreneurial actors. However, literature identifies the need for leadership in the ecosystem since it is regarded as an effective way to bring change among other actors in the value chain network and even change contextual factors (Kraaijenhagen, van Oppen, & Bocken, 2018).

Business model innovation is recognised as a pattern of EB that impacts the business performance of an organisation. However, the pattern corresponds to Delmar's (1996) business performance level since it highlights the organisation's business model.

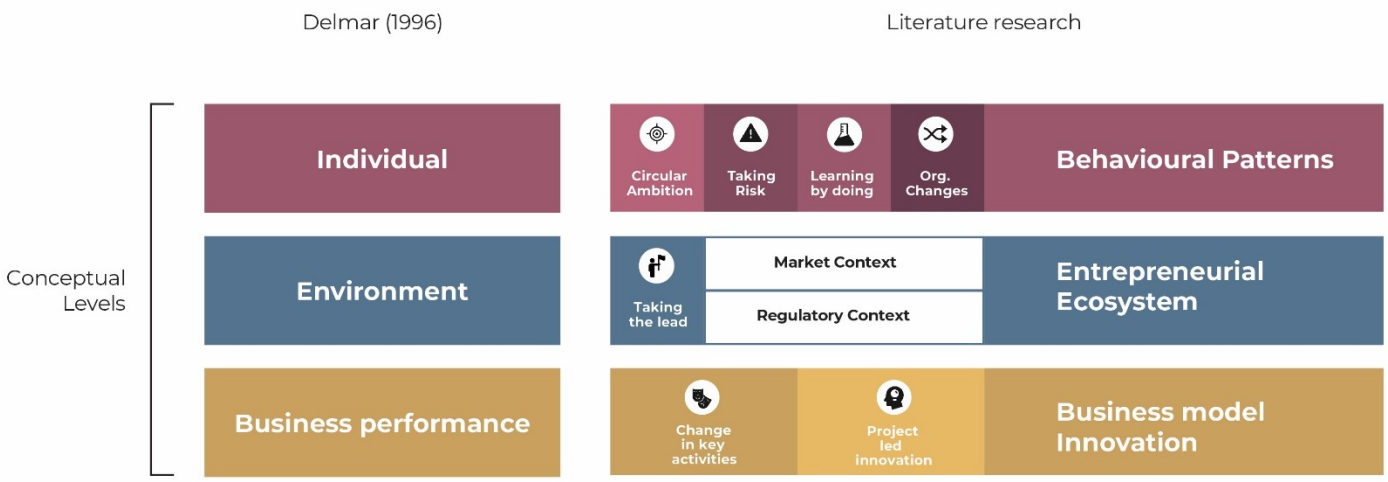


Figure 12: Classifying EB pattern according to conceptual levels

A new analytical framework is developed (Figure 13) based on the methodology explained in Figure 12. The analytical framework represents the hypothesis that patterns of EB must be shown on all levels to achieve the desired output i.e the transition to a CE. The framework is different from Delmar's (1996) model because it includes business model innovation as a contributor to EB compared to business performance as an output of EB. However, this framework supports newer literature (Zott, R. Amit, & Massa., 2011) that suggests that business model innovation influences an organisation's business performance. The analytical framework also acknowledges the external contextual factors within which entrepreneurial actors operate.

The three components that comprise EB can also be interpreted as the actor's value system (behavioural patterns), the actors role and importance in the ecosystem (entrepreneurial ecosystem) and the tools at the actor's disposal (business model innovation). The analytical framework is used as a guidance tool to carry out empirical case study research.

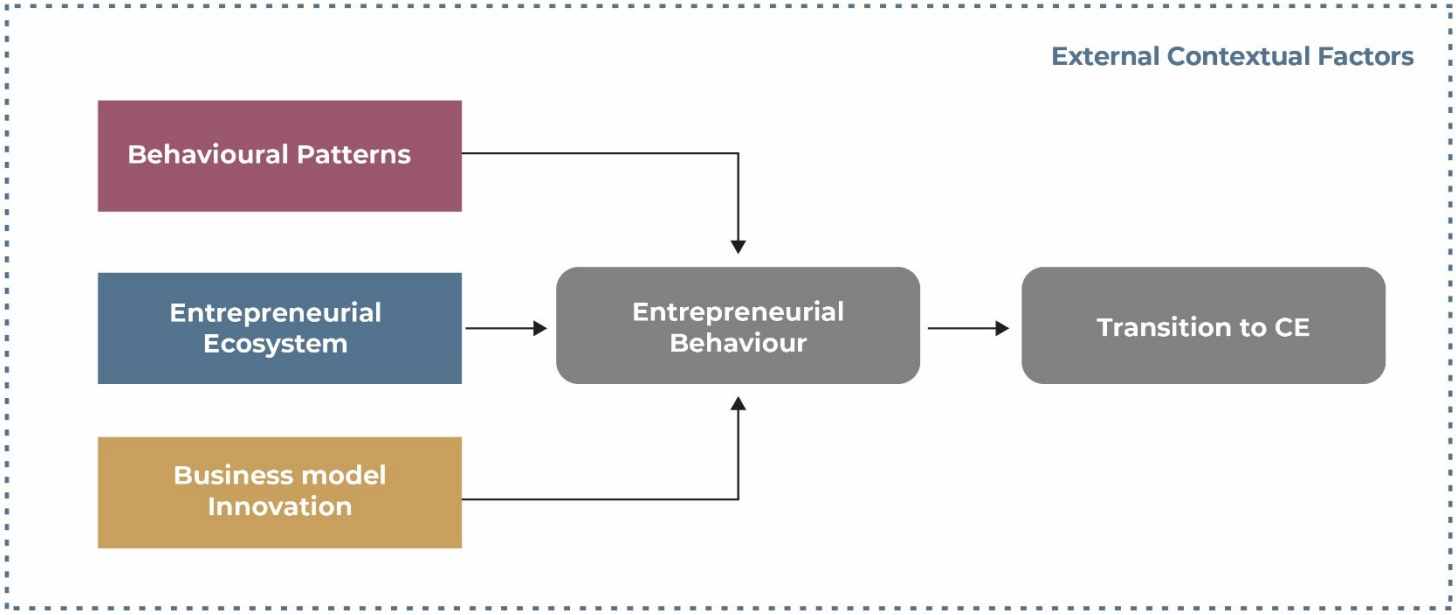


Figure 13: Analytical framework

4. Survey

This section provides insight on the role of the survey in the research and the main objectives behind conducting the survey. It also details the findings of the survey and what they imply for the conclusions of the research.

A survey was chosen as an additional qualitative research method to bolster and validate the findings from the literature review. The patterns of EB that are discovered because of the literature research are prone to the limitations that relate to the nature of the subject of entrepreneurship. Since EB and its definition is highly contextual, the findings can be substantiated in the context of the circular building processes in the BE with the help of this survey

A broad range of practitioners in the BE who have been involved in building projects that apply CE principles were approached. The participants were asked to rate the patterns of EB in terms of their importance in practice. The Likert scale (Joshi, Kale, Chandel, & Pal, 2015) is used to determine the measure of the importance of the patterns in the circular building processes. The online survey interviewed 31 (n) individuals who have first-hand experience in the development of building projects that follow one or more circular principles. The participants of the survey that represented organisations involved in circular practices in the BE held varying roles, thus providing results based on different perspectives of the BE. The composition of the participant pool is as follows: 12% academicians, 24.5% circularity consultants, 9% project managers, 12% architectural designers, 10% urban producers, 10% contractors, 5% developers, 2.5% demolition contractor, 2.5% investor, 2.5% supplier, 2.5% manufacturer, 2.5% dismantling expert, 2.5% sub-contractor, 2.5% services consultant. The roles are displayed as percentages and not absolute values because a lot of participating organisations held more than one role in the BE. Thus, even though the number of participants (n) = 31, number of roles (r) held are greater than (>) n. The survey response rate stands at 25.8% as the survey was electronically mailed to 120 candidates. The objectives of the survey are as follows:

- To validate if the output of the literature review (patterns of EB) is relevant in practice.

- To identify if some patterns of EB were more important than others in the circular construction processes.
- To identify a relationship between an actor's role in the BE and their perception of EB.

3.5 Findings

It is observed that across all 31 (n) responses, having a 'Circular ambition' was considered to be the most important part of a circular construction process. It received an average score of 4.7, where 0 = not important and 5 = Extremely important. The need for 'Product innovation' was ranked second with a score of 4.2 across *n* participants along a similar scale. The importance of 'learning through experimentation' was ranked third with a score of 4.1. The overall scores of each pattern of EB are represented in Figure 14. On an absolute scale, it is observed that the participants ranked the 'need for financial profits', 'ability to identify opportunity', and 'risk taking propensity' lower than the mean score (3.7). However, on closer scrutiny of these results it is observed that the importance given to certain EB patterns over the others could be a result of the role of the participant in the BE.

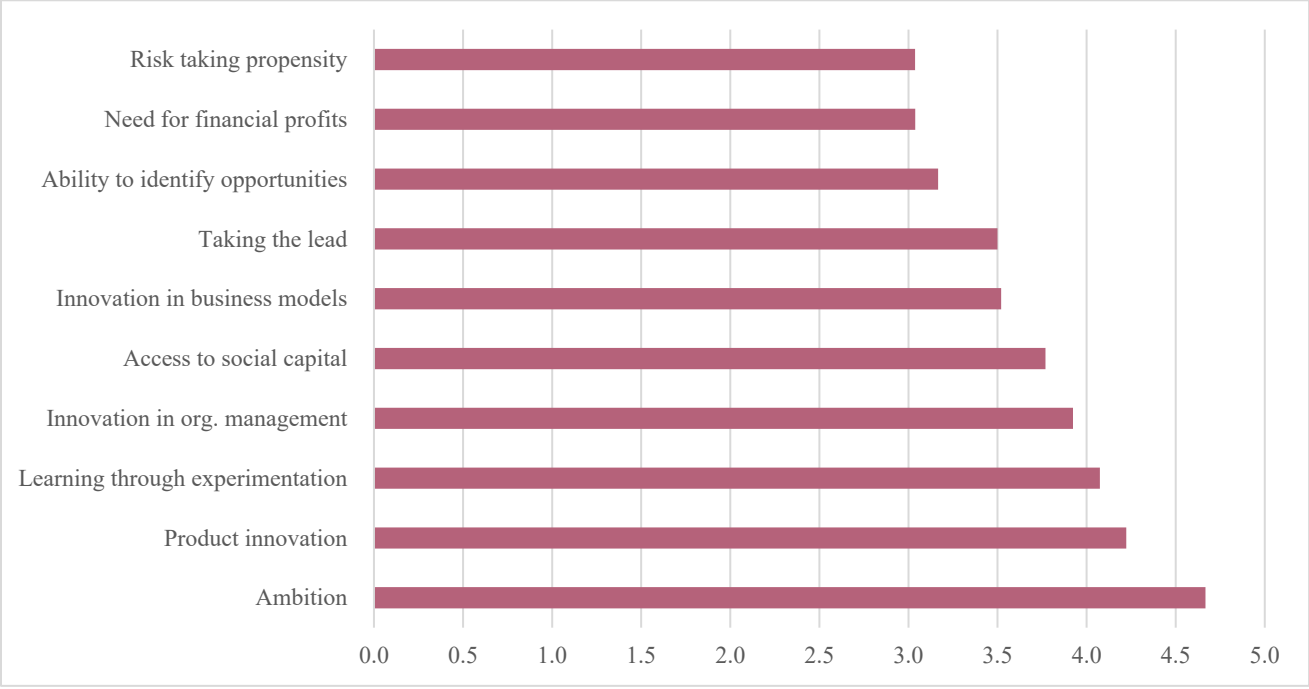


Figure 14: Survey results (n=31)

To test this assumption, the participant pool (n) was segregated into two different groups: Active building roles (Group A) and Supporting roles (Group B). Group A includes an array of roles that are directly involved in the building activities that take place on site, such as; Developers, contractors, architects, project managers, dismantling experts, demolition contractors, sub-contractors, manufacturers, suppliers, etc. On the other hand, Group B comprises of roles that are not directly involved in construction activities such as; Circularity consultants, academicians, and registration platforms. The segregation of these groups does not imply that one is more important than the other, but helps to identify the difference in objectives due to the nature of involvement in building projects. 9 participants were found to hold roles that belong to both Group A and B (Group C), while 15 participants belonged to Group A and 7 participants belonged to Group B.

When based on the grouping, the results are found to be comparable because of the variance in the perception of patterns of EB. Figure 15 displays the survey results of Group A, whereas Figure 16 and Figure 17 represent results from Group B and Group A+B respectively. On analysing the grouped results, it is understood that Group A held the need for financial profits in much higher regard (3.5) than Group B (2.2) and Group C (2.6). Similarly, the need for 'taking a leadership role' in construction projects that deal with circular processes is rated highly important (4.1) by Group A, whereas Group B and Group C do not share the same opinion (2.5 and 3.0). There was a consensus among all three groups for some patterns of EB in circular construction processes such as 'risk taking propensity', importance of 'learning through experimentation and 'need for a circular ambition'.

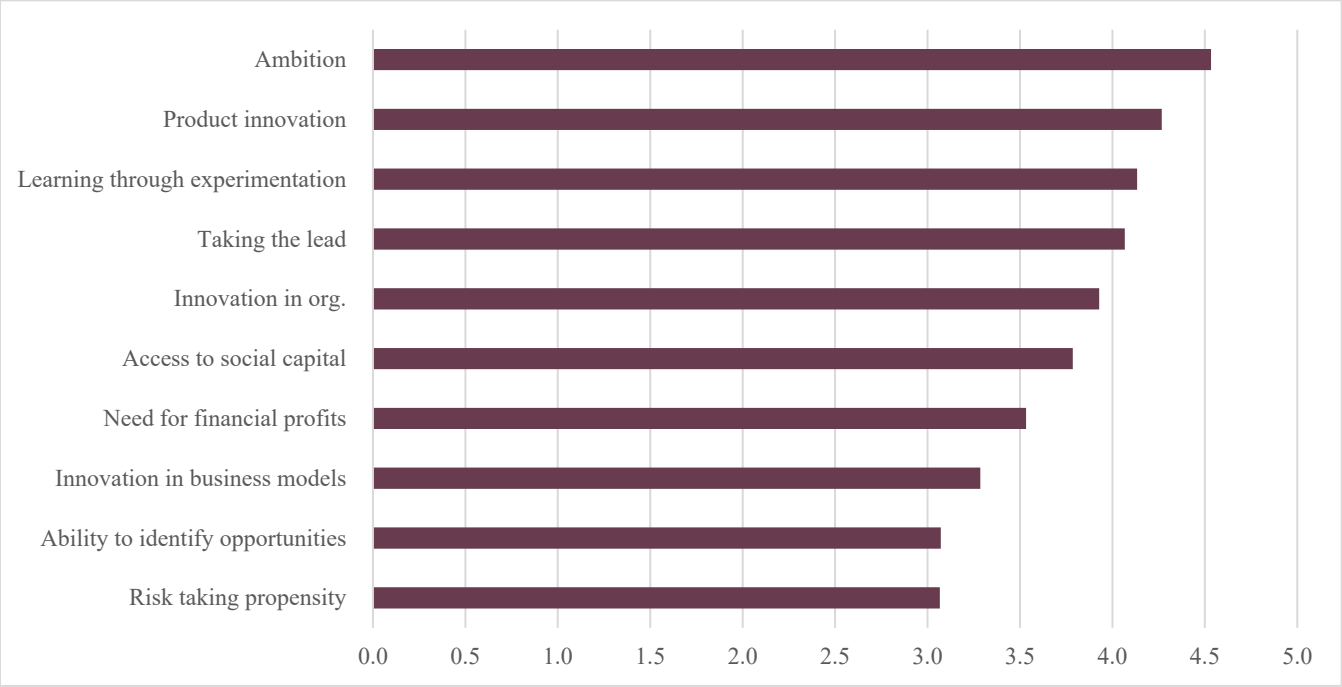


Figure 15: Survey results Group A (n=15)

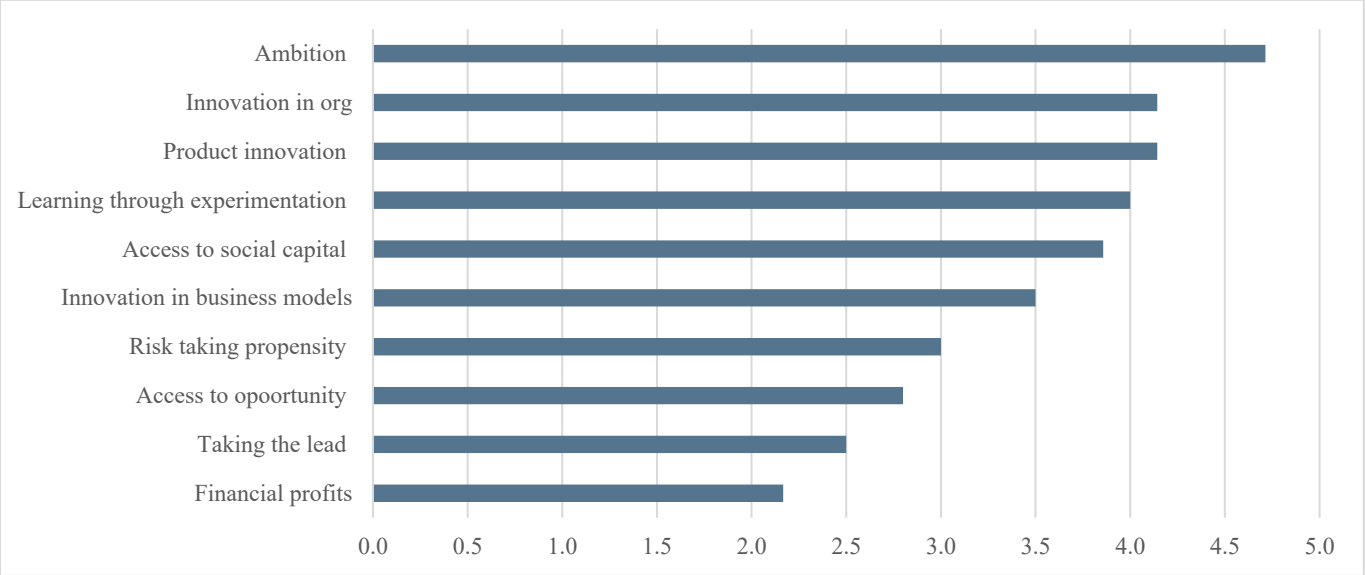


Figure 16: Survey results Group B (n=7)

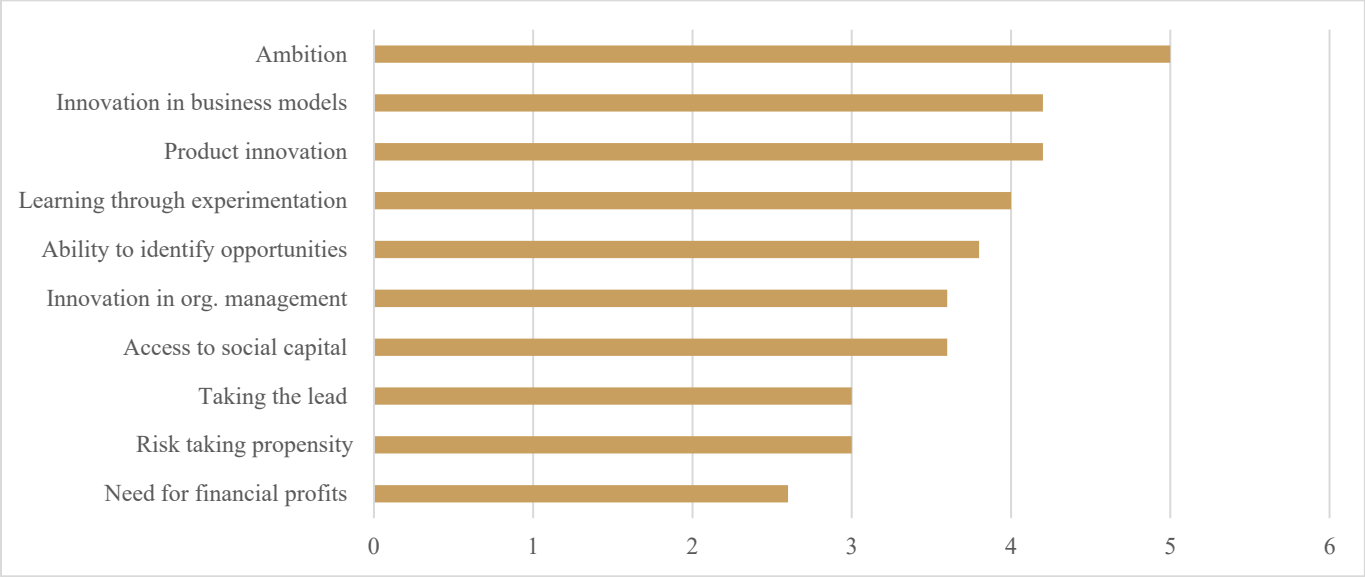


Figure 17: Survey results (Group A&B)

The findings of the survey indicate that the patterns of EB (Table 9) that are obtained through the literature review, hold relevance in practice. However, the Likert scale helped in determining that the importance of the listed EB patterns is not the same when it comes to their application in construction projects that employ circular principles and processes. The survey also concludes that the role the actor plays in the BE is instrumental in shaping their perspective of EB. Overall, the survey contributes to painting a picture of the types of patterns of EB that are unanimously agreed upon as 'most important' for circular construction practices.

3.6 Limitations

Granting that the online survey achieved a participation rate of 25.8%, the data was not sufficient in absolute numbers of responses because of the highly different proportions between the kinds of roles that responded to the survey. 31 responses are not conclusive in terms of the possible statistical analyses that could have been drawn from the survey. The survey also faces the limitation of being concise enough for the participant not to lose interest. Being in the middle of a pandemic where business-as-usual moved completely online also may have reduced the effectiveness of online surveys. The survey is designed to be completed within 4 minutes; however, such a qualitative nature of enquiry implies that every pattern of EB is open to

interpretation. The audience belongs to varying backgrounds and profiles within the extensive value chain of the BE. Thus misinterpretations of various concepts such as circular ambition, business model innovation is a possibility. The lack of consistency in terms of definitions was minimised by providing a short supporting text that explains the context of each question, however, this text had to be concise to make sure that the survey does not exceed the estimated 4-5 minutes of completion time.

5. Case Study

5.1 Selecting the cases

Case study research is defined as the primary method of qualitative data collection for this research because of its ability to provide knowledge from practice. To select the cases, a selection criterion was formulated based on the literature review outcomes. Thus, the objective of the selection criteria was to help filter circular construction projects that:

- have a circularity-related ambition
- have been completed and handed over to the end-user
- provide information about the involved actors
- provide information about the circular principles

The selected cases need to have a circularity related ambition so that information about the impact of the ambition on the organisational processes of the actors can be accessed. As determined by the literature review, circular ambition is also one of the primary individual patterns of EB. The selected case must also be a finished project so that the case analysis is based on a complete overview of the process and product from conception to completion. This streamlines the data collection process by providing certainty about the actors involved in the project's various phases.

Gerding's (2019) masters research included a similar criterion for her investigation about understanding the decision-making process between the actors of circular projects. While her research utilizes the case studies to analyse the actor ecosystem of circular building projects, this research focuses on the EB of the same actors involved in the case projects. Thus, it was a conscious decision to select the same circular construction projects as case studies so that the research could benefit from the exploration from Gerding's (2019) work and provide a perspective unique to the nature of this research. However, the addition of BlueCity to the original list of cases was a choice that resulted from the lack of access to relevant information about the involved actors for Townhall Brummen, one of the cases involved in Gerding's (2019) research

To conclude this section, the selected circular building projects are:

a) EDGE Olympic
b) The Green House
c) BlueCity

Figure 18: Case studies (from left to right: BlueCity, EDGE Olympic, The GreenHouse)

5.2 Method

Case studies were chosen as a research methodology to provide a practice-driven perspective to the learnings from the literature review. Semi-structured interviews with actors involved in the development process of the selected cases are the primary source of information. The nature of this research is qualitative, and it relies on the perspectives and experiences of the interviewed actors supported by relevant documentation. Thus, an interview protocol is created, which also guides the structure of the interview. The interview protocol is based on the analytical framework (Figure 13) developed as a result of the literature research (Appendix B).
Every case offered the possibility to interview actors across the value chain of the projects. However, keeping the feasibility of the research in mind, the interviewed actors (Table 10) were selected based on the results of Gerding's (2019) research. Gerding (2019) finds that actors involved in the project team of Case A and B have the highest influence on decision-making. Analysing actors who have a high influence on decision making would help the research make deductions in terms of the role of EB in the project's development. Although actors who are not integral to the project may be entrepreneurial, the degree of their involvement in the project is an important criterion. Table 10 includes the interviewed actors and their role in the project organisation.

Table 10: Case study participants

Case	Project role	Position in organisation	Part of the project team
A	Client - Developer - User	Director	Yes
A	Architect	Partner	Yes
A	Contractor	Project leader	Yes
A	Dismantling contractor	Commercial director	No
B	Circularity expert	Consultant	No
B	Client	Sustainability advisor	Yes
C	Developer - User	Director	Yes
C	Architect - User	Partner	Yes
C	Contractor	Sustainability manager	Yes

Due to practical limitations, interviews with all project team actors from the cases could not take place. However, all of the interviewed actors had significant contributions to the circular strategies deployed in the selected cases.

Case studies are an effective method for this research because it gives insights on the three levels of EB by offering the context of a project. It provides a practical perspective on how the circular development processes are carried and what influences their execution. Thus, the selected case studies do not only offer the project context but also provides insights on the nature of organisations that come to together to realise the underlying ambition. The cases help to focus on the dealings of the participating organisations without isolating them from the context of the ecosystem of the project. The selected cases are valid for drawing conclusions because they include a plethora of participating organisations which range from traditional actors, to born-circular actors. This provides a wide range of organisations to analyse, thus improving the wider applicability of the conclusions that can be drawn from the entrepreneurial patterns identified in them.

6. Cases

6.1 Case A: Edge Olympic

Figure 19: EDGE Olympic

The EDGE Olympic is a project which spans the renovation and addition of two floors to a former office building from the nineties in Amsterdam. The office was known as ‘Olympic Plaza’ before the project was taken over by the developers, OVG real estate which is now known

as EDGE technologies (Berning, 2021). The project was completed in May 2018 and serves to be a multi-tenant office building with a mix of stationary offices and flexible co-working spaces. The building currently houses the headquarters of EDGE technologies and a few other companies such as Software Improvement Group (SIG), Ebbing, and EVBox (van Leeuwen, 2018).

The building was a front-runner in implementing the trifecta of health and well-being, smart sensors and sustainability on a building scale. The building has received a WELL™ certification and is the first one in the Netherlands to receive a platinum score for its impact on health and wellbeing (Berning, 2021). Additionally, the extension received a Cradle2Cradle certificate as a result of its bio-based wooden structure. Table 11 documents the circular principles that have been deployed in the project along with the respective methods of implementation.

Table 11: Circular principles and implementation in EDGE Olympic

Circular Principles	Method of implementation
Prevention & Reduction	Transformation of existing building
	Lightweight construction
Repair & Maintenance	Smart monitoring
Re-use & Redistribution	Material re-use
Refurbishment & Remanufacturing	Renovate existing structure
Recycling	Material Recovery

6.2 Case B: The Green House

Figure 20: The GreenHouse Utrecht

The circular pavilion ' The Green House ' is a development by Strukton, Ballast Nedam, Facilicom and Albron (Alba Concepts , 2018) with an ambition that the pavilion should serve as a source of inspiration for the circular economy for 15 years. The pavilion is publicly commissioned by the Rijksvastgoedbedrijf (Metz, 2021) as a part of the redevelopment of the former Knoop barracks in Utrecht (Definitieve gunning rijkskantoor de knoop, 2015).

The consortium led by R Creators won the contract for the long term redevelopment of the barracks and the temporary construction of The Green House. The consortium includes partners such as Strukton, Ballast Nedam and Facilicom, and submitted the most economically advantageous tender in the European tendering procedure (Definitieve gunning rijkskantoor de knoop, 2015). The Green House is designed for disassembly using reused components from the old Knoop barracks (Ballast Nedam , 2017). After its end of life at 15 years, the building is expected to be placed elsewhere, making space for newer development. The reusable pavilion was built in three months (Ballast Nedam , 2017) and The Green House opened its doors in the spring of 2018. Table 12 documents the circular principles that have been deployed in the project along with the respective methods of implementation.

Table 12: Circular principles and implementation in The Green House

Circular Principles	Method of implementation
Prevention & Reduction	Lightweight construction
	Designed for disassembly
Repair & Maintenance	Take-back system
Re-use & Redistribution	Material re-use, Component re-use
Refurbishment & Remanufacturing	Take-back system
Recycling	Use of recycled material

6.3 Case C: BlueCity

Figure 21: BlueCity, Rotterdam

BlueCity is the name of an organisation housed in the former ‘Tropicana’ building in Rotterdam that used to be a swimming pool and water park. The building works as a landing place for innovative entrepreneurs and the hub of the circular economy in the city and the region. The building itself is circularly renovated from the service basement to the solar roof. The transition from a swimming pool to circular model city is supervised by architectural firm Superuse and developer COUP, both of which have been partners since its foundation. 90% of the circular office wing, with 100 workplaces for sustainable entrepreneurs, was realized with recycled material. This saved a total of 60 tons of CO2. The rest of the building also works according to circular principles (Circular construction in BlueCity, n.d) such as working with recycled and reused materials.

Moreover, they are sourced locally, which means there is also an environmental benefit in transport. In addition, the workspaces take full advantage of the building's climatic properties, which means that the addition of installations is kept to a minimum. Finally, several entrepreneurs help with the design, such as the recycling design platform Oogstkaart. Local labour and artisans were hired to carry out the construction processes. The goal of the project is to be a pioneer of CE in real estate. Table 13 documents the circular principles that have been deployed in the project along with the respective methods of implementation.

Table 13: Circular principles and implementation in BlueCity

Prevention & Reduction	Lightweight construction
	Transformation of the existing building
Repair & Maintenance	Renovate existing structure
Re-use & Redistribution	Material re-use, Component re-use
	Re-use existing structure
Refurbishment & Remanufacturing	Take-back system
Recycling	Use of recycled material
	Use of bio-based materials

7. Results

This section provides the findings by synthesising the data gathered from the case study research. The interview data has been transcribed and coded with adherence to the interview protocol (Appendix B). The findings are based on the framework that explicates the concept of EB into the three aspects of Behavioural patterns, Entrepreneurial Ecosystem, and Business model innovation (Figure 22)

Figure 22: 7 Patterns of Entrepreneurial Behaviour

6.4 Behavioural Patterns

6.4.1 Developing a circular ambition

For the EDGE Olympic, the conception of the idea of having a smart, sustainable, and healthy (Berning, 2021) building is credited to the client who is also the developer and user (tenant). The project had a clear vision for the building before the design stage had commenced. In the interview with Constantijn Berning (2021), it was highlighted that this vision resulted from creating a new brand identity for the client organisation. During the period of development of the project in 2018, the awareness about circularity was limited to material reduction and material re-use. Although the ambition for the project did not include circular principles, the client was determined to raise the bar in sustainable office building development. The client is the originator of the sustainable and circular ambition; however, they were not the only actor in the project organisation that shared the ambition. The dismantling contractor has a circular ambition imbibed in their organisation as a part of their three pillars of Circularity, Social Impact, Digitalization. The dismantling contractor ensures that their portfolio of projects revolves around these pillars or at least two out of the three (see interview with Hendricks, 2021). Circularity is identified as the most important of the three pillars. For the EDGE Olympic, the architect did not have a pre-conceived circular ambition as a part of their practice. The interview with the contracting company (Vrijzelaar, 2021) explained that the contracting organisation focuses on being an actor that uses new and sustainable materials in their projects.

> *" So the only way of, let's say be successful in such a process is that you have a team with players in the team, and it's the general contractor advisors, and also the developer self, with with the same, more or less the same ambition." – (Berning, 2021)*

For the Green House, the ambition for the project was drawn up by the public client organisation (Eitjes, 2019). The term 'circular' was not reflected in this ambition since it was not a

commonplace term. However, ‘cradle to cradle’ certified products were asked to be used in the construction, such as reused glass panels and reused balustrades from a temporary bridge. The client pushed this ambition by not charging the rent for the operation of the building. This was done to achieve a conclusive business case along with the consortium, thus trading off potential revenue generation streams for a longer-term ambition. Communicating the ambition within the organisation was challenging due to a lack of confidence from few team members in the beginning (Eitjes, 2019). The client also pointed out that the biggest challenge as an organisation is the lack of financial freedom in executing their extremely high ambitions about developing a portfolio with circular projects (Metz, 2021). Circular construction does not have a single definition yet, making it hard to communicate the client's demands to internal and external market parties. Asking the right questions in the tender stage thus becomes essential for clients. The public client for the Green House developed a tool called “BLOEI” which stands for re-use (beheren) of existing materials, lowest (laag) possible environmental impact, design (ontwerp), economic and collaboration models and information capture (Rijksoverheid , 2020). This tool is used in conversations with actors in the value-chain to provide actionable strategies and perspectives to make the right decisions within the broad area of circular construction.

The initial seeds of the idea for BlueCity were sown by the architect (Govaart, 2021) who established their organization based on the principles of circularity. Their circular ambition is defined by their principles of using as few resources as possible and using materials that are already available (see interview with Jongert, 2021). Jongert (2021) also mentions that the core focus of the architecture studio was material reuse and adapting building components into new construction to save them from ending in landfills. The architecture organisation was established based on principles aligned with the circular economy (Figure 10) called ‘Born-circular’ firms (Zucchella & Urban, 2019). Additionally, Jongert (2021) adds that they retained their founding ambition by not participating in ‘B’ projects such as traditional construction projects that exclude the principles of circularity. One of the other significant philosophies that steered the project was the ambition to create multiple value flows within the building so that excess energy or material can be supplied from one company to another within the same ecosystem. A similar ambition is shared by the developer of BlueCity, who has been involved in the project since the inception of the idea. Unlike the architecture firm, the developing organisation is not born-circular but has

made consistent efforts at implementing circular principles in their portfolio of development. BlueCity was their first foray into the circular construction ecosystem, and it has resulted in an increased level of consciousness within the decision-making process that helps the developer choose future projects (Govaart, 2021). The developers also chose to reinforce their ambition and commitment to BlueCity by reducing their initial revenues and exchanging them for equity.
The contracting organisation is one of the largest contractors in the Netherlands (Zandboer, 2021). Their involvement in BlueCity is driven by the ambition to show that circular construction processes can work as an industry standard. In his interview, Zandboer (2021) mentions that the organisation acknowledges that their status as a large organisation is accompanied with the responsibility to ensure the transition of the BE towards circular practices. However, at such a large and unwieldy company, the entire chain ranging from the director to the carpenter must be on board with the circular ambition. Zandboer (2021) points out that not only does the ambition have to be clear within the organisation, but it also has to be communicated and addressed with external partners such as suppliers and subcontractors.

6.4.2 Learning through experimentation

For the EDGE Olympic, an emergent development strategy was adopted by the developer/client because a lot of the circular design decisions were made as the project was getting developed. Initially, the client wanted to introduce the concepts of technology, health and well-being, and sustainability in the building as proof of concept. However, during the development, they learned that the project could push the bar higher on all three concepts. The emergent strategy was also reflected in the design and construction process. The architect of the project mentioned that every time one of the decision-makers came up with a new idea, they would devote time and resources to the idea to check whether it was worth trying (see interview with Van Noord, 2021). One of these experiments was the local replication of a wooden flooring technology that was initially to be procured from Switzerland but proved to be too expensive for the project.
Along with the local builder, the architects successfully prototype their wooden flooring system locally (Van Noord, 2021). This open and collaborative process was experimentative because there were chances that this idea would not follow through. However, these experiments and

ideas would feed back into the project in the form of ‘learning’, which is considered an asset by the actors. Vrijzelaar (2021) also pointed out the importance of experimentation in the project because the team would not have accomplished what they did otherwise.
The interview with the client (Berning, 2021) also reveals that the building, in its operational phase, is still used as a living laboratory where new techniques of planning and layouts are tested for feedback-based learning. The EDGE Olympic also provided the dismantling contractor with an opportunity to experiment with different business models in the project.

In essence, the Green House is a public building that is viewed as a pilot that demonstrates the potential of circularity. The project, which is designed based on the precondition of temporality, played the role of being a test-bed for joint participation of private and public parties in constructing a circular pavilion (Metz, 2021). As a result, the project was approached with a trial-error mindset towards essential processes such as tendering, project team organisation and contract forming. The client intends to use the learnings from the Green House in their future projects (Eitjes, 2019). The project was also used as one of the initial pilots for the Building Circularity Index or BCI (Van Vliet, 2021). The BCI is an assessment model used to determine the level of circularity of a real estate object, such as The Green House (AlbaConcepts, n.a). This tool was developed by the circularity consultant that was appointed for this project. The BCI is now a market-validated benchmark which has been since used in numerous projects. It enables the projects to be analysed based on their circularity with the help of a comparable metric. However, since its inception, the tool has undergone various iterations and developments to suit the market's demands (Van Vliet, 2021). The circularity consultants apply the Build-Measure-Learn cycle which is central to the growth of entrepreneurial start-ups (Ries, 2011) for their product.

“Sometimes feel we were a bit naive by jumping in and trying to get our head above and swim. But I don't regret it. Because if we wouldn't have done it, it would not have happened” (Govaart, 2021)

Figure 23: Learning from experiments in BlueCity

According to Govaart (2021), ‘learning by doing’ is a guiding principle in the circular economy. The importance of experimentation or ‘learning by doing’ is evident in the entire process of circular construction compared to traditional construction projects because circular projects are based on design principles (Govaart, 2021). A traditional design process is linear, which starts with the client developing the entire process that helps arrive at a final design, then issues a tender, usually based on cost and quality (Winch, 2009). On the other hand, an emergent and collaborative approach was implemented in BlueCity because none of the parties had foreknowledge about what kind of material will be encountered for high-quality re-use. Thus, room was made for experimentation by keeping the design flexible enough to accommodate different materials (Govaart, 2021). The architecture firm uses the term ‘dynamic final design’, indicates Zandboer (Govaart & Zandboer, 2021). The contracting organisation had to learn on the job to execute a definitive non-definitive building process, and BlueCity served as a testing ground for the management to internalise this approach. Using an experimentative and emergent approach to the building process often means that the project deviates from the plans (Van Hoven, tart with the end in mind - High-quality recycled materials passport and virtual residual value, 2021). ‘Learning by doing’ plays a pivotal role for the contracting organisation to

participate in BlueCity because they intend to develop learning within an organisation that usually operates using traditional methods.

6.4.3 Taking risks

The client-developer-user invested more than they would typically invest in an office building project in EDGE Olympic. Their decision to develop an existing building from their portfolio as a pilot for the organisation came with additional risks. Due to the lack of knowledge surrounding the implementation of circular principles in construction projects, the developer had to adopt an emergent process that allowed decisions to be made spontaneously. A cost and time overrun fir the project was a risk for the developer. Design decisions surrounding material re-use also demanded additional time and resources from the developer.
To achieve material re-use, the demolition contractor had to shift from traditional demolition to the dismantling of useful building materials and components. This resulted in additional risk for the demolition contractor because it required the company to invest more in the process. Despite of the risks involved, the demolition company embedded the circular process of dismantling in their business model by not burdening the developer with the risk premium. Instead, the demolition company assumed the risk by taking ownership of the material and quoting the developer with a more conservative cost minus the revenues from the material. The sale of re-used material is highly market dependent since the value of the materials are often based on the demand.

The client chose an integrated DBFMO (Design Built Finance Maintain and Operate) contract. Since the ambition document did not provide a clear requirement about the circular components of the project such as material re-use or design-for-disassembly, the dialogue was heavily dependent on the collaborative and trusting nature of the relationship between the actors.
The word ‘Circularity’ did not exist as common knowledge when the tender document was written. As a result, the demanded specifications were not concrete and the market parties could interpret them and propose solutions (Eitjes, 2019). The client made land available to develop The Green House to the consortium for no rental fee because it was the only wayhe project

would reach a conclusive business case (Eitjes, 2019). Despite being a public organisation, the client assumed the risk for the project not only in a direct way by trading off additional profits for circular ambition but also developing an open and collaborative process which was not done before.

Figure 24: Material bank at BlueCity, an unconventional building in operation

BlueCity is unlike a traditional building project since the building is in its design and construction phase while being operational at the same time. The building that tenants inhabit is constantly being transformed in phases. The risk of investing in an experimental project is attributed to the impact investors who share the circular ambition with the developer and architect (Govaart, 2021). However, the inclusion of the developer and architect as equity stakeholders in BlueCity resulted in a better alignment of interests and sharing of risks since it showed commitment towards the project. Since the architect and developers are involved in a multi-dimensional role in the project, they are responsible for the project on multiple levels across the project life cycle (as described in 6.5.1). This minimises the opportunity for either actor to exit the project in case of an uncertain situation (Jongert, 2021). Pioneering in circular construction techniques provides a conflicting situation for the actors when the decision is made between economically beneficial or purpose-driven interventions. Circular business models such as product-as-a-service systems also require the manufacturers or suppliers to take an additional

risk by retaining ownership of the material. The re-used cooling doors and walls were procured as a service so that the suppliers can ensure that the material is installed correctly and maintained to retain value after the end of its use at BlueCity.

6.4.4 Organisational change

The client of EDGE Olympic underwent a firm renewal process where they were formerly a developer who specialised in office buildings. The building, EDGE Olympic, is a pilot project for the client and a landmark for a new brand identity. Thus, the building embodies the new organisational strategy that focuses on health, sustainability, and smart data-driven offices. To make this transition happen, the client created a small innovation team within the existing organisation, which then turned into a new organisation (see interview with Berning, 2021). It was finally integrated into the project team, and this created an opportunity for the client to present innovative ideas and new strategies for the building. A similar strategy is deployed by the dismantling contractor who set up an innovative arm focused on circular innovations. The employees dedicated a certain percentage of their usual working hours to the innovation arm to be involved in the core business and the innovative activities of the organisation.

To support their circular ambition for the Green House, the client recognised the need to create a programme where more employees within the organisation can transition to circular building processes. A challenge for larger incumbent organisations is that higher-level strategies and visions are often not clear for every member; thus various initiatives and programs were devised to generate awareness in the organisation (Metz, 2021). Circular construction processes also require input from experts who can contribute specific knowledge in law and environmental impact. In the Green House, the client made some changes to the traditional way of organising knowledge by offering an integral role to the legal expert in safeguarding the tenability of the collaboration under procurement law (Eitjes, 2019). This helped overcome the lack of confidence that arose within the team due to the openness of the circular construction process. A similar strategy applied by the circularity consultants in terms of their team composition. The organisation makes sure consultants from different backgrounds such as business management,

facility management, innovation management, building engineering, civil engineering, and architecture are involved. This strategy helps them use internal resources to solve challenges in implementing CE that generally requires a broad spectrum of knowledge (Van Vliet, 2021). Integrating academic explorations within the organisations key activities by employing young students also proved to benefit the circularity consultants by pushing innovation through academic contributions that would lead to products such as the BCI (Van Vliet, 2021).

The BlueCity real estate company is an independent, professionalised enterprise that carries out all the business processes such as leasing spaces to tenants (Govaart, 2021). The real estate company is managed by the same actors, such as the developer who is part of the project team. On the other hand, for an ongoing project like BlueCity, the involved actors such as the developer and architect need to be involved in the project for a much longer duration than a traditional project usually handed over for the operation/use phase right after its delivery. The phase-wise development of the project leads to the constant change in roles such as the contractor and project manager, resulting in loss of information and knowledge every time a new partner is introduced. For the architects, guarding project-based knowledge throughout the life-cycle of the building's continuous development was made possible by concentrating the decision-making influence on assigned individuals involved in the project since the beginning (Jongert, 2021).

6.5 Circular Business Model Innovation

6.5.1 Embracing a role shift by changing the key activities

The key activities undertaken by the interviewed actors point towards the differences between their existing business model and their business model for the project (see interviews with Constantijn Berning and Axel Hendricks, 2021). Actors like the dismantling contractor did not have to deviate from their core business activities because their business model is integrally aligned with the circular principles included in the EDGE Olympic.

As a result of their new brand identity, the developer organisation also became one of the existing building tenants. The building was embedded with smart sensors, enabling the developer to assess and manage the data collected from the building during its operation and maintenance stage. This enhanced the developer's basic functions beyond traditional project development because they also became a data management organisation (Berning, 2021). Traditionally limited to architectural design services, the architect also developed a digital twin in BIM for the EDGE Olympic as a part of its maintenance strategy. This required the architect to skill their employees in BIM modelling software.

To ensure that The Green House would not be demolished after its lifespan of 15 years but would be dismantled and taken back by the responsible parties, the actors did not always work in the traditional way. For instance, the floor laying that took place with second-hand bricks required the brick layers to take additional time and care in the process that required additional responsibilities. The client organisation for The Green House extended beyond the traditional role of a public organisation by ensuring that they are continuously involved in all phases (Eitjes, 2019). As a result, the project organisation did not have to rely heavily on the agreement because when there is a constant flux in the parties' composition, the collaboration must resort to contractual agreements. However, increased involvement did not translate into increased time allocation because a DBFMO (Design-Build-Finance-Maintain-Operate) procurement method ensured the delegation of the planning and execution to the project team.

In BlueCity, the founding actors (architect and developer) who are also a part of the construction team are involved in the project with more than one role. The developer of BlueCity often adopts business models which allow them to have 'skin in the game' (Govaart, 2021). They established an equity partnership in the BlueCity real estate company, which is also a tenant of the project BlueCity. By creating a client organisation, the developers could involve themselves in the project as a client/customer. This implied that the developer's involvement in the operations/use stage of the project was aligned with their business functions as a client. By ensuring a position on both the demand and supply side of the project, the developer was able to design a system where their efforts could be rewarded based on the project's success.

The architecture organisation for BlueCity follows a similar business model since they too are an equity stakeholder of the BlueCity real estate organisation, besides being the principal designers of the project. Furthermore, their practice is located within BlueCity, making them active tenants of the project. Contrary to traditional architecture and construction, the architects also had to invest effort and resources into researching the project environment for possible suppliers, material options, design alternatives and economic feasibility for BlueCity. This made space for mutual development between the design processes of the project on the supply side and the growth of the client organisations on the demand side (Jongert, 2021).

6.5.2 Innovation in products/services

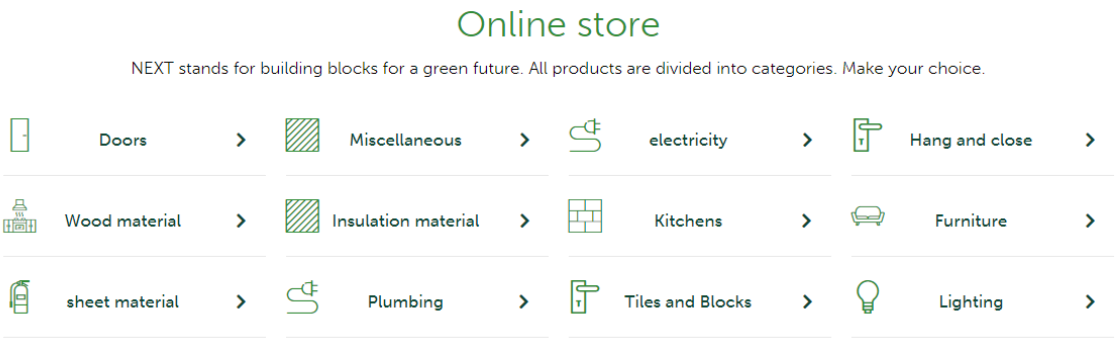


Figure 25: Online Marketplace offered by the dismantling contractor of EDGE Olympic

Implementation of circular principles often requires project-specific innovation because of how they can be applied across the different project stages. For the EDGE Olympic, innovations were carried out in either the products or processes offered by the actors. The client/developer co-founded a material passport platform called Madaster after completing the project keeping in mind the end-of-life scenario. This was in alignment with the client's new identity as a data-driven business. The dismantling contractor developed an online marketplace for re-used materials that would enable them to trade the salvaged material from the project. The introduction of such a business stream into their core business model helps them reduce material related risks and stimulates the market. The architects created a digital twin for the building so that they could streamline the process of maintenance and repairs using real-time BIM data. The EDGE Olympic led to creating an opportunity for the involved actors to innovate products and services.

Facilitating the process of innovations is as important as innovating for the public client of the Green House. The client organisation is responsible for the operation, maintenance and new construction of public buildings in the Netherlands. Thus, the most opportunity for innovation in the circular building process lies in the new construction because procedures and regulations impede the existing portfolio. The tender structure was designed innovatively, such that half the weight of the criteria was allocated to collaboration (Eitjes, 2019). This was a novel approach

compared to the traditional awarding criteria of cost, quality and time (Winch, 2009). A product-as-a-service agreement was established for the audiovisual equipment in the project with the suppliers on a pay-per-use basis. The responsibility of defects and maintenance was thus shifted from the management to the suppliers, with a take-back guarantee after its functional life at the Green House. The building is designed for disassembly all the way to the foundation so that the site of the project can be returned empty after the stipulated period of 15 years. The project innovates by re-using materials for a designed-for-disassembly project that traditionally encourages actors to use virgin materials because they are more convenient to use.

BlueCity has been a host to various project led innovations that have been carried out by the actors involved in the project. The architectural organisation was involved in knowledge and product development because the project requires additional tools that are not available yet (Jongert, 2021). However, while most of their revenues are generated from traditional design roles, the architects have developed new revenue streams such as trading materials and consulting to municipalities and other architecture firms (Jongert, 2021). In collaboration with a circular entrepreneur at BlueCity, the designers were able to develop an LCA (life cycle analysis) mapping method to compare the positive impact of traditional construction and the construction practices at BlueCity. The firm is also developing a material management solution that helps the construction teams (architect, developer, contractor, client) see the available materials and their associated financial and environmental costs transparently. This aims to improve transparency and accountability in decision-making in a highly integrated collaborative environment (Jongert, 2021). Innovations in the design and construction of BlueCity were accelerated by the project's treatmenas a laboratory where the construction team tried new techniques such as cutting concrete and turning it into bricks for walls (Jongert, 2021). With the help of a suitable supplier, the construction team could procure high-quality cooling walls and doors as a service. In this way, the supplier could benefit from fully functional materials that are cosmetically less beautiful because of wear and tear from use. Innovating traditional business models into as-a-service business models helped overcome the psychological and regulatory obstacles surrounding re-using materials.

6.6 Entrepreneurial Ecosystem

6.6.1 Taking the lead

During the different stages of project development, actors take the lead to steer the project towards the desired direction. For the EDGE Olympic, these actors were the dismantling contractor and the client/developer. The dismantling contractor was the most influential decision-maker in the deconstruction stage chronologically before the construction began. However, this does not mean that the dismantling contractor had complete autonomy in decision-making. During the deconstruction, the risk is shared by the demolition contractor and the client. Along with the client, architect, and contractor, the dismantling contractor provided high-value reuse of the materials salvaged from the existing building. The client plays a special role in the development of the EDGE Olympic because of various reasons. Firstly, in this case, the client is not just a client who commissions a building in the traditional way but is also an experienced developer and the end-user of the project. This helps the project have a clear image of the desired output throughout the different stages of development. EDGE technologies thus held a leading position from the conceptualisation to the operation of the building. It was observed that for the EDGE Olympic, the client created a network effect on the other participating actors. Convincing other individuals within the organisation and outside the organisation is necessary to accomplish the project with the given team structure. The contractor emphasises that they start conversations about circular products and processes with their existing suppliers to share additional knowledge.

A DBFMO contract was chosen for the Green House by the public client organisation, which held them in the primary position to define their ambition and create a selection criterion so that the project can be awarded to a suitable consortium. As a result, the client expressed its intention to market parties as a first step towards the co-creation of a project team. The emphasis on collaborative development was reflected in the client's pursuit for partners who are pro-active, flexible, creative, trustworthy, and synergetic, amongst other qualities (Rijksvastgoedbedrijf, 2013). Although circularity and design-for-disassembly were not integral to the outcome of the decision process, the emphasis on innovation and collaboration resulted in partnerships with parties who pushed the envelope for the project. The spider-in-the-web for this project was the

project manager who was involved since the tender phase. The project manager played an essential role as the actor who propagated the client's vision to everyone (Bosch, 2019). The project manager mediated decisions about topics such as circular strategies, suppliers for as-a-service products and spatial requirements of the building.

For the developer of BlueCity, a pilot in the form of this project helped create a sense of consciousness towards the CE within the organisation (Govaart, 2021). The project contractor saw a similar example in BlueCity by showing the rest of the organisation their learnings and mistakes from the project. The commitment to developing with circular principles is conveyed to the entire chain by the team leading the project, from the carpenters to the board of directors (Zandboer, 2021). The project was organised by a construction team from the beginning, creating a context of collaboration that facilitated mutual learning. The involvement of a large organisation as a contractor helped create a stir in the market and the value chain. As a result of the creation of demand for high-quality recycled materials, a significant player in the market took steps to start purchasing differently (Zandboer, 2021).

"The BlueCity project has generated positive reactions in the highest echelons of the company. And more importantly: for even more internal support." – (Van Hoven, 2021)

6.7 External contextual factors

The case studies identified external factors that play an influential role in the circular aspect of the project's development. These factors are specified separately in this paper because they are outside the control of the actors of the value chain. The context of the project serves as the underlying conditions for the involved actors (Winch, 2009) that are perceived as enablers or barriers based on their impact on the business opportunity.

6.7.1 Market context

Circular principles such as material re-use are highly dependent on the supply and demand dynamics of the material market. The process of disassembly of high-quality materials requires an investment of additional resources such as time, energy and money (Hendricks, 2021). However, the disassembly/material dismantling business model is subject to the market demand for the salvaged products. Since the market for re-used material is still not mature, it serves as a barrier to implementing circular construction principles. A glass atrium from the EDGE Olympic was carefully dismantled as a single component, however, the component had to be re-used in parts since finding the right match for the whole component could not be accomplished.

On the other hand, the market context also serves as an enabler of material re-use. Certain material supply chains have reached a higher level of market maturity regarding material re-use, recycling, and re-manufacturing. This has been achieved for the material flow of gypsum, which is salvaged from existing buildings and produced into a gypsum board. The shift to a circular model by the whole supply chain has increased the economic feasibility of the process, making it more desirable than the disposal of the material (Hendricks, 2021).

Market validation of innovative projects, products, or processes is also essential to stimulate the transition. Certifications and assessments are integral to the market validation process because they provide benchmarks that make the added value measurable and comparable. Financial investors increasingly prefer investing in projects associated with a high rating in certifications such as BREEAM and WELL (Berning, 2021). Thus, third party actors are involved in the project to assess the requirements of the certifications and provide accreditation, as it was observed in the EDGE Olympic.
The BCI (Building Circularity Index) tool developed by the circularity consultant for The Green House is an example of an assessment framework recognised by market parties (Van Vliet, 2021). Thus, the perceived value of such tools and certificates is linked with the market demand for certainty in the circular building processes. The existence of circularity consultants and advisors is a pattern that the market is inclined towards growth in circularity-based business cases (Berning, 2021).

"And there is demand. But it is still quite a new business. So you need entrepreneurial behaviour. It is crucial" (Berning, 2021)

6.7.2 Regulatory context

The regulatory context represents the policymakers and government bodies involved in the value chain. Hendricks (2021) believes that the government can stimulate the CE market with the help of policy instruments that can dictate the standard practices in the BE. Berning (2021) adds that the government, just like the market actors is also learning from pilots and gaining more knowledge about CE. However, policymakers have not yet capitalised on their ability to incentivise sustainable practices in the BE with the help of tax subsidies on recycled materials (Zandboer, 2021). Jongert (2021) adds that the regulatory bodies can develop standard procedure surrounding the quality and legalities of re-used materials so that more actors in the value chain can adopt circular practices in the BE.

8. Discussion

In this section, the findings of the case study analysis are discussed in relation to concepts derived from literature. The section also provides the results of the findings with respect to the challenges of implementing CE principles in construction projects and the role of EB in overcoming them. Additionally, the limitations of the methods and results are outlined.

8.1 Reviewing Current Challenges

This chapter reviews the challenges of CE discussed in chapter 3.1.4 and adds new learnings obtained from the case studies.

The challenges of implementing circular principles in the BE are identified in supporting literature (Table 8). However, the case study analysis has identified additional challenges (Table 14) that were encountered in one or more of the three CE based construction projects (Table 14). The recognition of these challenges is highly subjective since it depends on the actor who is asked; a challenge for a contractor may not hold value for a circularity consultant. Thus, in addition to challenges specified in literature, Table 14 includes challenges mentioned by the interviewed actors identified as key-decision makers for the assessed projects.

Table 14: Challenges in the selected cases (own table adapted from Hart J. , Adams, Giesekam, Tingley, & Pomponi, 2019)

	Code	Challenge
Cultural	C4	Attitude towards material value and ownership
Sectoral	S7	Lack of market mechanisms
	S8	Difficulty in scaling
	S9	Lack of continuity across project life cycle

Attitude towards material value and ownership (C6) is a challenge that results from the implementation of circular principles such as material re-use and transformation of existing buildings. There is resistance from the investing actors regarding re-used material because of the lack of confidence. In the Green House, members of the client organisation were hesitant about using re-used steel because of uncertainty surrounding the warranties. Virgin materials are thus preferred because they are supported by validated labels that are accepted as market standards. The lack of market mechanisms (S7) such as project financing, trade of re-used materials, business cases for product-as-service systems and other factors that drive the market demand for circular building projects impedes the transition. It is a sectoral challenge that is closely related to cultural challenges because it is indicative of the acceptability and adoption of new circular business models across the construction value chain. According to Hendricks (2021), the current construction industry lacks a sophisticated market for material reuse.

Explorations in circular building practices such as designing for disassembly and materiel re-use; and circular business models such as product-service-systems are limited and context-specific. Difficulty in scaling (S8) is closely associated with lack of standardisation (S2) because of the limitations provided by the re-use of materials or space. For BlueCity, craftsmanship was central to the approach of material re-use compared to modular construction techniques. This obstructed scalability because the high-quality re-use of materials is dependent on the skilled craftsmen instead of a standardized process. Lack of continuity across the project life cycle (S9) is an organisational challenge for actors to retain project-based knowledge. A ‘Silo’ approach to organising the supply-chain leads to a lack of continuity amongst the actors across the building's lifecycle (Häkkinen & Belloni, 2011). This makes it challenging to establish the ownership of material flows within the BE, which is required for a CE. The fragmentation and misalignment of the actors can also cause a disparity in the distribution of benefits of adopting CE (Adams, Osmani, Thorpe, & Thornback, 2017). Traditionally, levels of involvement are limited to the different phases in the project lifecycle depending on the role of the actors. Circular principles require knowledge about material flows to be passed on from one phase to another, thus resulting in exchange of open-source information across various actors. For projects like BlueCity that are developed in multiple phases over a long duration of time, there are high chances for actors such as contractors and suppliers to be in a state of flux.

8.2 Role of EB as an enabler

This chapter investigates how EB can contribute to overcoming the documented challenges that actors in the BE face.

The findings of the case studies elaborate on the different patterns of EB displayed by actors involved in the three projects. To investigate whether EB plays the role of an enabler of circularity, the challenges from Table 8 and Table 14 are taken into consideration. Enablers are less clearly defined than challenges because evidence that certain actions will promote principles of CE must be obtained (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019).

Table 15: Case specific challenges for CE in the BE (own table adapted from from Hart J. , Adams, Giesekam, Tingley, & Pomponi, 2019

	Code	Challenge	Cases
Cultural	C1	Lack of interest, skills/knowledge and engagement	A / B / C
	C2	Lack of collaboration between business functions	A / B / C
	C3	Risk aversion	B
	C4	Attitude towards material value and ownership	B / C
Regulatory	R1	Lack of a consistent regulatory framework	A / B / C
	R2	Obstructing laws and regulations	A / B / C
	R3	Lack of incentives for CE	A / B / C
Financial	F1	CAPEX prioritised over OPEX	-
	F2	Greater investment costs	A / C
	F3	Low prices for virgin materials	C
	F4	Limited funding	-
	F5	Unclear business case	B
Sectoral	S1	Lack of coherent vision	B
	S2	Lack of standardization	A / C
	S3	Split incentives	C
	S4	Long product lifecycles (buildings and materials)	A / B / C
	S5	Technical challenges	A / B / C

	Code	Challenge	Cases
	S6	Insufficient use or development of CE-focused design and collaboration tools, information, and metrics	A / B / C
	S7	Lack of market mechanisms	A / B / C
	S8	Difficulty in scaling	A / C
	S9	Lack of continuity across project life cycle	A / B / C

Leading the way

The lack of interest, skills or knowledge, and engagement (C1) appears within the actors' organisations and between actors for the Green House and EDGE Olympic case. Kraaijenhagen et al. (2019) mention the importance of cultivating clear visions and values to engage colleagues and partners to collaborate on the project. Although an ambition emphasises the 'why' a CE approach must be adopted, a link must be made to the organisational strategy of 'how' the ambition will be achieved (Sinek, 2009). A lack of interest was encountered in the form of friction from within the client organisation for the Green House. Besides having a clearly defined ambition about the technical cradle-to-cradle requirements, the client gave equal emphasis to the need for a collaborative development process. The conscious decision to give market parties space to develop their ambition in harmony with the client's requirements cultivated a collaborative environment between the involved actors of the project.

The literature identifies leadership as an enabler for C1 (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019) since C1 describes more than one type of cultural challenge of the same nature. Leadership is effective in overcoming the challenge (C1) since pointing out the rational aspects such as economic benefits and the role of the organisation in the current societal context are as important as conveying the emotional motivation to apply CE principles to building projects (Kraaijenhagen, van Oppen, & Bocken, 2018). The developer of BlueCity acknowledges the importance of engaging the organisation in dialogue about sustainable construction practices to spread the 'virus' across people (see interview with Govaart, 2021). The developer of EDGE Olympic further provides evidence for a link between 'circular ambition' and 'taking the lead' by stating that the organisation's ambition and belief had a convincing effect on actors such as the

contractors, who were more traditional than them (see interview with Berning, 2021). The role of an organisation's ambition in helping to create a guiding framework for partners and collaborators has been described in the literature as a metaphor for building actor networks (Smith, Stirling, & Berkhout, 2005).

"Our ambition did strengthen our ambition" - Berning, 2021

A shared ambition

The lack of collaboration between actors and their business functions (C2) is a challenge that thrives on the fragmented nature of the value-chain of the traditional construction industry. This challenge is mainly related to the nature of partnerships that are required for circular building processes. In all the three cases studied, the collaborative aspects of partnerships within the value chain were pushed forth by actors responsible for managing the development process. However, each approach was different in its way because of the type of project and the varying circular strategies that were deployed. The developer for BlueCity and EDGE Olympic, and the project manager and client for the Green House are identified as key decision-makers in managing the project's development. These interviewees indicated that their engagements with external parties depended heavily on shared visions and ambitions regarding circularity. The tendering criteria for the Green House gave half the weight to specific clauses that stated the need for a collaborative and transparent partner. The interviews also confirmed that finding the right partners who share similar ambitions is as important as having an ambition for one's own organisation. Developing a circular ambition impacts the actor's organisational mechanisms and brings changes to their core business models. As a result, the collaborative process between actors in CE becomes more accessible since the traditional actors identified in the case studies are integrating circular knowledge and resources into their organisation.

According to the literature, a coherent vision (S1) is required to guide project-specific decision-making across all levels and actors (Hart, Adams, Giesekam, Tingley, & Pomponi, 2019).

The development of a decision-making framework guided by ambition is essential for the actors to understand the risk-reward dynamic when choosing to implement circular principles in their projects or businesses.

Internalising risks

Challenges labelled C3 and C4 are closely related to the inherent risks associated with circular development practices. Literature mentions that CE implementation requires the actors to change their core business models radically, which is often perceived as exposing the business to additional risk (Masi, Day, & Godsell, 2017). The hesitancy towards sustained ownership of materials and lack of clarity about material value contribute to the risk aversion of actors in the value chain. Literature frequently references *risk-taking propensity* as a critical aspect of the entrepreneurial decision-making process (Douglas and Shephard, 1999; Keh et al., 2002; Krueger, 1993; Simon et al., 2000). The risks taken by actors in the analysed case studies played decisive roles in successfully completing the projects. To develop the EDGE Olympic, the developer risked investing more financial resources than they would in a traditional building (F2) in addition to adopting an emergent development process where few decisions regarding material re-use were taken during the construction phase (Van Noord, 2021). The perception of risk depends on the role and involvement of the actor in the project. The case study research shows that the clients take greater project-related risks than other actors.

Sharing risks

In addition to the need to take risks, the case studies prove that sharing risks is pivotal to implementing circular business models by overcoming challenges such as split incentives (S3). The deployment of product-service systems in BlueCity and The Green House ensured increased accountability from the suppliers of the products or components and reduced risks for the client or developer in a cooperative manner. Interviewed suppliers acknowledged the urgency to work along with the CE principles (van Rossem & van den Berg, 2021) and were willing to retain ownership and maintain their materials and products for an extended lifespan at risk. Shared risk models adopted by risk-taking actors play an integral role in shaping the collaborative process because they culminate in a shared success model.

Public actor participation

Regulatory and financial challenges such as R1 to R3 and F1 to F5 point towards the contextual factors (section 6.7) that are beyond the control of private actors of the studied cases. The

literature points out that actors who are not directly involved in the construction process such as government bodies, policy-makers and financial institutions, play an instrumental role in implementing regulatory and financial instruments that stimulate circular solutions to the construction process (WBCSD & Circle Economy, 2018). The Green House provides an exemplary case of a public-client organisation that plays a stimulant for the market parties to innovate collaboratively. More than 15% of all construction activities are carried out by the public organisations in the Netherlands (WBCSD & Circle Economy, 2018). Through 'leading by example', market risks can be reduced because public organisations have the resources to stimulate the transition on a larger scale than the private organisations.

Scaling through pilots

Scaling through pilots has been an effective tool for actors to overcome the recurring challenge of the lack of experience in circular business models and building processes (S5). All three projects included in the case study are pilot projects that offer the capacity to measure and capture learnings in an iterative manner. Literature identifies *learning through experimentation* an essential step in the entrepreneurial process and an enabler that leads to generation of proof-of-concepts at scale (S8). The interviews show that a collaborative experimentation is adopted by the project actors of all three case studies. The experimentational nature of projects like BlueCity leads to large incumbent organisations' participation in circular building practices to explore innovative business models and construction techniques and processes.

New routines

Organisational changes are instrumental in internalising the ambition to transition to a circular model. Literature mentions different types of methods of incorporating organisational changes to stimulate innovation such as renewal in organisational routines, structures, and systems over time. Few actors in the specified case studies adopted such changes at different times along the project life cycle. For the EDGE Olympic, the client-user organisation and demolition contractors made efforts to go beyond their traditional business models by creating smaller innovation teams to accelerate their sustainability ambition. The opportunity provided by the CE also lead to the creation of new affiliate organisations and new brand identities for the actors, thus shaping the core mission and values of the organisations internally. Guth and Ginsberg (1990) observed these strategies as signs of corporate entrepreneurship as they point towards new venture creation within existing organisations and transformation of the organisations. Although literature states that an organisation's internal environment is recognised as an antecedent of their EB, the cases provide specific information about the impact of organising the actors on challenges such as collaboration between actors (C2) and lack of coherent vision (S1). An example of innovation in organising the interaction between the actors is establishing the BlueCity real estate firm. It indicates the structural changes implemented in actor relationships to enable the management of CE-based construction projects.

Early partnerships

Based on the insights from the interviews, it is understood that there is no best way to approach the organising process. Thus the actors had to invent their own procedures over time. However, involving as many actors on the table as early as possible was observed as an effective method to secure the circular ambition early in the project. Strategic partnerships are frequently used by actors such as the public-client for The Green House so that specific knowledge can be leveraged in a collaborative manner. Strategic partnerships with actors such as dismantling experts, legal experts, and circularity consultants during the preparation phase of the projects played an important role in overcoming the technical challenges of implementation of circular principles (S5) and providing additional CE focused resources and knowledge to the project team (S6).

Capturing more value

Actors from all three cases point out the lack of a regulated market that addresses the mismatch between supply and demand of essential elements of circular construction such as re-used materials. However, actors such as the demolition contractor for EDGE Olympic and architect for BlueCity undertook efforts to create an integrated market by diversifying their business using horizontal or vertical supply-chain integration. Thus, business model innovation is identified as a key enabler in fulfilling the lack of market mechanisms (S7). The two EB patterns that are derived from business model innovation, Re-thinking roles and Innovation in products and services, differentiate the actors of CE based building projects from actors operating in the traditional industry.

Literature discusses that innovation across all components of business models (value proposition, value creation, value delivery and value capture) is an important driver for the transition of the BE to a CE. Based on the case study analysis, changing the value proposition (the what) required the actors in the value-chain must re-think their role in the construction projects (the how). Most interviewees saw themselves to be taking up a new identity which was not similar to their contemporaries in the linear economy. For example, the developer of EDGE Olympic recognised their expansion into data management due to an increased duration of involvement in the project life-cycle. Similarly, the architect of BlueCity used the term 'Dynamic final design', which points towards the fact that circularity-based construction projects do not follow the traditional rules of transferring accountability from one actor to another. The literature identifies the need for a new 'breed' of value-chain actors that break out of the silo mentality and adopt an integrated and collaborative approach in construction processes. The actors who had the most influence in steering circularity in the case studies were found to have this pattern of EB which leads to innovation in business models. It is also observed that challenges such as long product life-cycles (S4) and lack of continuity across the project life-cycle (S9) are closely related to the need for extended involvement of actors for the different layers that have varying life-cycles (Brand, 1994). Circular business models such as product-service systems that have been actively used in the studied cases, increase the need for accountability and collaboration between suppliers and project team actors such as contractors and architects. Thus, pointing out that the change in perception of roles must be adopted by actors across the whole supply chain.

Creating new value

Implementation of circular principles in construction projects required ingenuity and innovation from the involved actors across different project life-cycle phases. The case study projects were a source to few project-led innovations carried out by actors specifically for the implementation of circular principles in the project. Product innovations by actors such as the development of material passport tools, material trading platforms and integration of data systems into the construction process brough substantial change to the core service offerings of the actors. Such innovations are congruent with diversification strategies adopted by businesses since they are directly linked to the EB pattern of re-thinking roles since they augmented the traditional roles of the actors. Innovations such as development of material trading platforms are perceived as what would be traditionally labelled as investments in research and development because they fuel the circular ambition of actors by augmenting their existing business models and providing competitive advantage for future projects that implement circular principles.

The case projects also give rise to innovations that were restricted to traditional roles of the actors, such as innovative construction techniques to salvage and re-use existing materials. Such innovations were mainly technical challenges related to the actors' core competences (S5). However, it is observed that the actors who show other patterns of EB such as circular ambition, taking risk, re-thinking roles and taking the lead were more inclined towards introducing new products and services to facilitate innovations in their business models.

8.3 Operationalising Entrepreneurial Behaviour

The research shows that patterns of EB try to explain phenomena on a conceptual level, thus providing an overarching concept instead of specific actions. For example, the EB pattern '*learning through experimentation*' explains a process of feedback-based learning that can be applied on conceptual levels within the actor's organisation or the project organisation, or physical levels such as developing pilots or prototypes.
The interviewed actors from the selected case studies provide insights on two levels; the organisation level and the project level. The entrepreneurial motivations that drive the actor's involvement in building projects contributing to the CE are identified as the circular ambition. All interviewees held a common motivation to participate in the circular BE, although in varying degrees of intensity. While some actors were intrinsically impact-driven to reduce the social and environmental externalities caused by the construction industry, it is hard for the research to identify underlying reasons that would drive that motivation. Organisations may also show varying patterns of EB depending on the level they are analysed on. Since the case study research was carried out on a project level, the organisations are analysed with the project as a context for their entrepreneurial performance.

The research also finds that the actors who have a high influence on decision-making in one or more phases of the project showed more patterns of EB than the actors who had more passive roles. In the studied cases, it is observed that the actors who are involved in the conceptualisation of the project before the initiation phase often steer the decision-making across the project. However, the research also discovers the importance of entrepreneurial market actors such as material suppliers and investors who are not an integral part of the project team. The successful implementation of CE principles such as circular business models and material re-use were facilitated by the support of actors such as suppliers and investors who shared the vision of the initiators of the project. Thus, the cases indicate no correlation between the EB of actors and their position in the project organisation.

The EDGE Olympic, BlueCity and The Green House have different clients: a private owner-developer-user, a private user, and a public owner. It is observed that the clients of all three projects are influential in the decision-making process in different ways due to the nature of the organisation. Despite the limitations offered through the public tendering procedure the public client who has the most influential role before the tender is awarded to the market parties, the client retained active involvement in the project's development. The interviews with the clients and literature (Kraaijenhagen, van Oppen, & Bocken, 2018) highlight the need for active participation in the construction processes because the client's ambition plays an integral part in creating a shared ambition for the project with the right partners.

"you want to know, right from the start, what your ambition is because, in the end, you get a better project" – Berning (2021)

Table 16: Enabling patterns

Enabling EB Pattern	Challenges to implementation of CE
Circular Ambition	C1, C2
Learning from experimentation	S5, S8, S2
Taking risks	C3, C4, S3
Innovation in organisation	C2, S1, S6
Re-thinking roles	S4, S9
Business model innovation	S7
Taking the lead	C1

Based on the case study analysis, the research identifies the role of EB in serving as enablers to the challenges of transitioning to a CE. Table 16 represents the patterns of EB that the case actors displayed to overcome the corresponding challenges in the projects. Furthermore, the enabling patterns are based on their presence in one or more of the analysed cases by one or more actors across the project life-cycle. The results observed that most enabling patterns correspond with more than one identified challenge because of the challenges' thin differences and highly interdependent nature.

This research identifies seven patterns of EB as a common finding between the literature research and the case studies. Since the context of the entrepreneurship literature is mostly general and not connected to CE practices in the BE, this research establishes the connection by understanding the application of entrepreneurship theory by actors in the BE. Sinek's (2009) golden circle is used as a guiding tool to illustrate the role EB can play for an organisation by answering the three leading questions 'why', 'how' and 'what'. Figure 26 represents the methodical approach that was used to develop a matrix that compiles the results of the research in Figure 27. The matrix aims to provide a complete overview of the role played by EB in the selected cases.

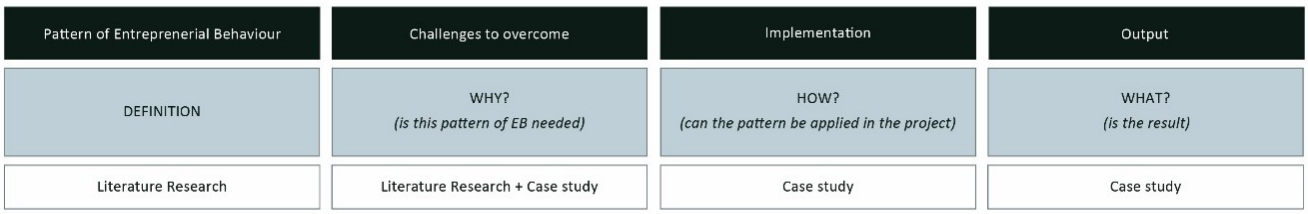


Figure 26: Method for Matrix development

As a first step, the matrix recognises, classifies, and defines the seven types of EB that are extracted from the analytical framework (Figure 13). The classification of the patterns is based on their relation to the conceptual levels that are identified by Delmar (1996) in Figure 11. Thus, the matrix provides insight on how EB is not one-dimensional in the way it should be incorporated into an organisation. Literature research provides several definitions that are identified for every pattern of EB, however the definition that is most relevant to circular practices in the BE is selected for the matrix. These definitions are subject to interpretation and change due to the qualitative and context specific nature of entrepreneurship research.

Second, the matrix provides the answer to the 'why' (Figure 26)by addressing the importance of EB in actors who are part of the value chain. Chapter 8.2 provides insight on how decision-

making actors in the case projects deployed one or more patterns of EB to overcome the respective challenges (C1 to S9) that are specific to the BE's transition to a CE. Overcoming the challenges improves the project's outcome by facilitating the actors to achieve their personal and collective ambitions, and evidence from the case study analysis illustrates the enabling role played by EB.

The third component of the matrix highlights the learnings from the case studies in terms of 'how' the entrepreneurial actors operationalised patterns of EB during the project development process. The concept of EB is a process (Reynolds, Carter, & Gartner, 2009) with multiple approaches to implementation that depend on the actor and context of the project. The learnings included in the matrix are based on the case-specific decisions made by entrepreneurial actors across the value chain.

The final component of the matrix highlights the outcome of applying the patterns on EB in the development process. The outcome is indicative of the result that an actor may expect when a challenge stated in the second component of the matrix is overcome. The outcomes detailed in the matrix are some of the many possible outcomes that can be mapped based on variables such as the context, timeline, and actors of the project.

7 *Patterns of Entrepreneurial behaviour*

	What is it?	Why is it needed?	How can it be done?	Output
Circular Ambition	Developing an ambition to improve the environmental, social and economic impact of building processes	• To guide decision-making on all levels • To establish an identity in circular development • Attract partners with similar ambition Build coalitions	• Defining the ambition • Communicating the ambition across the whole organization + external parties • Deciding between long term ambition and short term gains	Securing ideals of circularity and sustainability within the organisation and its environment
Experiment & Learn	Utilising the Build-measure-learn loop to build a sustainable business as an outcome of smaller controlled experiments	• To develop new knowledge • To deliver proof of concepts • To reduce risks	• Taking up smaller projects • Living labs for research and development • Invest in pilots	Creation of specific-knowledge and leverage
Take Risks	The propensity to bear the additional risk and tolerate ambiguity poed by uncertainties in the CE	• Circular construction process includes more uncertainties than planned construction • To deliver proof of concepts	• Partnering with risk-taking actors • Shared risk business models	Internalising externalities (Kraaijenhagen et al., 2018)
Org. Innovation	Changes that are brought about within the organisational environment due to the nature of circular construction projects	• To internalise the process shift from traditional building to circular building • To improve problem-solving capacity • To facilitate innovative ideas	• Creating a team with diverse skill sets/expertise • Managing project based involvement • Developing strategic partnerships	Boosting market readiness
Take the lead	Playing a central role in pushing circular ambition across the value chain	• To develop awareness, interest and urgency in coalition actors	• Involving partners as early as possible • Aligning the interests of the varying actors • Developing relationships based on transparency and collaboration	Project governance
Role Shift	To look beyond the traditional role of the developer and integrate other supply chain functions into the role	• Increase accountability across the project lifecycle • Align incentives across the long lifecycle	• Diversification in key activities • Develop long lasting relationships • Extend responsibility into operation and end of life phases	Increasing skin in the game
Innovation in Business Models	Innovating the product/service delivery leading creation of new and undiscovered value	• To view circularity as a business opportunity • To stimulate the market mechanisms • To deliver a feasible business case	• Widening the core competencies • Collaboration based business models • Diversification into new products and services	Business models that add economic, environmental and social value

Figure 27: 7 Patterns of EB: the why, how, and what matrix

8.4 Implications and limitations of the research

This research contributes to the academic field by proposing a theoretical framework for understanding EB in the context of the BE (Figure 13). It also addresses the need for EB in practice by developing a matrix (Figure 27) that enables actors in the value chain to implement the research results in CE- based construction practices.

8.4.1 Theoretical Implications

The research aims to open new doors for future investigations that address entrepreneurship in the BE as an effective tool to stimulate the CE transition. The EB approach adopted by this research is one of the various possible methods applied for a study of this nature. Thus far, no research has been conducted that links the need for EB in the BE concerning the transition to a CE. CE studies that focus on the technical aspects are in abundance compared to investigations on the social and economic impact on the BE. Similarly, concepts of entrepreneurship have been studied extensively in general management studies compared to the BE. Thus, this research finds its gap in the two areas where BE-related studies lag behind other disciples. Since both areas of the social aspect of CE and EB aspect of entrepreneurship are relatively new, finding concepts that connect the two subjects was challenging.

Thus, this study contributes to research by proposing a theoretical framework (Figure 13) that helps analyse patterns of EB in value chain actors of the construction industry. The framework is developed using a methodology that extracts information from two different concepts (EB and CE), which have been studied extensively in isolation. Thus, there is an opportunity to sharpen the theoretical enquiry by exploring other ways of understanding the influence of one concept on another. This research assumes EB as the independent variable which causes an impact in the transition to CE. During the course of the study, it was reflected that a reverse enquiry about the

impact of CE on EB (or other concepts relating to entrepreneurship) could greatly benefit the purpose of finding a correlation between the two concepts.

The analytical framework helped structure the research by providing structure to the scattered concepts of EB. Delmar's (1996) model had the qualities of being open-ended and definitive at the same time, which helped streamline the course of the research. Thus the theoretical framework proposed in this research builds on Delmar's (1996) model.

8.4.2 Practical Implications

The research increases awareness about the fundamental need for behavioural change in the value chain actors as a first step towards the transition to a CE. It provides a fresh perspective on how actors in the BE can overcome the CE challenges by evaluating the way their business or organisation operates on the individual, ecosystem and business level. The research also uses exemplary cases to show that existing actors use EB to overcome project-specific challenges.
The matrix that describes the seven patterns of EB (Figure 27) helps the practising actors develop a methodology to ask the right questions about their organisation's role and contributions to the CE. In addition, it provides clues in the form of recognised patterns of EB so that the actors can use the matrix as a facilitating tool to organise their business processes.
The matrix has been developed and validated with the help of the developer of the studied case, BlueCity. The frequent consultation provided additional credibility to the practical use of EB concepts in managing organisations and interactions in the CE.

8.5 Limitations

8.5.1 Theoretical Limitations

EB can be regarded as an enabler to the transition by reviewing the challenges faced by actors. However, one of the main limitations resulting from the research's qualitative and empirical nature is that there is no method to prove the effectiveness of EB alone compared to other enablers operating at the same time. Thus, providing weight to the importance of EB and its

effectiveness is not possible and the research can only suggest with contextual evidence that EB facilitates the transition to CE. The feasibility of this research limited the theoretical investigation of concepts surrounding EB. This study mentions that entrepreneurship literature is heavily based on the perspective and context of the investigation. Thus, the EB patterns that have been identified are heavily based on factors such as (i) access to information, (ii) focus on EB literature compared to other entrepreneurial concepts such as entrepreneurial orientation or intention and (iii) limited time.

It is also observed that the literary sources of EB patterns are compiled across different periods and contexts (starting in 1960). The main reason for this was that recent literature about EB also refers to the dated sources, thus indicating the validity and relevance of the concepts in contemporary times. Comparatively, CE literature is new and focused on new societal, economic and technological developments.

8.5.2 Methodological Limitations

The empirical research methodology was carried out with the help of case study research. The cases were selected based on selection criteria that ensured that the circular ambition was achieved in the end. All three cases can be considered as successful translations of ambitions into projects. Thus there is a chance that the cases provide a biased understanding of EB because of a lack of a control case. The effectiveness of EB could be addressed strongly if a case was selected where the decision-making actors did not show EB and it negatively affected the project. However, during the selection of the cases, there was no opportunity to address this limitation because the information about the actors was not known beforehand.

Evidence of EB as an enabler to the transition is provided in relation to the challenges that are documented in the literature and experienced in the case projects. However, the challenges stated in Table 14 are highly interrelated and open to interpretation. Similarly, the research proves that EB patterns are also interdependent because they complement and influence each other. Thus, developing a rational method that assigns specific challenges to patterns of EB (Table 16) resulted from the researchers understanding and interpretation based on the knowledge attained in the course of the study.

Since interviews were the primary source of data collection, the quality of data differed from actor to actor. Some interviews did not reveal new information because of reasons like (i) interviewing the wrong person of interests in the organisation, (ii) interviewees were involved in the project, thus they did not have information about the functioning of the organisation on an individual level, and (iii) some interviewees were not willing to share trade secrets. This created an imbalance in the quality of information.

9. Conclusion

This research investigates prevailing theoretical concepts from literature and subsequently analyses three innovative cases that implement principles of CE to answer the main research question:

"How does entrepreneurial behaviour in the value-chain actors of the built-environment contribute to its transition to a circular economy?"

The research shows that Entrepreneurial Behaviour in the value-chain actors of the built environment can contribute to the transition to a circular economy. A new generation of value-chain actors who are; driven by a strong ambition to reduce the environmental and social externalities caused by the construction industry; adopting trial-and-error based learning in their practice; willing to take risks; innovating in their internal processes and business models; leading the change within and between organisations are needed to stimulate the transition to a circular economy.

Four sub-questions are formulated to support the investigation of the main research question. The sub-questions are also related to specific methods that are applied in the research: the development of a conceptual framework based on a literature research and survey, a case study analysis, and the development of a framework to synthesise the learnings for practical use.
The first sub-question that plays a central role in the discovery of the theoretical concepts about CE and EB is:

1. *How is entrepreneurial behaviour identified in the circular economy?*

This research supports the finding that entrepreneurial behaviour does not have an absolute definition, however the model of entrepreneurial behaviour by Delmar (1996) is used to describe it as a multi-level phenomenon. The conceptual levels of the organisational, environment and business performance are interlinked with one another. Firstly, with the help of a literature research and expert survey, this research concludes that entrepreneurial behaviour can be

identified into specific patterns such as creating an ambition, taking risks, learning through experimentation, innovating the organisational mechanisms, business model innovations, and leadership. The second conclusion is drawn in the form of an analytical framework (Figure 28) that classifies the identified patterns based on Delmar's model for entrepreneurial behaviour. The conducted expert survey validates the applicability of the analytical framework in circular practices in the built environment.

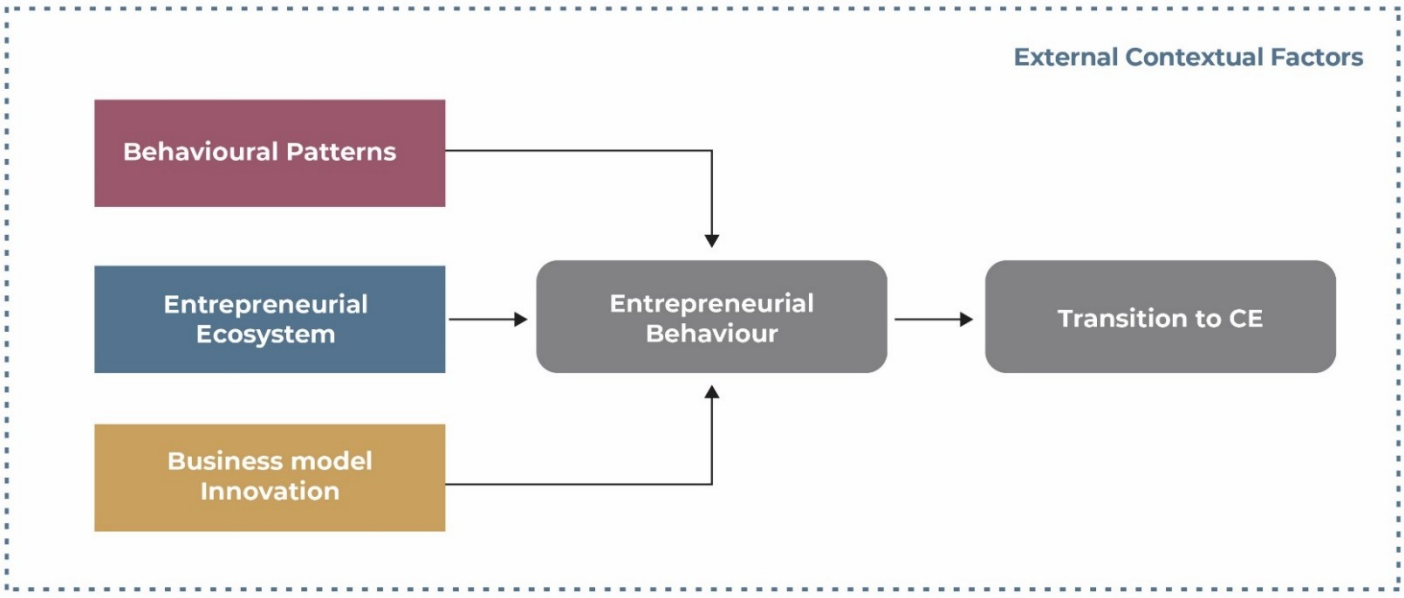


Figure 28: Analytical framework

2. *How are patterns of entrepreneurial behaviour deployed in circular building projects?*

The implementation of circular principles in the building process is a continuous process where value-chain actors contribute to the circular ambition during different project life-cycle phases. This research concludes that actors show general patterns of entrepreneurial behaviour on one or more conceptual levels (organisational, environment, business performance).

On an organisational level, the behavioural pattern of *developing an ambition* is a first step towards participating in circular building practices. Developing an ambition aimed at circularity is observed as a first step towards developing a team with a shared vision. The circular ambition of the actors plays a vital role in the initiation phase of the project because it sets the foundation for collaborative partnerships. The research discovers that adopting an entrepreneurial pattern such as *developing an ambition* is not possible without the supplementary implementation of other patterns at the same time. Making organisational changes, taking additional risks, or adopting a new business model are some methods to strengthen the circular ambition of the actors. Thus, proving Delmar's (1996) theory that entrepreneurial behaviour is a multi-level phenomenon where patterns of entrepreneurial behaviour can not be isolated from each other.

Learning through experimentation or *learning by doing* is an entrepreneurial pattern prevalent across different project life cycles. Actors adopt the development of pilot projects and new business models or get involved in existing building projects that implement circular principles as organizational learning methods. The research stresses the need for *learning by doing* as an effective way of advancing knowledge around the circular economy in the built environment.

The research observes *Organisational change* as an entrepreneurial pattern in actors on both the organisational and project levels. Actors undergo organizational changes such as developing a new brand identity, a new organisation, or innovation-based teams within their organisation dedicated to the circular ambition. Actors also develop strategic partnerships with expert actors and organisations to increase their competence in areas that require specific knowledge about circularity. On a project level, consultations with specialists such as demolition contractors or material suppliers are held in open and continuous dialogue as early as the initiation phase.

The research concludes that *risk-sharing* models improve collaboration and alignment of objectives between actors. *Risk-sharing* between actors on a project level results from *risk-taking* at an organisational level since actors willing to take risks in their capacity contribute towards attaining common goals like material take-back systems, high-quality material-reuse, and product-service systems.

Taking the lead was identified as a pattern that was shown by the decision making actors of the case projects to ensure that the circular ambition is accomplished. Leadership often uses other patterns of EB to deliver proof of concepts or strategise the execution of circular building processes. For example, innovation in public tendering with contracts focused on collaborative performance instead of those that emphasise technical specifications, was crucial in leading the circular dialogue in one of the cases. However, this decision was the outcome of taking the lead since it formed the foundation of the project coalition.

Business model innovation aimed at creating financial, social, and economic value based on the principles of circular economy is an enabler for circular construction practices. The innovation process starts with evaluating the value-proposition of the actor in comparison with the circular ambition. Exploring new business models such as product-service systems, take-back systems, material sharing platforms, material passports and technology-enabled real estate requires actors to diversify and increase their stakes and accountability in the project. For example, suppliers that regularly limit their role to the project's construction phase expand their involvement into the operations, maintenance, and disassembly phase due to their prolonged stake in the project.

Diversification of the traditional role results in *innovation in products and services* where actors must develop or deploy new products or services to meet the needs of the new value propositions. These innovations help the actors integrate with horizontal or vertical business processes and provide the actor more control over the circular value-chain.

3. *Which actors show patterns of entrepreneurial behaviour in the circular building process?*

This study corroborates that actors of different disciplines show patterns of entrepreneurial behaviour in the project life-cycle. Actors who showed entrepreneurial behaviour are found to have more involvement in the project life-cycle than traditional counterparts. Thus, actors with a business motivation aligned with circularity-related concepts such as material lifespan extension, sustained ownership models, material take-back models, and material re-use are more

entrepreneurial than actors whose core business model is not affiliated with circular principles in the built environment. It is also found that actors who play a steering role in the decision-making in one or more phases of the project life-cycle display more patterns of entrepreneurial behaviour than actors who are not involved in steering the project towards its ambition.

Furthermore, this research concludes that the entrepreneurial behaviour of entrepreneurial actors depends on value-chain partners who share the same qualities, have a similar vision, are driven by similar motivations, are not averse to uncertainties, and have an open mindset. The general goal of involved actors should align with the ambition of the project.

4. *What is the contribution of entrepreneurial behaviour in the selected circular cases for the built environment?*

The research concludes that entrepreneurial behaviour contributed to overcoming the challenges faced by the analysed circular cases. By *developing a circular ambition, the actors could* guide decision-making on an organisational level and the project level. The influence of the ambition on decision-making ranges from reducing paper use for office purposes to choosing to transform a building with re-used materials. A contracting procedure that emphasises a *circular ambition* also contributed to selecting partners with collective goals.

Learning through experimentation using the build-measure-learn feedback cycle helped the actors reduce uncertainties posed by the circular economy due to the lack of knowledge surrounding it. Actors, both new and incumbent, use this entrepreneurial pattern to learn the tropes of circular construction processes. While treating pilot projects as controlled experiments reduces uncertainties and creates new knowledge, actors need to take additional risks to conduct the experiments. Although actors encounter these risks in terms of additional investment of time and resources, they help overcome cultural barriers like attitude towards ownership of materials by providing proofs-of-concept in collaboration with other risk-taking actors. *Organisational changes* implemented by actors help them develop an innovation based approach within their organisation and the project development process. Strategic partnerships help organisations

improve their competence regarding questions about circular economy. Innovation in the project organising process introduces an emphasis on elements that facilitate collaboration across the value-chain.
The research concludes that patterns such as *leadership* are essential in gaining commitment to circular ambitions by finding sponsorship internally and externally. Actors overcome a lack of interest and engagement towards circular economy activities by creating a collective awareness of the circular economy's potential in the built environment. The research observes that the leading actors have can use their ambitions to influence partner actors in the value chain.

Concerning the main research question:

"How does entrepreneurial behaviour in the value-chain actors of the built-environment contribute to its transition to a circular economy?"

This research concludes that value-chain actors of the built-environment should demonstrate entrepreneurial behaviour to stimulate the transition to the circular economy. In order to develop projects that are aligned with circular principles, patterns of entrepreneurial behaviour should be adopted by multiple value-chain actors on a systemic level. The study emphasises that the patterns must be implemented on multiple, if not all, conceptual levels of the individual organisation, the project environment, and the business model. The patterns are closely related and influence each other; thus, they cannot be implemented independently.
The research provides an actor-oriented perspective while maintaining a focus on the overall transition. Thus, implying that the transition as a whole depends on the actions of individual actors of the value chain and their interactions with each other in the development process. Through the case studies it was observed that entrepreneurial behaviour is identified as the characteristic of an actor but its impact is seen on all three levels of the actor's organisation, ecosystem and the business. This basis can be applied to specific actors such as public or governmental organisations which have high amount of influence on the transition due to their regulatory powers. In this research, it is observed that actors have high levels of interdependency to execute circular principles. For example, the case study findings point out the external factors

that make up the environment of the entrepreneurs or entrepreneurial actors. It is found that the actors of the value-chain are highly dependent on these external factors since they form the regulatory and market context. Thus, the restrictive behaviour of one actor can hinder the entrepreneurial ambitions of another. This research concludes that to enable the paradigm shift, actors across the value-chain of the construction industry including policy makers must apply patterns of entrepreneurial behaviour in their own capacities and methods. While concrete solutions can be customised from project to project, the approach determined by entrepreneurial patterns can stimulate the transition to a circular economy.

In conclusion, the research identifies entrepreneurial behaviour as an enabler in the transition to the circular economy, however, it is one of the many possible approaches that value-chain actors can adopt to overcome cultural, technical, and sector-specific challenges. The research contributes to existing knowledge in the disciplines of circular economy in the built environment and entrepreneurship by demonstrating how entrepreneurial actors are better equipped to steer the transition because of behavioural patterns that differentiate them from traditional actors.

10.Recommendations

10.1 Recommendations for further research

Further research in the domain of entrepreneurship and CE can be conducted to investigate unexplored concepts and overcome the limitations of this research. The research refers to the circular strategies that can be applied in the BE in chapter 3.1.2, however the link between EB and specific CE strategies such as designing for disassembly, material re-use, sharing platforms, etc. could not be established. This research focuses more on the relationship between the actor organization and the implementation of the CE principles. A more specific approach to understanding the implication of EB on circular strategies could help to provide a more detailed perspective on the role of EB in enabling the transition. Thus, a possible research question could be, 'What is the role of EB in implementing product service systems in building projects?' or 'What is the role of EB in implementing design for disassembly in building projects?' . Research that builds on the EB model of Delmar (1996) and the analytical model proposed in this study can better understand EB patterns such as ambition. risk taking, leadership, organisational change, experimentation and business model innovation. The research questions could look something like this: '*Why do actors in circular construction value chains need to take risks?'* or '*How can organisational changes help value-chain actors implement circular ambitions?'*.

10.2 Recommendations for practice

This research aims to unearth the values of entrepreneurship that have been adopted by organisations that have steered disruptions and innovations. The learnings from this research can be used in real-life scenarios by actor organisations involved in circular building practices or want to make an entry in the circular BE as a value chain actor. To overcome the challenges that actor organisations face in practice, actors in practice can use the '7 patterns of Entrepreneurial Behaviour' matrix (Figure 28) to design strategies systematically.

Actors in practice can adopt a step-by-step process (Figure 29) to apply the matrix in their organisations:

1. The first step that the actors must take is to identify the challenge that they are facing in practice. These challenges could be similar to the challenges specified in Table 9 or specific to the project context.
2. The identified challenge defines the need for an enabler. Thus, as a next step the actor can refer to the prescribed matrix to check whether the challenge has been identified in the column labelled ‘why is it needed?’.
3. The next step is to identify the corresponding pattern of EB and its definition. This step helps the actor to determine which conceptual level requires a change. The patterns of EB are segregated based on the level of operation. Thus if an individual level pattern is identified, the actor can recognise that the needed change must be implemented on the internal values or functioning of the organisation. A business-level change would mean that the actor must re-evaluate their business model regarding their value proposition and value creation aspects. If the change identified must be implemented on the entrepreneurial ecosystem level, then the actor must re-evaluate their interactions and role within the value chain.
4. After identifying the pattern and the level that the change must be implemented on, the next step is to look at possible methods to implement the required change. The column ‘How can it be done?’ prescribes methods based on the learnings of the case studies. Thus, actors can refer to seek inspiration about how patterns of EB can be deployed using actionable strategies. However, the matrix contents are not exhaustive as they propose few of the endless ways in which organisations can adopt patterns of EB.
5. Once the actor identifies a suitable strategy in the ‘how can it be done?’ column, the next step helps them evaluate the outcome of the whole process. The outcome is the result of all the choices made from step 1 to step 4 of the matrix. Identifying and outlining the outcome helps the actor to compare it with their initial ambitions. For example, if the outcome of the process is ‘creation of specific knowledge’, the actor can ask whether the initial problem of ‘lack of knowledge’ is addressed.

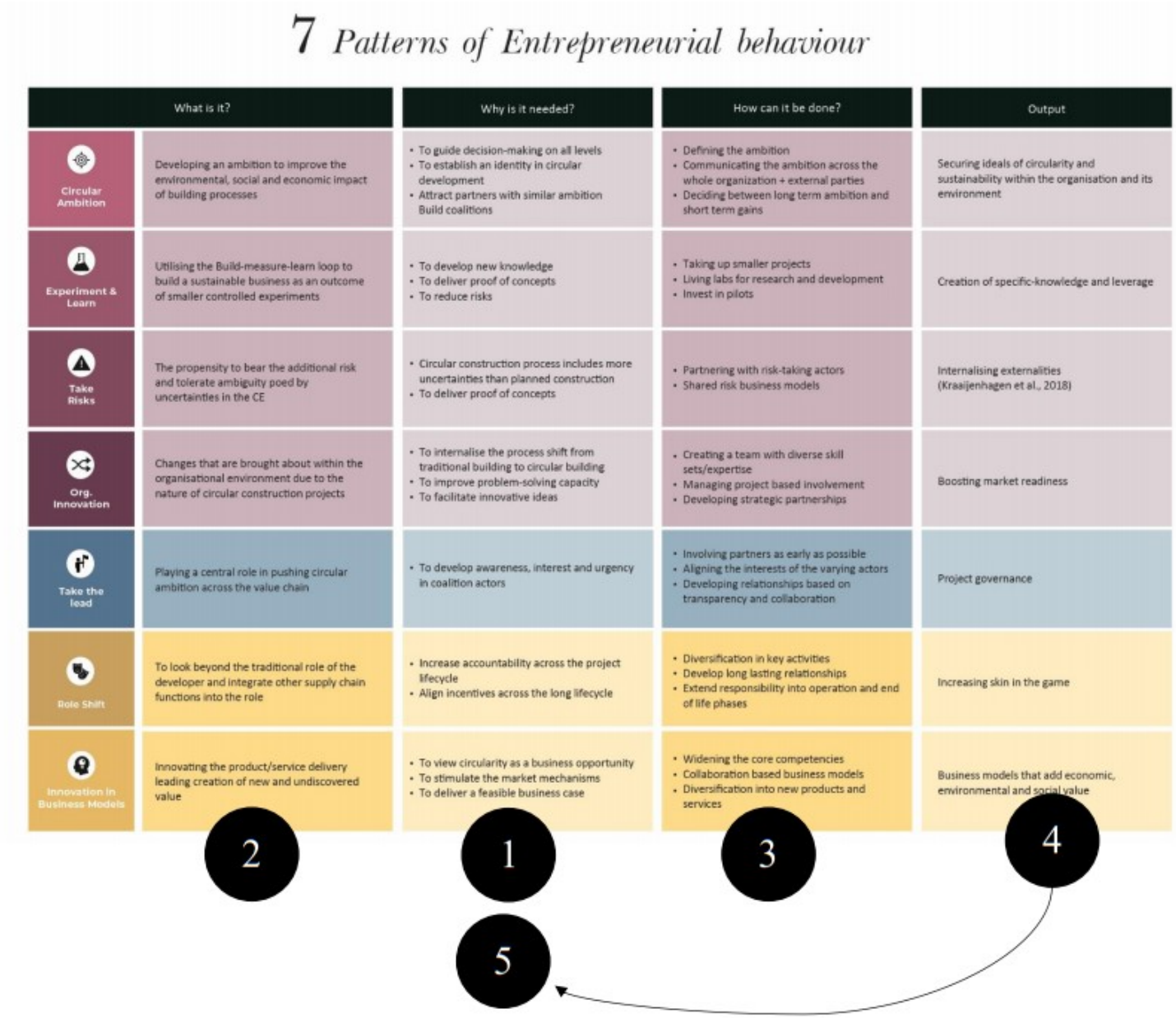


Figure 29: Using the matrix

11.Reflection

Developing research that identifies the qualitative ingredients of entrepreneurship and explores the application or demand for such behaviour in CE practices of the construction industry is an iterative and exploratory process. The research revealed that when actors steered CE principles in building projects, EB pervaded most organisational decisions, processes, and interactions. The interviews showed that the actors who showed patterns of EB had common qualities, visions and perceptions of the future of their organisation and the BE. However, there are different ways in which EB is deployed and perceived by the actors. In the approach adopted by this research, EB is understood and identified by evaluating the actions and the underlying motivations of the actors. Thus, understanding how an actor organisation operates in independence and within the context of the project was essential.

The research also points out that there are numerous ways actors have deployed EB to pursue their circular ambitions, and this research only identifies out a few of them. Since the BE is a project-based industry where every project provides new challenges and contexts, it is challenging for the research to make a generalised suggestion that the patterns of EB have universal application. However, patterns of EB were identified across the case studies, although they were from different contexts and periods in time. The qualitative concept of EB enables the research to categorise various sets of organisational process and actions within patterns using modeling tools such as the conceptual levels observed by Delmar (1996). This increases the applicability of the research in practice because the prescribed patterns of EB (circular ambition, risk-taking, experimentation, leadership, organisational changes, business model innovation) can be interpreted based on the actor organisations existing status and the project’s context.

Since the CE is inherently different from the linear economic model, most management and entrepreneurship theories developed on the linear line of thinking need to be re-evaluated. This research provides a starting ground for further enquiry into topics that link organisational behaviour to their performance in the CE. Organisations must adopt behavioural change because projects that implement CE require a shift at the value chain's grassroots level. The research

unravels the emergent behaviour of project value chains by observing that when actors act entrepreneurially by showing patterns of EB on their own, they create an impact on other actors and create an innovation-driven environment.

Actors in circular focused building projects often reach roadblocks where the challenges are out of their sphere of influence. For example, if a change in policy impacts the downstream actors' implementation of material reuse, the actors on the site of the project are subject to external contextual challenges. Their entrepreneurial behaviour may not induce a direct impact on that challenge due to the structure of the ecosystem. However, when the challenge is more local and within the sphere of the influence of the actors, they can utilise the *7 patterns of entrepreneurial behaviour* matrix to not only find solutions but also diagnose the problems. Disagreements or conflicts between actors can be traced back to patterns of entrepreneurial behaviour based on the logic that if a circular strategy is successful due to the presence of entrepreneurial behaviour of one or more actors, it may fail due to the lack thereof. Thus, the lack of risk taking of an actor, or lack of circular ambition, or a narrow role mindset can be diagnosed as the problem. Finding the problem is often as important as finding the solution, and using the lens that looks at actor actions through entrepreneurial patterns can help the coalition actors identify the challenges.

This research uses the 'why, how and what' framework to simplify complex concepts into achievable steps for actors in practice and integrates it into the matrix (Figure 27). However, the matrix is based on the learnings of the three case studies, thus the contents of the matrix are contextual and take place in space and time. Actors in the cases adopted different approaches or processes in order to solve challenges. While the matrix provides a strategic structure to identifying a challenge and overcoming it, the process of implementing it is assumed to be unique to the actors. Thus, if the matrix is to be used as a guiding tool by actors to define their actions and strategies, the addition of an empty 'process' column can not only help organisations ideate their entrepreneurial patters but also plan a tangible process that can be applied given the organisations internal circumstances.

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Appendix A – Survey Questionnaire

BECOMING ENTREPRENEURIAL:

A STRATEGY FOR A CIRCULAR BUILT ENVIRONMENT

A research by Akshit S Parmar (Management in the Built Environment, TU Delft)
Supervised by: Prof. Hans Wamelink & Prof. Catherine De Wolf

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1. Please enter the following details before we proceed

(a) Full Name : _____

(b) Email Address : _____

2. What is the name of your organisation?

_____

3. Which of these options best describes your role in the built environment?

- ☐ Client
- ☐ Architect
- ☐ Designer
- ☐ Contractor
- ☐ Sub-contractor

- ☐ Demolition contractorInvestor
- ☐ Financier
- ☐ Circularity consultant
- ☐ Project manager
- ☐ Supplier
- ☐ Manufacturer
- ☐ Services consultant
- ☐ Dismantling expert
- ☐ Reclamation expert
- ☐ Urban producer
- ☐ Academician
- ☐ Other (Please specify) _____

4. Have you been directly involved in a circular building project?

A circular building project is a project in the built environment that follows the main principles of the circular economy in its design and construction phase:
Increase productivity of materials by doing the same or more with less
Eliminating waste by defining materials as either technical or biological nutrients enabling them to be within closed material loops
Thinking in systems by studying the flows of materials and energy

- ☐ Yes
- ☐ No (Please specify your connection to the circular building project) _____

5. How important is it to have a clear CIRCULAR AMBITION in the start of the project? **(Select one option)**

1	2	3	4	5
○	○	○	○	○
Not Important				Extremely important

6. Does working in circular project add more risk compared to a traditional project of the same type/scale?

Risk: A situation that threatens a company's ability to achieve its goals (Select one option)

1	2	3	4	5
○	○	○	○	○
There is no added risk				It is highly risky

7. How necessary is it to innovate the traditional building technology for circular construction methods? (Select one option)

1	2	3	4	5
○	○	○	○	○
Not necessary				Extremely necessary

8. How important is
'learning through experimentation' when it comes to the designing and construction of a c
ircular building? (Select one option)

1	2	3	4	5
○	○	○	○	○
It can be omitted				Pilots are a must

9. To what extent
does the access to social capital impact the process of circular construction?

Social capital can be described as the process by which social actors create and mobilize their network connections within and between organizations to gain access to other social actors' resources. (Select one option)

1	2	3	4	5
○	○	○	○	○
Minimal Impact				Highly Influential

10. How important
is it to make changes to the organisational mechanisms to accomplish a circular project?

A few examples of organisational mechanisms are:
More autonomy to employees
Rewards and reinforcements
Creation of new teams within the organisation
(Select one option)

1	2	3	4	5
○	○	○	○	○
Not important at all				Very important

11. Does your organisation take a LEADING role for making important decisions for the circular project? **(Select one option)**

1	2	3	4	5
○	○	○	○	○
Don't need to				Always have to

12. How important is it for your company to make profits in the circular project? (Select one option)

1	2	3	4	5
○	○	○	○	○
Don't need to				Always have to

13. How easy is it to find an opportunity to work in a circular building project? (Select one option)

1	2	3	4	5
○	○	○	○	○

The opportunity presents itself	One must actively search for opportunity

14. To what extent should the core business model be transformed to adapt to a circular building project?

Some components of the business model are:
Revenue streams
Cost structures
Key partners
Key activities
Target customers
(Select one option)

1	2	3	4	5
○	○	○	○	○
Change is not needed				Change is needed across the whole model

15. Please add a comment about your experience in the circular building process, and how it can be made possible by polishing any of the above prompts

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Appendix B – Interview Protocol

1. Entrepreneurial Behaviour indicators:
    a. Circular Ambition
        i. What was your main motivation to do this project?
        ii. Did your role in this project align with your role outside of this project?
        iii. Does your company have a circular ambition?
        iv. If yes, What are the steps that your company took to push your circular ambition?

2. Innovation in product/service technology?
    a. What is your main role in the project?
    b. Do you think your role changed before the project and after the project?
    c. If yes, how?
    d. Did this project require you to change your original activities?
    e. How did this change occur?
    f. Were there any internal changes that had to be made in the organisation as a result of the change?
    g. What was done differently in this project by you which can contribute to the existing knowledge about circular construction?
    h. What would u do differently
    i. Did you have to invest in RnD or innovate in your core activities for this project or was it an easy job for you?
3. Experimentation
    a. Was this project your first circular undertaking?
    b. If yes, was it treated as a pilot project for your organisation?
    c. How do you stay updated with the latest technologies in your sector?
4. Access to social capital

    a. Did you already have a personal or professional relationship with any other actor in the project?
    b. If yes, was the involvement a result of a referral?
    c. If no, refer to question e(i)
    d. How do you acquire your customers?
    e. How are you able to scale the business?
    f. Have you gotten more projects after your work at the Edge Olympic?
    g. Did you share learnings or problems via educational institutions/ professional relationships/personal network?
5. Leadership
    a. (Internal) Who took the lead in this circular project and how was it conveyed to the organisation?
    b. (External) Did you find yourself in the position where you had to take the lead in decision-making?
    c. If yes, how often?
6. Risk-taking
    a. What were some of the biggest risks in this project for you?
    b. And what was your plan to respond to that risk?
    c. Flexibility in contract
    d. Why were you willing to operate in an uncertain environment?
7. Opportunity identification
    a. How did you come to be the designer/contractor/manager for the project?
    b. OR how did you decide to build this project?
    c. How did you identify this project as a business opportunity?
    d. What do you look for in a project before accepting it or bidding for it?
8. Circular business model Innovation
    a. What are some new business models that are needed in the circular dismantling industry? (harvest values instead of residual values?)
    b. Do circular projects require a change in the revenue model of your business?
    c. If yes, which models were adopted?
    d. Policy does it help?

e. MPG - mejor prestatie gebouw
f. Do circular projects require additional costs for you? Do you pass them on to the clients?

9. Entrepreneurial ecosystem
    a. What efforts were made by you to integrate better with partners in the supply chain?
    b. How would you describe your relationships with the other actors of the project's supply-chain?
10. Innovation in organisational mechanisms
    a. Did your circular activities require you to make changes to your organisation?
    b. If yes, what changes were made?
    c. Are there partners you can't work without?
11. Challenges
    a. What were the biggest challenges that you faced in this project?
    b. How did you overcome it?
    c. Experiences
    d. What did you learn in this circular project which is of great value for your future projects?
    e. How does your organisation feed project based learning back into the organisation?
12. End
    a. Would you call your organisation entrepreneurial?
    b. What would be your advice to a company that wants to do circular projects?