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CIRCULAR ECONOMY IN THE CONSTRUCTION INDUSTRY:

BARRIERS AND DRIVERS FOR THE IMPLEMENTATION OF CIRCULARITY IN FAMILY-OWNED CONSTRUCTION COMPANIES IN GERMANY

Master of Science, Sustainable Entrepreneurship

Sustainable Entrepreneurship Project
Word count: 8396 words

June 4th, 2023

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Abstract

Increasing pressures and constraints on the environment and society give rise to the necessity of a regenerative system represented by the circular economy. To transition to the circular economy, companies must implement circularity in their business models. This circular business model innovation process is complex and influenced by several barriers and drivers that can be grouped into socio-cultural, technological, economic, institutional, and external implementation factors. This research conducts a qualitative case study via semi-structured interviews to investigate these factors in the context of the construction industry and family ownership in Germany, as the construction industry is one of the most constraining industries and family-owned companies are considered particularly capable to engage in complex processes like circular business model innovation. The findings resonate with the implementation factors identified in the literature. Yet, the context of the construction industry and family ownership influence the dynamics of the implementation factors causing new factors to arise and some factors to be more or less relevant than suggested by the literature. Accordingly, the interaction between the factors and the process of circular business model innovation seems to be different in the context of the construction industry and family ownership.

Keywords

Circular economy, construction industry, barriers, drivers, implementation factors, business model, circular business model innovation

List of Abbreviations

BM	Business Model
BMI	Business Model Innovation
CBM	Circular Business Model
CBMI	Circular Business Model Innovation
CE	Circular Economy
CI	Construction Industry
EU	European Union
R&D	Research and Development

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INTRODUCTION

In the face of finite resources, overconsumption and ever-increasing constraints on the environment and societies, the need for a new, regenerative economic system becomes increasingly prominent. The circular economy (CE), in contrast to the linear economic model, is designed to be restorative and regenerative aiming at sustainable development by closing resource and consumption flows (1–10). Thereby, it allows for a growing economy within planetary boundaries (11). The concept of the CE has been gaining increasing attention among scholars and practitioners in the past years (1–3,5,6), despite not being a recently emerging concept (7,8). Germany, for instance, already introduced the CE into national law with the Closed Substance Cycle and Waste Management Act in 1994 (12). However, the transition toward the CE is slow. The construction industry (CI), one of the ecologically most constraining industries (8,10,13–15) with great potential to operate in a circular system (8,9), still operates linearly (7,10). In the European Union (EU), the CI "accounts for about 50% of all extracted material" and generates over 35% of waste (11). In Germany, the CI is responsible for more than half of the generated waste (10), making it the biggest waste-polluting industry. Accordingly, the CI illustrates the need for a new, regenerative economic system. Hence, it is worth investigating the CE in the context of the CI to identify barriers and drivers for implementing circularity.

Policies and action plans are set in place on the EU and German national levels to incentivise and accelerate the transition to the CE in the CI (11,16,17). The EU introduced a CE action plan within the EU Green Deal in which the CI is targeted (11). Further, the German Sustainable Building Council sets several incentives for constructing houses that adhere to circularity principles (16). Moreover, a large share of the anthropogenic material stocks, i.e., resources designated as waste yet suitable for reuse and recycling, "can be located in the built environment" (18), exemplifying the potential of the CI for the CE in Germany. Arguably,

Germany presents promising preconditions to scale up the CE in the CI. Yet, there appears to be a lack of knowledge and strategies to accelerate the transition to a CE in this industry (19). Scholars argue that a bottom-up approach is necessary to successfully transition toward the CE (1,4,6,7,20). For instance, Franco (7) argues that a transition in companies is the prerequisite for a transition on the industrial level, suggesting the need for a bottom-up approach. Moreover, Long (20) explains that contextual factors are insufficient to drive a successful transition toward sustainability, further suggesting a bottom-up approach. As the CE aims for sustainable development, this observation can arguably be applied to transitions toward circularity. Hence, to accelerate this transition, the micro level, i.e., companies, consumers, and products (1), play a crucial role. Nevertheless, literature on the implementation of the CE at this level is scarce (1,4,7,9,21,22). As business models (BMs) are named as crucial enablers for the transition to the CE on the micro level (6,22,23), it is relevant to investigate barriers and drivers for circular business model innovation (CBMI).

CBMI is necessary to implement circularity at the core of the BM (24), as this process strategically and purposefully combines economic and circular benefits (20). Thus, CBMI is the process by which BMs become enablers for CE implementation. Scholars argue that family-owned companies have stronger abilities to engage in CBMI (25,26). Accordingly, it is particularly interesting to look at family-owned companies in this context. As most companies in the CI in Germany are family-owned (27,28), one could assume high receptivity to innovations for circularity, thus, enabling the implementation of the CE. Nevertheless, reality shows that the CE implementation is progressing slowly (29). Further, despite the beneficial attributes of family-owned companies, little research has been conducted that links family business with the CE (26). Arguably, it is interesting to investigate the following research question:

What are the barriers and drivers for family-owned construction companies in Germany to implement circularity in their business model?

To answer the research question, this research conducts a qualitative case study in the form of semi-structured interviews with a family-owned, German construction company specialising in single-family houses. To analyse the data, a comprehensive theoretical approach was adopted based on the relevant literature. This research finds that most barriers and drivers for CBMI on the micro level can be confirmed in the context of the CI and family ownership. Nevertheless, some barriers and drivers do not apply to the CI due to the complexity of buildings in relation to the CE. The aspect of family ownership presents as both a driver and a barrier for CBMI. Further, macro- and meso-level barriers and drivers seem to play a more relevant role in CBMI than anticipated based on the literature.

This research first establishes the theoretical approach by analysing the relevant literature and situating itself in the academic debate surrounding the research problem. Second, the methodology is explained in detail. Third, the findings are presented and discussed. Lastly, the implications of this research, as well as limitations and venues for further research are outlined.

THEORY

The theory is divided into several sub-sections to allow for a systematic analysis of the relevant literature. First, scholarly accounts on the concept of the CE are reviewed to adopt a suitable and scientifically sound definition of the concept. Second, the understanding of the CE in the CI is defined. Lastly, the literature on CBMI, the influence of family ownership on CBMI, and barriers and drivers for CBMI is reviewed to establish the theoretical framework.

Circular Economy

The CE is a debated concept lacking a common definition (1–3,5–7,9). Nevertheless, scholarly accounts of the CE exemplify overlapping characteristics attributed to the concept. The CE is commonly understood as a closed-loop economy with the intention of being regenerative and restorative (1–7,9,10). Further, the CE creates an economic system that integrates economic benefits with environmental and social benefits (1,2,4,7). While the social dimension is debated (1,4–7,30), scholars widely agree that the CE ensures the availability of resources to present and future generations to allow for the fulfilment of every generation's needs (1,3–5,8). Arguably, successful implementation of the CE entails a systemic shift or optimisation (1,4). The requirement of a systemic change implies that the CE operates on different levels (1,7–9), namely "the micro level (products, companies, consumers), meso level (eco-industrial parks), and macro level (city, region, nation and beyond)" (1: p. 229). While Franco (7) argues that the CE is best implemented via a bottom-up approach, Górecki et al. (9) argue the opposite. Scholarly support, however, can predominantly be found for the former argument, despite the lack of substantive research on the implementation of CE at the micro level (1,4,6,7).

For this research, a definition close to that of Kirchherr et al. (1,23) is adopted including all aspects of the CE discussed above. Under this definition, the CE is understood as a closed-loop economic system operating at the micro, meso, and macro levels and aiming at sustainable development creating intergenerational equity, as well as economic, environmental, and social benefits. The most powerful enablers for the CE can be found on the micro level.

Circular Economy in the Construction Industry

Research on the CE in the CI is predominantly focused on the flow of resources. The CI poses one of the largest pressures on natural resources (8,10,14,15,17,19). To decrease these

ecological constraints, scholars emphasise the benefit of transitioning to the CE (8,14,19). Nevertheless, many scholars question the feasibility of such a transition and point to the difficulties and complexity of transitioning the CI to the CE considering that the CE finds little practice in the CI (5,8,10,13–15,19). According to Antwi-Afari et al. (5), only 9% of the global anthropogenic stock is recycled in the CI. Dräger et al. (10) state that in the EU only around half of the construction and demolition waste is recycled and that in Germany the CE is still at the beginning. Comparing these findings with statistical data, the EU and Germany seem to perform better. According to Eurostat (31), the statistical office of the EU, 89% of construction and demolition waste was recovered EU-wide in 2020 and 94% in Germany in the same year. Notwithstanding, only a small portion of the recovered material is recycled or reused (32,33). Accordingly, many scholars argue that the material flow is still highly linear (5,8,10,18).

In the context of the CI, the CE is understood as closing, slowing, and narrowing resource loops to minimise the use of energy and raw materials, and the generation of waste, leading to reduced costs, fewer constraints on the environment, and the availability of resources across generations (5,8,14,19,22). Closing resource loops means that the resources of a used product form the basis for a new production cycle of a similar or different product and is associated with reusing, remanufacturing, and recycling resources (5,8,34–37). Slowing resource loops is understood as a prolonged lifecycle of products and their resources and is associated with repairing and maintaining products (5,8,34–37). Narrowing resource loops describes the reduced use of resources and is associated with the reduction and optimisation of resource consumption, aiming at resource efficiency (8,34–37).

A CE transition is challenging in the CI. Buildings have an average life cycle of at least 50 to 90 years causing them to not fit into the classic CE paradigm of products that typically have a much shorter lifespan (8,14,15). Further, buildings are often designed and constructed to be permanent, leaving little to no room for flexibility in terms of usage change or lifetime extension (14,15). Moreover, buildings consist of numerous products, each with different

lifecycles, increasing the complexity of buildings (8,15). Arguably, buildings are highly complex in relation to the CE as different lifecycles of a building's components presuppose different resource flows and loops, making the implementation of the CE challenging for the CI.

Barriers and Drivers for Circular Business Model Innovation

To enable a circular transition, scholars argue for the central role of CBMs (5,7,22–24). In order to introduce circularity at the core of construction companies' BMs, CBMI is necessary (24,34,36,38). Accordingly, CBMI is crucial to facilitate a transition to the CE.

Circular Business Model Innovation is commonly defined as a radical innovation process aligning a company's value proposition and approach for value creation, delivery, and capture with the CE paradigm (22,24,34,36–39). Hence, CBMI changes a company's BM and thereby its strategy for doing business and competing in the market (22,30,34,37–40). Nevertheless, CBMI is complex, challenging, and uncertain in terms of outcome making it a difficult process for companies to accomplish (24,34,37,38). In line with sustainable development and a flourishing economy that the CE aims at, as well as the understanding of the CE in the CI, CBMI aims at creating CBMs that narrow, slow, and close resource loops (24,34–38,40). CBMI requires an iterative process of experimentation to test suitable approaches for a company in a given context. Moreover, collaboration with key stakeholders is important to navigate the uncertainty around the innovation process (34,36–38). CBMI is a continuous innovation and learning process which involves the rethinking of a company's dominant paradigm that defines the value proposition, company-internal structures and culture, as well as structures in the supply chain and the relation to key stakeholders (22,26,36,38–41). Arguably, CBMI is highly subjective given the company and context.

The influence of family ownership on CBMI is debated in the literature as the conduciveness of this influence depends on the attributes of family companies (e.g., 24,25,40–42). Family companies are largely considered to be drivers for sustainable development due to their long-term vision, low hierarchies, and their concerns for the continuity and success of the firm, present and later generations' prosperity, and their ties to their key stakeholders (25,26,41–43). Yet, some scholars argue that family ownership can also negatively impact sustainable development (e.g., 40,41) and thus CBMI. For instance, while Bergfeld and Weber (25) stress that family companies view continuous innovation as a tool for improving their strategies and performance enabling them to conduct radical innovations as necessary for CBMI, Breton-Miller and Miller (42) underline that family companies tend to be rather traditional and, thus, reluctant to innovate their strategies and practices. Nevertheless, one must acknowledge that a family company's willingness and ability to innovate largely depend on the embeddedness of the family in the company, its leadership structures, and values (25,26,41–43), as well as other barriers and drivers associated with CBMI.

Barriers and drivers identified in the literature can be categorised into socio-cultural, technological, economic, institutional, and external barriers and drivers which affect CE implementation on every level at which the CE operates (22,23,29,35–38,40,44–50). While these barriers and drivers are interdependent and present on every level, they are understood differently on each level (23,29). Yet, most barriers and drivers are linked to company structures and culture (29,44) on the micro level which aligns with the centrality of CBMs and CBMI in the transition toward the CE. Therefore, this research focuses on socio-cultural, technological, and economic barriers and drivers specific to CBMI on the micro-level. These categories can be further divided into subcategories. Socio-cultural barriers and drivers comprise the company culture, company structure, value chain collaboration, and consumer awareness and interest (22,23,29,36,37,44–50). Technological barriers and drivers include the subcategories of

innovation and technologies, skills and knowledge, product design, and the availability and quality of circular resources (22,23,29,36,45–50). Economic barriers and drivers consist of the economic viability of CBMs and the allocation of exclusive resources for CBMI (23,29,36,44–50) (Appendix A). While the research on CBMI and respective barriers and drivers is extensive and dominated by consensus, Kirchherr et al. (23) identify the lack of sector-specific research on barriers and drivers for CE implementation and Bilal et al. (50) suggest further research on CI-specific barriers and drivers for CBMI. Accordingly, this research adds to the literature by investigating CI-specific barriers and drivers for CBMI. To this end, the theoretical framework illustrated in Appendix B is adopted in this research.

METHOD

Research Design

This research is abductive in nature as it is based on a defined theoretical framework while "allowing for observational surprises" (22: p.169). It analyses the data accounting for both existing theoretical contributions and emerging aspects in the data to ultimately enrich the chosen framework. As this research aims to gain specific insights into barriers and drivers for CBMI in the context of the CI and family ownership, a qualitative case study approach was chosen. While this approach allows for the attainment of data with limited generalisability, it enables an in-depth investigation of the research topic through the specific case which is suitable when deeper knowledge of underlying processes is sought (52–54). Moreover, qualitative case studies enable investigations of complex phenomena lacking a common understanding (52,55). The CE proves to be a complex concept lacking a common definition despite increasing interest in the CE in academia and practice (1,2). Furthermore, the CE in the CI has primarily been investigated either under quantitative research approaches criticised for questionable assumptions and simplifications (21) or in the form of systematic, large-scale

literature reviews (e.g., 5,8,13,15,17,19) giving rise to the necessity of qualitative, case-study research in this field. Accordingly, a qualitative case study design is appropriate for this research.

Case Description and Selection

The case company is a German, family-owned construction company as defined by the European Commission (56). It was founded in 1954 and is in its third generation of family ownership. The company specialises in single-family houses and was selected because it is committed to sustainability efforts including social and ecological sustainability. Further, it showcases engagement in research and development (R&D) for future fit technologies (Company Website). The latest example of the company's commitment to sustainability and R&D is the project "SmartCity" which entails the construction of a climate-neutral ecovillage and the development of sustainable technologies for house construction (Company Website) which include principles from the CE like the recycling of resources (Company Website; 1,5,29–31). Moreover, the case company attended the 26th UN Climate Conference in Glasgow to present the project (Company COP 26 Report; Company Website). Accordingly, it can be expected that the case company is receptive to discussing micro-level drivers and barriers for CBMI, making it a suitable case for this research.

Data Collection

The data was gathered via semi-structured interviews which allow for a standardised interview conduction as the pre-defined interview guide creates practicality and coherence. Further, semi-structured interviews provide flexibility for adapting the questions during the conduction of interviews if unforeseen, yet valuable, aspects emerge (57). The interview guide (Appendix C) was organised according to the themes of the theoretical framework (Appendix

A). Considering the research topic, it was necessary to account for social desirability biases. The topic guide and the flexibility of semi-structured interviews helped minimise these biases as leading questions could be avoided, and critical questions could be reformulated.

Ten interviews were conducted to ensure data saturation. The interviews had a duration of approximately 60 minutes (Appendix D) and were conducted between the 26th of April and the 10th of May 2023 in a face-to-face setting ensuring consistency in the interviewing process and minimising situational biases. One interview was conducted via Microsoft Teams due to the distant working locations of the researcher and the interviewee. The interviews were recorded, and the audio files were stored until the interviews were transcribed to enable proper data analysis.

The interviewees were selected via purposive sampling to ensure the selection of an information-rich sample (58). This sampling method allowed for the alignment of the research sample and the research aim, benefiting the trustworthiness and rigour of the research (59). This research interviewed senior managers in different departments of the company as they have more leverage on the organisational governance structures and, thus, on the implementation of circularity in the company (44,60–62). Additionally, to gain insights into the integration of circularity within the company, employees outside the senior management were interviewed (Appendix D). The interviews were conducted in German to prevent language barriers and literacy bias. Further, definitions of key concepts were provided before the interviews to ensure a profound understanding of the research topic.

Data Analysis

The data was analysed in a two-step approach. First, the interviews were transcribed (Appendix E) with the transcription tool in Microsoft Word to increase time efficiency considering the limited timeframe of this research. Second, the interview transcripts were coded

abductively via open, axial, and selective coding (Appendix F). The coding process was assisted by the computer software *ATLAS.ti* as it allows for efficient and coherent coding across multiple interviews. Where suitable, secondary data in the form of policy documents, reports, and statistics on circularity in the CI in the EU and Germany were used to contextualise the data. Thereby, the findings were placed within the nested context of CE implementation which increases the validity, credibility, and reliability of the findings (63).

Ethical Considerations

As this research involved the participation of humans, the research was conducted in line with the RUG guide for ethical research. Interviewee informed consent was obtained via a consent form including information on the topic and purpose of the research (Appendix G). To ensure confidentiality, the collected data was anonymised. Regarding data storage, the audio files were deleted after transcription and the transcripts were stored in a Google Drive folder only accessible to those in possession of the access link. This link is provided in Appendix E and is, thus, only available to the assessors of this research paper.

RESULTS AND DISCUSSION

The data shows that the barriers and drivers for CBMI present as a two-sided coin, meaning that depending on their dynamics or interpretation, they function as either barriers or drivers for CBMI. This ambiguity can be linked to the complexity linked to CBMI (24,38) and the changing interpretations within the case company across different departments. Therefore, they are generally referred to as implementation factors in this chapter. Overall, while resonating with the literature, the findings show that in the context of the CI and family ownership, certain dynamics of the factors change, giving rise to new factors while making others irrelevant. The refined theoretical model is illustrated in Appendix H.

Implementation Factors

Family ownership impacts the process of CBMI in several ways. While it is not a significant determinant of whether the CE finds its way onto the company's agenda (I1, I9), it impacts the company's ability to engage in CBMI (I1, I2, I5-I7). Several interviewees reported that the family component creates benefits in terms of company structure as the hierarchies are flatter, enabling faster decision-making and implementation processes (I4-I8). Moreover, confirming the literature (25,26,41–43), the family component creates intergenerational awareness "*since the company has to reposition itself…over the generations*" (I4) which requires system thinking and sensemaking to ensure business success across the generations (I4, I5, I7, I8, I10). This effect is beneficial for CBMI, as it allows the company to be more dynamic and flexible in adapting to changing environments, a crucial characteristic for successful CBMI according to Pieroni et al. (24). Further, the family component represents a point of identification for employees (I4-I10), making interactions less anonymous (I10) and creating a strong company culture of togetherness (I9). One interviewee described it as "*you are a bit infected with this [company] virus...So it's really strong, this feeling of togetherness and how people stand behind this company*" (I9). Arguably, this characteristic creates a shared vision enabling the diffusion of values and goals. Accordingly, this point of identification positively impacts CBMI and sets employees up to be "*multipliers*" (I8) spreading awareness on the matter to key stakeholders and beyond. Hence, family ownership can also translate into a driving force beyond the micro level.

Nevertheless, family ownership can be a barrier to CBMI due to a certain degree of conservatism and traditionalism (42); I6, I10). One interviewee expressed that "*innovation is difficult sometimes in a company that has done things the way it has done it for 69 years*" (I6). While this argument also holds for non-family companies (62,64), another interviewee criticised "*the company being family-owned is a barrier, as certain dogmas that are carried within the company were cradled [into the next generation of owners]*" (I10). Thus, family

ownership can function as a significant driver for CBMI due to the company structure and culture it creates, and a barrier due to traditions that are carried on. Hence, the findings confirm the literature on family ownership and innovation. Yet, family ownership per se does not guarantee that CE implementation is a central aspiration the company pursues as "*it could as well be put on the agenda by a managerial board*" (I9). Accordingly, it is rather the company leadership that determines the engagement in CBMI while the family component creates a beneficial company structure and culture that can ease the CBMI process.

Considering that family-owned companies represent the dominant company type in Germany (28), the aspect of family ownership should be added to the implementation factors for CBMI. As family ownership influences the company culture and structure, it can be included in the wider grouping of socio-cultural implementation factors.

Socio-cultural factors include the company culture and structure, collaboration, and customer demand and interest. Leadership, education and training, and resistance were mentioned as the most influential on the **company culture**. Some interviewees expressed that enabling CBMI is a responsibility of **leadership** (I3, I5, I8), as it "*is a topic that must be lead and kept track of*" (I3). To this end, proactive leadership is necessary as it creates a shared vision and culture (22,46,48). Hence, like family ownership, proactive leadership provides a point of identification for employees that enhances the commitment to CBMI within the company (I2, I3, I5, I6, I8). Thereby, uncertainty is reduced and **resistance** among the employees can be circumvented (I5, I8). The data indicates that the biggest barrier to a conducive company culture for CBMI is "*the people, no one likes new things…change is perceived as bad because it triggers fear*" (I10). This observation is in line with Doppelt (62) who argues that resistance to change is triggered by fear. Accordingly, leadership plays a crucial role in overcoming the barrier of resistance and risk aversion. Nevertheless, leadership can only

be a driver for CBMI if it is proactive. If it is itself resistant and risk-averse, it fosters a resistant culture, constituting a barrier to CBMI (29,36,44–47,49).

Education and training emerged as a stronger factor from the data than from the literature. Scholars argue that education and training are important to develop the ability to put theoretical knowledge of the CE into practice. Conversely, if there is a lack of education and training on the matter, companies are unlikely to implement CE practices (44,46,48,50). While this research finds that "*education…is an incredibly important factor to drive the topic [CBMI]*" (I1) and put theory into practice (I2-I4, I8), the data also shows that education and training have the purpose of creating a conducive company culture across generations (I4, I5, I8). The case company "*intends to introduce young employees to the topic to make them ambassadors for the topic as they are likely to stay in the company for a long time*" (I5). Thus, education and training for circularity are important to create a company culture that motivates employees to collectively work toward a CE transition in the long run (I1-I5, I8), an aspect that did not arise from the literature. Yet, it rather impacts CBMI indirectly by enabling a conducive company culture and the acquisition of suitable skills.

The company culture is also influenced by the **company structure**. According to the literature, the CBMI process is optimally supported when circular values are streamlined throughout the company (22,36,44–48,64). This argument cannot be entirely confirmed by the data. In the case company, certain departments are exclusively tasked to engage with the topic of circularity (I1, I3, I4, I6-I8, I10), suggesting that the company structure is characterised by silos rather than diffusion. These departments "*simply dictate what is to be built*" (I7) leaving the operative departments "*little leeway*" (I9) which is beneficial for the radical implementation of sustainability-related changes in the product design (I7-I9). Notwithstanding, silos create cultural differences due to a lack of company-internal collaboration, challenging the implementation process (29,44,47,48). This barrier is enhanced by company-internal resistance (I5, I7, I8). Similarly, CBMI is hampered when circular values are not streamlined in the

strategy and mission (23,36,44–46,48,49). This barrier applies to the case company. Although it is developing a holistic sustainability strategy (I1, I4, I10), the current strategy focuses "*on the product, not on the company*" (I10). According to Kuckertz et al. (65), this narrowly defined strategy limits the company's value creation compared to a holistic strategy that would be regenerative by nature and thus suitable for CE implementation. Consequently, this research finds that the company structure is a driving factor for CBMI under two conditions. First, the company adopts a holistic strategy. Second, the CE vision and mission are diffused throughout the company to enhance collaboration and ease the implementation of changes during the CBMI process.

Collaboration is widely perceived as a driver for CBMI by scholars (22,39,48–50). While the case company engages in open innovation, it also pursues a strategy of exclusivity (I1-I10). Collaboration and open innovation are beneficial for CE implementation as they increase the pool of ideas for innovation and enable knowledge transfer enriching the expertise of all parties involved which creates a "*win-win situation*" (I9). Accordingly, the company's capabilities for CBMI are enhanced, making collaboration a driver for CBMI. In the collaboration process, a transition beyond the micro level can be initiated, benefitting a wide-ranging CE implementation on all levels. One interviewee explained that "*the ultimate goal is to develop products that can be used in several branches of the industry as it would generate a greater impact*" (I1). Accordingly, the findings confirm the literature (22,36,46–48). Competition-wise, however, collaboration is often viewed as unbeneficial (23,29,36,45,47,48,50), which is confirmed by some interviewees (I4, I9). One interviewee explained that the exclusivity strategy is increasingly reduced "*as it is A too expensive, and B a very slow process to enhance sustainable development as this approach has way too little impact*" (I4). Accordingly, transitioning toward the CE "*is nothing that can be done alone*" (I2). Consequently, collaboration only becomes a factor influencing CBMI if the company perceives

collaboration as a beneficial process for innovation and knowledge development. Hence, if present, collaboration can only interfere as a driving force.

Further, **customers** significantly influence the implementation of circularity (23,31,46–52; I1-I10). The demand and interest of customers determine what kind of product is viable on the market, as without demand the company cannot sustain itself (29,46–48). Hence, customer demands influence how a company creates, delivers, and captures value and consequently the CBMI process, as the products are designed "*to appeal to and deliver on [customer demands]*" (I2). According to Tura et al. (47), it is crucial to understand customer demands to successfully adapt the product, an aspect that was also mentioned by several interviewees (I2-I4, I6). Based on the data, this research finds that the dominant customer interests are the affordable construction of a single-family house (I4-I7, I9, I10) which is linked to interest in funding (I4, I6, I8, I9), and sustainability (I1, I2, I4-I10). However, the demand for sustainability is dependent upon the affordability of sustainable house construction given the naturally high price point of house construction (I1, I4, I6, I8). Accordingly, customer decisions are dominated by trade-offs that often do not favour sustainable or circular construction, as it is more expensive (23,45). To make circular construction more affordable, funding plays a crucial role. This factor is further explained in the section on economic factors. Although the findings confirm customer demand and interest as a positive and negative implementation factor, the data shows that it is not uncertainty about customer demands constituting a barrier to CBMI as suggested by several scholars (23,31,46–52). Instead, financial considerations influence whether customers demand circularity. Hence, this factor only plays out as a driver if circular products are financially more attractive than linear products, which is not yet the case. Thus, it is more likely that customer demand and interest will present as a barrier to CBMI until the CE transition progresses.

Technological factors comprise innovation and technologies, product design, the availability and quality of resources, and skills and knowledge. Innovation and technologies as

well as skills and knowledge are factors that can be confirmed by the data. For product design, the findings indicate different dynamics of the factor in the context of the CI compared to that in the literature. Further, the factor of availability and quality of circular resources cannot be fully confirmed by the data.

The **skills and knowledge** to recognise CE opportunities and produce circular products determine a company's ability to engage in CBMI (22,23,29,36,45–48,50). One interviewee explained that in the case of new circular resources, employees report that "*[they] do not know how to work with them*" (I7) which influences the ability to implement circular product designs. To overcome this barrier, the company "*provides education and training*" (I2) to familiarise the employees with the resources. Scholars argue that previous sustainability practices and continuous innovation and experimentation can help mitigate this barrier as they provide experience (29,36,46–48). This argument can be confirmed by the data (I1-I10). Through the process of **innovation and experimentation** the company "*knows what can and cannot be implemented and why…providing the learning effects*" (I2) that are needed to acquire the skills and knowledge to implement circular product designs (I1-I10). Moreover, innovation and experimentation are necessary to develop and improve circular technologies to make them more attractive and viable for the market (29,36,46–48). Often circular technologies are criticised for not yet being proven to work effectively for the mass market (23,29,36,48,50). This concern was also expressed by several interviewees (I1, I4, I6-I8, I10), as "*the technologies…are still in the early stages of development*" (I4), oftentimes making it more attractive to work with conventional technologies. Accordingly, this research finds that the lack of proven technologies for circularity constitutes a barrier for CBMI as already suggested in the literature (23,29,36,48,50). This barrier, however, only refers to available technologies in the market. It does not necessarily constitute a barrier to a company's ability to develop adequate technologies itself or engage in CBMI. The data shows that innovation and experimentation are the company's primary activities taking up "*80% of its time*" (I10) to develop and improve

technologies until "*they can be introduced to the market*" (I6) to "*incorporate them into the product*" (I4). Hence, the company aims to improve its product design for circularity, showcasing engagement in CBMI as changing the product design influences how a company creates and delivers value (35,38,39). These findings confirm the centrality of continuous innovation and experimentation to CBMI (34,36–38) which are therefore considered important drivers (29,36,46–48).

Depending on whether the **product design** is circular or linear, it functions as a driver (22,29,36) or barrier (23,29,45,49) to CBMI. In the context of the CI, differentiating between linear and circular product designs is more difficult. Buildings have a longer lifecycle than typical products the CE paradigm applies to (8,14,15). This design for durability illustrates one aspect of circular product designs, namely attention to slowing resource loops (5,8,34–37). The data confirms that designing products for slowing is inherent to the CI (I1-I6, I7, I9), as "*a house stands for at least 50, 60, 100 years*" (I9). Arguably, circularity to some extent is naturally included in the product design creating a conducive basis for CBMI. Nevertheless, scholars argue that it is complex to design buildings fully circularly considering that they consist of numerous components that have different lifecycles (8,15). While the data confirms that the case company "*combines many components in its product*" (I4), it also shows that by applying criteria to the resource acquisition, the problem raised in the literature (8,15) can be mitigated (I1, I3-I5, I8, I9). The case company, for instance, assesses the lifecycle of every component used for the house to ensure that "*no resources are used that are not suitable for the lifecycle of a house*" (I5). Thereby, a house has a lifecycle of "*80 to 100 years…without requiring components to be renewed and disposed of*" (I5). Accordingly, the application of criteria to the resource acquisition and the naturally long lifecycle of buildings enable circular product design, subsequently functioning as drivers for CBMI.

Nevertheless, the design of the product is dependent on the **availability and perceived quality of these resources** (29,45,47,49). This can be confirmed by the data (I1-I4, I8-I10).

One interviewee explained that the product design and the extent to which the company can implement circularity are "*influenced by the kind of resources that is supplied*" (I1). Further, virgin materials "*are more dimensionally stable, they are cleaned, they are abundant, they are easy to work with, they are cheaper*" (I1), suggesting that the quality of new resources is perceived as better compared to circular resources. Therefore, in line with the literature (29,45,47,49), this research finds that an unreliable supply of circular resources paired with their perceived lower quality constitutes a barrier to implementing circularity. Scholars argue that this barrier can be overcome when virgin materials become scarce (29,47,48). Based on the data, however, virgin materials "*are abundant*" (I1), indicating that this driver does not hold for the CI. A driver that emerged from the data is the rethinking of resource loops (I3, I4, I9, I10). One interviewee argued that "*if you think about the recyclable materials, which are quite valuable…then you wouldn't go there with an excavator, you would invest in an automated system to recycle these materials*" (I10). Considering that Germany has a rich anthropogenic stock (18), circular resources can be reliably supplied after a rethinking of resource loops. Consequently, this rethinking could function as a driver for CBMI.

Economic factors encompass the economic viability of a CBM, the exclusive allocation of resources, and governmental funding. While the factors of economic viability and exclusive allocation of resources are widely present in the literature, funding emerged as a new factor from the data.

Within the factor of economic viability, **high up-front costs** present the biggest economic barrier to CBMI (I1, I3-I10). High up-front costs relate to the higher price point of sustainable and circular resources compared to linear ones and the lack of short-term returns (23,29,36,44,45,47–50). Accordingly, they constrain the economic viability of a CBM in the short run, as "*even a minimal increase in the prices would make it economically unviable for the company*" (I1) to sell a house. Consequently, the high up-front costs are linked to the barrier

of cannibalization. Unlike in the literature, where cannibalization is conceptualised as the fear of making the BM unviable due to slowing resource and consumption loops (48), the data revealed the high up-front costs to threaten the survival of a CBM. This difference can be explained by the interaction between buildings and the CE paradigm. As buildings are designed for durability (8,14,15), a core aspect of slowing resource loops (5,8,34–37), it is unlikely that CBMI would cause cannibalization.

Governmental funding can mitigate this barrier. While funding is not mentioned in the literature, it was frequently mentioned as a driver to reduce short-term costs (I1-I10). All interviewees stressed that currently "*it only works if you have funding…so it pays off for the customer, otherwise the company- and a company is forced to be profitable to sustain itself- …cannot do anything.*" (I8). While funding is a significant economic driver, it is also linked to institutional implementation factors, as suggested by Masi et al. (45). This understanding of funding is elaborated upon in the section on institutional factors.

In contrast to Kirchherr et al. (23) who explain that being a pioneer is disadvantageous as it requires high investments while second movers can reap the benefits, the data indicates that being a pioneer creates a **competitive advantage** (I1-I10). Being a pioneer provides a unique selling point that differentiates the case company from competitors, increasing both the economic viability of a CBM and its influence on the market and institutions:

> "*We prefer setting the bar high, showing what is possible, taking along the political side so that regulations are being developed in this direction. And since you put in the effort you are in a position where you can offer it to the customers leaving them no way around it. It sure is a very economically motivated approach, but not a bad one if it emphasises sustainability.*" (I4)

This finding is more in line with Sarja et al. (48) who argue that proactive engagement in CBMI can increase a company's leverage on strategies and policies, creating a first-mover advantage. Seeking competitive advantage is linked to adopting a **long-term perspective**, another driver identified in the literature (36,44,46) and confirmed by the data (I1-I8, I10). For instance, the company prefers to "*invest in better technologies, better material and resources, better soil usage now rather than a multiple thereof at a later moment*" (I1). Further, the company has noticed that this approach creates "*a unique selling point, especially because all houses are eligible for funding*" (I7). Accordingly, the adoption of long-term perspectives enhances the economic viability of CBMs by ensuring the eligibility for funding and enabling the company to become a pioneer, thereby, influencing the market and institutions.

Similarly, the **exclusive allocation of resources** to CBMI is confirmed to be an economic driver (35; I4-I10). The case company has an innovation department which allows the company to make innovation a daily business besides the operational business of planning and constructing single-family houses. As the company tries to keep the employees in the innovation department "*out of the daily operational business*" (I8), the company allocates exclusive resources for innovation. Since these resources "*have been allocated exclusively to sustainability topics in the past three years*" (I4), the company is facilitating sustainable innovation, one of the key technological drivers for CBMI (29,36,46–48). This allocation is also practised externally "*to give start-ups a chance*" (I4). Accordingly, the company facilitates innovation and sustainable development on the micro and meso levels. This finding links back to the socio-cultural driver of collaboration, illustrating the interdependent nature of CE implementation and the implementation factors (23,29).

Implementation Factors Beyond the Micro Level

Institutional factors were frequently mentioned, despite the focus on micro-level factors for CBMI. Arguably, institutional factors have a significant impact on CE implementation. However, this research finds that they do not primarily determine engagement in the process of CBMI. Institutional factors include regulations and norms, funding policies, and lobbyism.

Regulations and norms influence whether pursuing CBMI is attractive (21,23,29,36,45,47–49,66). In the CI, many norms "*make prescriptions that complicate the use of more sustainable products*" (I7) of which "*most are forbidden*" (I1). Thus, they prohibit the implementation of sustainable and circular innovations (23,29,45,48,66), hampering circular construction (I1, I4, I5, I7, I9, I10). Further, as suggested by several scholars (36,45,49), this research finds that the regulatory framework around the recycling of construction and demolition waste creates a barrier to closing resource loops (I1, I3, I4, I7). One interviewee explained that "*this is still a very difficult legal issue. The issue is often about the purity of the material*" (I1). These findings give rise to the necessity of beneficial regulations and norms. Almost all interviewees (I1-I8, I10) stressed that regulatory pressure is necessary to motivate companies to engage in CBMI. To create this pressure, regulations and norms must specify under which conditions new houses can be constructed leading to an "*enrichment of the product portfolio [for circularity] in the market*" (I2), impacting CE implementation also on the meso level. Consequently, regulations and norms significantly influence CE implementation on all levels. Arguably, in contrast to the literature (1,4,6,7), a top-down approach might be necessary to successfully implement circularity in the CI.

While funding is an important economic driver for CBMI, the design of **funding policies** is an institutional implementation factor determining whether funding supports CBMI (I3, I9, I10). In fact, Masi et al. (45) explain that if funding policies favour linear operating systems, they are deemed to fail in supporting CBMI. Similarly, this research finds that an

ineffectual design of funding policies leads to the adoption of ineffective sustainability and circularity strategies like certificates (I3, I9, I10). Certificates are a requirement to receive funding (67,68). Yet, a certificate "*only certifies what we do, we don't have to bend over backwards for it*" (I10). Consequently, the funding policies are ineffectively designed to drive innovation for circularity as they do not require substantial change. Moreover, the effectiveness of funding is hampered by the limited allocation of governmental financial means to the funds (I9), as was the case with the *EH40*-fund in 2022 which was exhausted within weeks despite having been intended for several months (68). Hence, in line with Tura et al. (47), governmental financial incentives like funds can only be conducive to CBMI and CE implementation if they are designed sensibly and effectively.

Lobbyism emerged as a new factor from the data. Although lobbyism is an activity that is pursued by the case company, it impacts CE implementation on the macro level by influencing regulations. Hence, it is considered an institutional factor. Lobbyism is considered an important activity as "*it is the only way to really have leverage on the issue*" (I1) by placing circularity in the political debate to steer it in a favourable direction. While this influence can be a driver for CE implementation (I1, I2, I4, I5, I7, I8, I10), it can also be a barrier, depending on the receptivity of the institutions and the dominance of certain interest groups within the CI (I2, I4). Hence, like most implementation factors, lobbyism can function as both a barrier and a driver.

Socio-cultural factors on the meso level are competition. This factor is only briefly mentioned in the literature as a driver for innovation to ensure competitive advantage and survival in the market, important economic aspects of CE implementation (46,29). The data confirms this driving force (I2-I4, I6, I8, I9). Competition motivates the company to engage in CBMI to identify and exploit opportunities through innovation as it "*re-establish[es] this advantage by creating unique selling points*" (I6). However, competition is only a driver as

long as the company remains open to collaboration and open innovation which would allow for the creation of a market dominated by circular innovation, technologies, and products. Consequently, a transition toward the CE would be possible on the meso level. Yet, if competition makes the company resort to exclusivity, only few people can benefit from the innovation. Thereby, no conducive market can be established and the economic viability of CBMs is jeopardised as there is only "*one supplier and that supplier wants to have so much [money] that…it becomes too expensive*" (I2). Arguably, long-term benefits cannot be reaped from the innovation as the economic viability of the CBM cannot be secured due to the high price point.

External events, like the Covid-19 pandemic, the Ukrainian War, and economic recessions, create uncertainty influencing companies' engagement in CBMI (46,47). This research finds that this uncertainty affects the CBMI process in two ways. On the one hand, external events make the constraints on society and the environment visible, creating a connection between cause and effect and a sense of urgency to diminish these constraints (I10). Thereby, they force companies to innovate to navigate the uncertainty (I5, I6, I10), as "*if [they] don't change something now, it will be too late one day*" (I10). On the other hand, the uncertainty triggers a stronger tendency to resort to known methods (I1, I2, I6, I7, I9, I10), leading to risk-aversion (29,36,44–47,49) and "*a rather conservative approach*" (I10; (23,36,42,44–46,48,49). Thereby, external events create a barrier to CBMI.

External events will increase if the constraints on society and the environment are not reduced (69,70). Considering this development and the impact of external events on CBMI, external events constitute a considerable implementation factor despite falling outside the micro level. Whether external events function as a barrier or driver, however, depends on the company's approach to them, making them a highly subjective implementation factor.

CONCLUSION

This research investigated barriers and drivers for the implementation of circularity in the business model of family-owned construction companies in Germany. The findings show that the barriers and drivers can be grouped into socio-cultural, technological, economic, institutional, and external implementation factors that depending on their dynamics enable or impede the CBMI process. While the implementation factors identified in this research resonate with those discussed in the literature, the context of family ownership and the CI influences the dynamics of the implementation factors. Hence, this research adds to the academic debate by contextualising implementation factors for CBMI in two under-researched contexts that seem to interact slightly differently than suggested by the literature. Considering socio-cultural factors, family ownership influences the company structure and culture to be more conducive for CBMI by breaking up hierarchies and creating a strong feeling of togetherness allowing for faster decision-making and implementation. The context of the CI has a considerable impact on technological factors, as buildings engage in different temporal dimensions than typical products the CE applies to, given their long lifecycles and design for durability. Further, due to the naturally high price point of house construction, economic factors arguably influence CBMI in the CI at a different scale, making governmental funding a necessity to ensure the economic viability of CBMs. One of the most striking findings is that in the CI a top-down approach seems to be important given that regulatory pressure was considered necessary by most interviewees to enable the implementation of circularity. This finding explains why institutional factors were so frequently mentioned despite a focus on micro-level factors. Lastly, external events present as a subjective implementation factor attributing agency to the company to either translate uncertainty caused by external events into an enabling or impeding force for CBMI.

Implications for Practitioners

The findings give rise to certain implications for practitioners. First, while the product is the primary mean to create, deliver, and capture value, CE implementation also requires a conducive company culture and structure. Thus, the focus should be laid on both when engaging in CBMI. The findings indicate that such an approach must be fostered by leadership to provide a point of identification for employees. Thereby, company-internal resistance can be minimised, and open-mindedness can be increased which helps implement change. Accordingly, practitioners should ensure that the senior management leads by example.

Second, practitioners should seek collaboration and open innovation to accelerate the development of circular technologies and products and to increase their impact. Through collaboration and open innovation, practitioners enable the implementation of the CE beyond the company which is crucial to ensure the viability of CBMs. Thereby, a systemic shift can be initiated.

Third, to establish favourable conditions for CBMI, practitioners should engage politically. The findings show that regulations, norms, and policies have considerable influence on the feasibility and attractiveness to engage in CBMI. Accordingly, practitioners who are keen to drive sustainable development should try to influence political and regulatory institutions through lobbyism. To this end, collaboration with like-minded practitioners can be beneficial to increase one's leverage in steering regulatory development into a direction beneficial for CE implementation.

Limitations and Further Research

While this research has given deeper insights into implementation factors for CBMI in two under-researched contexts, the CI and family ownership, the case-study design limits the generalisability of the findings. Thus, further research should explore both contexts with

different methodological approaches. Considering that most research on CBMI in the CI is based on literature research, more primary research is needed. First, comparative case studies could test and verify the results of this research creating a better overview of CBMI implementation factors in the CI in Germany. Second, longitudinal studies observing the CBMI process could provide a different perspective on the implementation factors and their interdependence. Thereby, practitioners could receive more detailed and applicable insights into the CBMI process, potentially enabling more successful CBMI. Lastly, further research on implementation factors for CBMI with a focus on family ownership would be useful to isolate the family component as an influence on the CBMI process. A cross-sectional, comparative research design could be useful to this end. A similar design can be applied to identify differences between family- and non-family businesses and the CBMI process.

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APPENDICES

Appendix A: Barriers and Drivers for CBMI based on the Literature

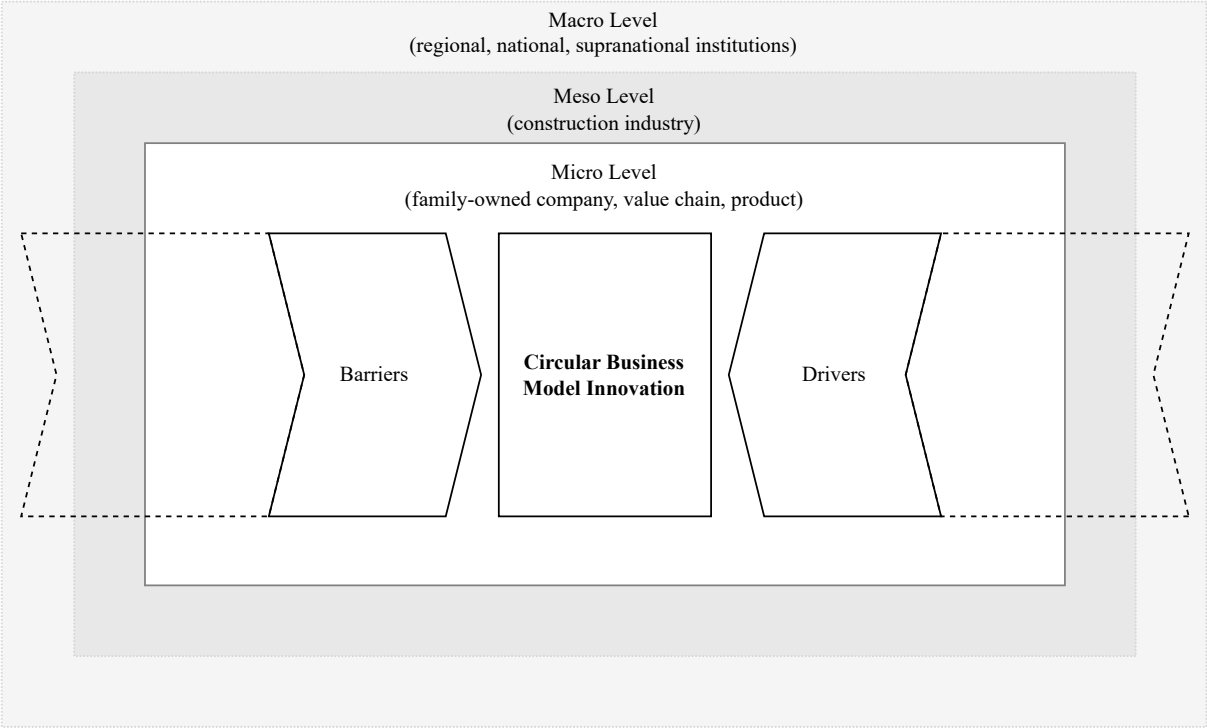
Category	Subcategory	Barriers	References	Drivers	References
Socio-cultural	Company culture	Risk-averse & resistant leadership - Traditional/conservative - Lack of system thinking - Lack of engagement with CE - Lack of communication - Lack of commitment - Hierarchies	(29,36,44–47,49)	(pro-)active leadership - Encourages open decision-making - Clear narrative and vision - Provides shared vision and understanding - Incentivises engagement with CE - Commitment - Motivation	(22,46,48)
				Diffused power - No concentrated power - Ensures successful collaboration within the company	(36,44)
		Lack of aspiration - Lack of learning capacity & capability - Lack of learning incentives - Lack of motivation - Lack of commitment - Focus on short-term results	(44,46–48,50)	Aspiration - Learning capacity and capability - Experimentation - Focus on long-term impact - Motivation - Commitment	(36,46–48)
	Company structure	Silos/lack of horizontalization - Different cultures within the company - CE no relevant topic in all departments - Lack of circular value proposition - CE not mainstreamed in strategy, mission, vision, goals, incentive structure	(23,29,36,44–49)	Horizontalization - CE relevant in all departments, activities, and decisions within the company and supply chain - Circular value proposition - CE mainstreamed in values, mission, goals, strategy, incentive structure - Shared understanding - Shared culture	(22,36,44–48,64)
		Linear BM - Narrowly defined strategies	(23,36,44,47)	Pre-existing sustainability strategies and practices	(36,46,48)

		- Lock-in in the dominant paradigm/threat to business as usual		- Different perception of barriers - Easier transition - Awareness - Ability to identify opportunities	
	Value chain collaboration	<u>Lack of collaboration</u> - Collaboration perceived as unbeneficial for competition - Lack of trust - Lack of information exchange/transparency - CE not streamlined across the value chain	(23,29,36,45, 47,48,50)	<u>Co-creation and -development</u> - Long-term relationships with partner companies - Creation of viable market - Diffusion of CE values, practices, strategies - Importance of trust - Information sharing/transparency	(22,36,46–48)
	Customer awareness and interest	<u>Uncertainty about consumer awareness and interest</u> - Mismatch between consumer awareness and action creates uncertainty about CBM success - Resistance to change	(23,29,44–50)	<u>Demand for CE products and resources</u> - Demand must exceed that of linear virgin resources - Certainty about success of CBM - Understanding of demand	(29,46–48)
Technological	Innovation and technologies	<u>Lack of proven/adequate CE technologies</u> - Often niche technologies - Requires expertise - Requires R&D	(23,29,36,48, 50)	<u>Continuous innovation</u> - Aspiration to improve sustainable/CE performance - Experimentation - Learning - Development/improvement of technologies - Potentially triggered by competition	(29,36,46–48)
	Skills and knowledge	<u>Lack of skills and knowledge</u> - Inability and uncertainty to deliver high-quality CE products - Inability to identify CE opportunities - Lack of learning incentives and training	(23,29,36,45 –48,50)	<u>Availability of skills and knowledge</u> - Performance measurement (e.g., life-cycle assessments) - Understanding value creation across value chain - Ability to identify CE opportunities - Open-minded search for CE opportunities	(22,36,45,47, 48)

	Product design	Lack of circular product design - Dominance of linear principles - Little attention to end-of-life - Focus of short-term returns of investment	(23,29,45,49)	Circular product design - Attention to end-of-life due to life-cycle assessments - Attention to narrowing, slowing, and closing resource loops	(22,29,36)
	Availability and quality of resources	Lack of reliable supply - Inelastic as it relies on previous consumption patterns	(29,45,47)	Resource scarcity of linear virgin resources - Threat to business as usual, forces CBMI - Creates pressure to reduce negative externalities	(29,47,48)
		(perceived) lower quality of CE resources - Lack of trust in resources - Uncertainty to deliver high-quality CE products	(29,45,49)		
Economic	Economic viability and profitability of CBM	First-mover disadvantage - Large necessity for learning - Fear of cannibalisation (reduced sales due to narrowing, slowing, and closing resource loops) - Second mover will benefit from first-mover efforts	(23,44,48)	Long-term economic and environmental benefits - Ensures profitability - Necessary to sustain CBM - Enhanced by resource efficiency due to cost savings and maximisation of value of existing resources	(29,36,46–48)
		High up-front costs - Limited affordability of CE resources compared to linear virgin resources - No short-term return of investment due to necessity of long-term investments	(23,29,36,44,45,47–50)	Long-term investments - Less focus on short-term returns of investment/long-term returns of investment - CBMs operate at different timelines and financial structures than linear BMs	(36,44,46)
	Exclusive allocation of resources	Lack of exclusive budget/means - Insufficient human resources - Insufficient financial resources - Lack of incentives	(44)	Specific allocation of resources for CBMI - Incentives - Human resources - Financial resources - Commitment	(36,36)

Appendix B: Theoretical Model

Figure 1 – Theoretical Model



Note. Figure created by the researcher based on literature research

To account for the nested and interdependent nature of the CE and the barriers and drivers influencing its implementation (23,29), the model situates the micro level, as well as the barriers and drivers for CBMI within the meso and macro levels. Still, the primary focus of this research is laid on micro-level barriers and drivers for CBMI.

Appendix C: Interview Guide

Introduction
Hello [Interviewee],

Thank you very much for taking the time to do an interview with me today. The interview is taking place as part of my master's thesis on the topic of barriers and drivers for the implementation of the circular economy at the core of the business model of family-owned construction companies in Germany.

In this context, I will ask you questions about sustainability and the circular economy in your company and its value chain. These will include questions regarding the company structure and culture, resource procurement and use, and strategies and innovation related to sustainability and circularity. In addition, you will be asked for your own opinion at some points.

Your participation in my master's thesis is very valuable but completely voluntary. Therefore, you are not obliged to answer questions if you do not want to. Likewise, you can stop the interview at any time. However, I would like to assure you that your participation and this interview will be treated with strict confidentiality. This means that any material used in the master thesis will be anonymised. For the purpose of data analysis, this interview will be recorded; however, the audio file will only be accessible to me. Is that okay with you?

[Wait for answer]

Great, thank you very much. The interview will last about 60 minutes. Do you have any questions before we start?

[Wait for answer]

Interview Guide

Category	Subcategory	Questions
Sustainability/ Circular Economy	Definition	How does the company define sustainability and what role does circularity play in this definition?
Socio-cultural factors	Company structure	1) How is sustainability/circularity integrated in the company? a. *Is it a relevant issue in all departments and work processes?* b. *Is it a relevant issue in all decision-making processes?* *2)* To what extent is sustainability in general and circularity in particular part of the business model?
	Company culture	1) What is the company's value proposition? 2) Why does the company 'do' sustainability? a. *What is the company's sustainability strategy?* b. *What would be good motivators to drive sustainability/circularity?* c. *What do you think prevents the advancement of sustainability/circularity?* 3) Are there specific sustainability and/or circularity targets the company has? *(e.g., development of a climate-neutral house type by 2035, specific sales figures for sustainable house types).*

		4) How does the characteristic of family ownership influence the company's sustainability/circularity?
	Value chain	1) Are there external actors influencing the corporate structure and culture in terms of sustainability and/or circularity? *a. Where would you situate the company in the competition for sustainability?* 2) To what extent does the company collaborate with suppliers regarding sustainability/circular economy goals?
		3) How would you describe the demand for sustainable/circular construction? 4) What concerns and considerations most influence your customers' purchasing decisions?
Technological factors	Innovation/Research and Development & Product design	1) What does sustainable/circular innovation involve at the company *(product innovation, business model innovation, etc.)*? *a. Does it affect how you design your products?* *b. Do you conduct life cycle assessments? If so, how do they influence/inform innovation at the company?*
	Resource acquisition & use	1) Is your resource procurement guided by specific criteria? If so, by which criteria? 2) How efficiently are your resources used? *a. Is much being thrown away; Are resources/surplus/waste being reused?*
Economic factors	Profitability/ economic efficiency	1) In your opinion, would you describe sustainability/circularity as profitable? Why? 2) Do you have an exclusive budget for sustainability/circularity? If yes, how is it distributed within the company?

Closing

That's it from my side. Thank you very much for your participation and your time.
Do you have any questions or anything else you would like to share with me that was not brought up in the interview?

[Wait for answer]

All right. In case you have any questions or concerns afterwards, please feel free to contact me at any time.

Appendix D: Overview Interviews

Interviews	Interviewee Position	Duration
I1	Corporate Governance & Management	01:14:30
I2	Project Management	00:48:00
I3	Purchasing & Logistics	00:58:00
I4	Technical Innovation	01:05:20
I5	Employee Development and Learning	01:06:00
I6	Sales	01:06:00
I7	Innovation	01:07:00
I8	Human Resources	01:09:40
I9	Construction Management	00:43:40
I10	Sustainability	01:18:30

Appendix E: Transcripts

The transcripts can be accessed via this link.

Appendix F: Coding Tree

Selective Coding	Axial Coding	Open Coding	Illustrative Quote
Socio-cultural factors	Family Ownership	Driver – Flatter Hierarchies	"The family-owned company has flatter hierarchies. Hence, you have a lot of contact with the owners, you can make decisions quickly; you basically pitch your idea to those that give their name for it" (I4)
		Driver – Faster Decision-Making	
		Driver – Faster Implementation	
		Driver – Identification/Togetherness	"The family aspect…we had a site manager training a few months ago and someone [external] spoke to me afterwards and said, 'actually you are a cult', and it is true, you are a bit infected with this [company] virus...So it's really strong, this feeling of togetherness and how people stand behind this company" (I9)
		Driver – Intergenerational Awareness	"Since the company has to reposition itself every 30 years over the generations, this is quite a good sphere of activity. You get quite a good milieu here to really bring such topics forward" (I4)
		Barrier – Tradition/Conservatism	"The company being family-owned is a barrier, as the certain dogmas that are carried within the company were cradled [into the next generation of owners]" (I10)
	Company Culture	Driver – Leadership	"It starts with the senior management and has to be carried downwards, and it is not enough to hold a meeting once a year and somehow tell them how great you are, but you have to convey this penetratingly again and again, at every opportunity." (I8)
		Driver – Identification/Togetherness	"Of course, you always have to take your own tribe, your own people with you first. They are all multipliers. We now have just over 1200 employees in the company, our own employees, and they all have families, they all have acquaintances, they are all in sports clubs and so on." (I8)
		Driver – Education & Training	"Education - both active and passive - is certainly an incredibly important factor to drive the topic [CBMI]." (I1)
		Barrier – Resistance	"The people, no one likes new things; that is the biggest challenge for everyone. The idea can be a bomb, it can pay off gigantically, so somehow everyone goes home with €2 more in their pockets, the customer is happy, the legislator is happy, bomb topic; if it's not what I've always done, it's already difficult from the employees' point of view." (I10)
	Company Structure	Driver – Diffusion/Streamlining	"I think the management of the company and the board members have managed to really anchor this deeply in the corporate philosophy, the idea

			of sustainability...and everyone defines it a little differently, independently of that. In any case, [sustainability] is more or less definitely always present in the back of the minds of all employees, I believe." (I2)
		Barrier – Silos	"A lot of people have little influence on sustainability, because basically the [company] dictates how things are done. Of course, there are employees who come forward and say 'hey, I have an idea', so we have a lot of employee ideas that we follow up on if they are realistic and feasible. But for them, I don't think the topic is nearly as present as it is for us, because they have to absorb what we do. I think they can partly have quite little influence on how sustainably [our houses] are built." (I7)
	Collaboration	Driver – Open Innovation	"It can be mutually beneficial; you just have to think bigger and have an idea behind it and also the industry that goes along with it. Then it becomes a win-win situation." (I9)
		Barrier – Exclusivity	"So we are not open to technology in the sense that someone else can use it. We have filed I don't know how many patents. I really don't know how many. I think the predecessor of [our technical director] has filed around 40 patents in his name, exactly very many." (I10)
	Customer demand & interest	Driver – Sustainability	"The customer willingly demands sustainability, yet, depending on the customer's financial capacity, sustainability is not the main motive the customer spends money on. In the end, the house should not overstep financial boundaries and that is where cutbacks are made" (I4)
		Barrier – Affordability	
		Driver – Funding	"Politics can now help again by saying that particularly efficient houses also get special subsidies through favourable loans and repayment subsidies and things like that. So if you do that, it makes it attractive again for customers to really think about building efficiently." (I5)
	Competition	Driver – Unique Selling Point	"In the past few years, it [the competitive advantage] decreased, now there are a lot of competitors who also do photovoltaics and you have to recognise where you can re-establish this advantage by creating unique selling points." (I6)
		Driver - Aspiration	"We want to be pioneers, we want to be the first, that is what we have set out to do. That's what we continue to do." (I9)
		Barrier - Exclusivity	"Without variety, there is no competition…then I only have one supplier and that supplier wants to have so much [money] that…it becomes too expensive" (I2).

Technological factors	Innovation & Technologies	Driver – Continuous Innovation & Experimentation	"Pilot projects... just to stay on track. Should this be necessary in the future, then we will have had experience with it. Then we will know whether we can implement it, and if not, why and so on. So we try to make these learning effects happen somehow." (I2)
		Barrier – Lack of Proven/Adequate Technologies	"The technologies…are still in the early stages of development" (I4)
	Skills & Knowledge	Driver – Experience/Expertise	"As far as this topic is concerned, we have been working on it for a very long time already, e.g., insulating houses well, not firing houses with gas but using a much more efficient heat pump technology, using the yield from the sun are things that we have been doing for over 20 years. So, that means that the topic of sustainability has not exactly grown in our company at the current time when everyone is doing it." (I1)
		Driver – Education & Training	"The operational departments, i.e., the craftsmen who then install the [material] on the construction site, must also be able to do this and then the company provides education and training." (I2)
		Driver – Continuous Innovation & Experimentation	"Pilot projects... just to stay on track. Should this be necessary in the future, then we will have had experience with it. Then we will know whether we can implement it, and if not, why and so on. So we try to make these learning effects happen somehow." (I2)
		Barrier – Lack of Knowledge/Inability	"I think the operational departments are sometimes a bit more conservative than we are and say 'yes, it sounds nice, but we don't know how to work with them [the components]'." (I7)
	Product Design	Driver – Circular Product Design	"We have two test houses, one for theory, one for practice, where we try out everything that has to do with construction materials, which means that before we install something, it is really tested in terms of lifecycle." (I6)
		Driver – Resource Selection Criteria	"No resources are used that are not suitable for lifecycle of the house...the house should last 80 or 100 years, if possible, without requiring components to be renewed and disposed of." (I5)
		Barrier – Resource Supply	"So of course we are influenced by the kind of resources that is supplied to us and by what can be done with houses and its components, that is, the deconstruction materials from houses. That of course influences what we do." (I1)

	Availability & Quality of Resources	Driver – Rethinking of Resource Loops	"if you think about the recyclable materials, which are quite valuable…then you wouldn't go there with an excavator, you would invest in an automated system to recycle these materials" (I10)
		Barrier – Resource Supply	"So of course we are influenced by the kind of resources that is supplied to us and by what can be done with houses and its components, that is, the deconstruction materials from houses. That of course influences what we do." (I1)
		Barrier – (perceived) Quality of Resources	"It is nicer to use new building materials than to use old building materials. They are more dimensionally stable, they are cleaned, they are abundant, they are easy to work with, they are cheaper. There are no disadvantages at all." (I1)
Economic factors	Economic Viability	Driver – Competitive Advantage/Pioneer	"We prefer setting the bar high, showing what is possible, taking along the political side so that regulations are being developed in this direction. And since you put in the effort you are in a position where you can offer it to the customers leaving them no way around it. It sure is a very economically motivated approach, but not a bad one if it emphasises sustainability." (I4)
		Driver – Long-term Perspective	"It is better to invest more money now in better technology and better materials and better land use than a multiple thereof at a later moment." (I1)
		Barrier – High up-front costs	"Many products that can be considered sustainable are simply more expensive than conventional construction materials." (I7)
		Barrier – Fear of Cannibalization	"It is rather the problem that even a minimal increase in the prices would make it economically unviable for the company. Hence, we do not talk about profitability anymore, but rather that it would no longer pay off to sell a house." (I1)
	Exclusive Allocation of Resources	Driver – Exclusive Allocation to Innovation	"Innovation requires innovation management, of course. We are willing, and it also costs money, to make resources available, in human resources, but also in capital, there is a budget with which things can be tried out, to perhaps give start-ups the opportunity to say 'OK, we'll do something together, we'll try something out.'" (I4)
		Driver – Exclusive Allocation to Sustainability/Circularity	"The resources have been exclusively allocated to sustainability topics in the past three years." (I4)

	Governmental Funding	Driver – Funding	“At the moment it only works if you have funding…so it pays off for the customer, otherwise the company- and a company is forced to be profitable to sustain itself-…cannot do anything.” (I8)
Institutional factors	Regulations & Norms	Driver – Regulatory Pressure	“That doesn't come itself. So every industry partner is getting more and more requirements now...that they have to adapt their production accordingly. This is a demand that we have been making for years, but we have noticed that this process is very slow [without regulatory pressure].” (I3)
		Barrier – Ineffective Design	“In my work, I read a lot of norms and so on, and they make many prescription that complicate the use of more sustainable products. For example, if there is a precise definition of how a product has to be, which one has to use, you often don't have a free choice of what you use.” (I7)
	Funding Policies	Driver – Funding Conditions	“We actually do the life cycle assessment...because they are now required to receive funding. For example, for the QNG-certificate it is required.” (I2)
		Barrier – Ineffective Policy Design	“Nevertheless, the certificate only certifies what we do, we don't have to bend over backwards for it. You have to collect more signatures, which means that when my son asks me in 20 years' time, 'What did you do with the sustainability certificate back then?' Then I could tell him 'Our client had all documents before the construction started but we still have climate change.' So it is not sensibly designed, the sustainability certificate.” (I10)
	Lobbyism	Driver – Political Influence	“I also see the issue of political influence as important, because it is the only way to really have leverage on the issue.” (I1)
		Barrier – Lack of Leverage	“That means competition, we are very well positioned, if you look at it objectively on the basis of the figures, but as I said, due to the lobby, due to the reputation of a solid house manufacturer, if you don't look closely behind it, I would say we don't have the best cards.” (I2)
External Events	Crises	Driver – Connection & Awareness	“The crisis, the crisis in the construction industry, along with all the other crises, helped to change things a bit. The management, they are not stupid, it's not just the management, but there was more willingness and acceptance to change things because it was much clearer than ever before that if we don't change now, it will be too late one day; so the single-family house has to change, it can't always look the way it looks today.” (I10)

		Barrier - Uncertainty	“In the last six months, however, all of this has been pretty much stomped on and rolled back…That has been rolled back a lot. It's a bit, it's not just a bit, it's 95% due to the crisis, that the construction industry simply took a hit and had to think about how to turn the tide again. And then it came through that the management has a rather conservative approach inside, namely 'trust is good, control is better'.” (I10)

Appendix G: Information Sheet and Consent Form

INFORMATION SHEET FOR THE RESEARCH

Title of the study:
Circular Economy in the Construction Industry:
Barriers and Drivers for the Implementation of Circularity in Family-Owned Construction Companies in Germany

Dear [participant],

Thank you for your interest in participating in this research. This letter explains what the research entails and how the research will be conducted. Please take time to read the following information carefully. If any information is not clear kindly ask questions using the contact details of the researcher provided at the end of this letter.

WHAT THIS STUDY IS ABOUT?
- The research explores the barriers and drivers for the implementation of circularity at the core of the business model of family-owned construction companies in Germany
- There will be at least 6 interviews conducted with different employees of the case company
- You have been asked to participate in the study as you are employed in a leading or managerial position and can, thus, provide valuable insights for the research

WHAT DOES PARTICIPATION INVOLVE?
- Participation involves one interview conducted in a face-to-face setting for a duration of approximately 60 minutes

DO YOU HAVE TO PARTICIPATE?
- Participation in this research is completely voluntary
- You can withdraw from the research at any moment
- You are under no obligation to answer any questions, thus, choosing not to answer questions is without consequences

ARE THERE ANY RISKS IN PARTICIPATING?
- There are no risks for you in participating in the interview
- The collected data will be handled with confidentiality

ARE THERE ANY BENEFITS IN PARTICIPATING?
- There are no direct benefits for you, but the interview will help the research and may enrich the overarching research topic
- The interview can further help with establishing implications for the practical implementation of circularity in businesses

HOW WILL THE INFORMATION YOU PROVIDE BE RECORDED, STORED AND PROTECTED?
- The interviewees' names will be removed and replaced with a number to prevent traceability between the information and the participant
- Only the researcher will have access to the audio recordings of the interviews
- Once the interviews have been transcribed, the original audio file of the recording will be deleted

- The transcripts will be fully anonymized from the beginning
- The data will be stored according to the GDPR rules of the University of Groningen
- Only the researcher and the first and second assessor of the master thesis have access to the anonymised transcripts

WHAT WILL HAPPEN TO THE RESULTS OF THE STUDY?
- The results will primarily be used for the master thesis, however, there is a chance for publishing the research
- In any case, strict confidentiality applies, and all information will be anonymised

ETHICAL APPROVAL
- The research has received ethical approval from the Campus Fryslân Ethics Committee
- The researcher will uphold herself to relevant ethical standards
- Should any changes occur with regard to the research topic or the purpose of the research, this information will be communicated transparently to all participants, who will, in such a case, be asked again to give informed consent

INFORMED CONSENT FORM
- If you would like to participate in the research, please sign the consent form below
- Even if you agree to participate and sign the form, you can still withdraw at any time

WHOM SHOULD YOU CONTACT FOR FURTHER INFORMATION?
- Elena Elisabeth Ahrens
- Email: e.e.ahrens@student.rug.nl

INFORMED CONSENT FORM

Title of the study:
Circular Economy in the Construction Industry:
Barriers and Drivers for the Implementation of Circularity in Family-Owned Construction Companies in Germany

Name participant:

Assessment
- I have read the information sheet and was able to ask any additional questions to the researcher.
- I understand I may ask questions about the study at any time.
- I understand I have the right to withdraw from the study at any time without giving a reason.
- I understand that at any time I can refuse to answer any question without any consequences.
- I understand that I will not benefit directly from participating in this research.

Confidentiality and Data Use
- I understand that none of my individual information will be disclosed to anyone outside the study team and my name will not be published.
- I understand that the information provided will be used only for this research and publications directly related to this research project.

- I understand that data (consent forms, interview transcripts) will be retained on the Y-drive of the University of Groningen server for 5 years, in correspondence with the university GDPR legislation.

Future involvement
- I wish to receive a copy of the scientific output of the project.
- I consent to be re-contacted for participating in future studies.

Having read and understood all the above, I agree to participate in the research study: yes / no

Date

Signature

To be filled in by the researcher

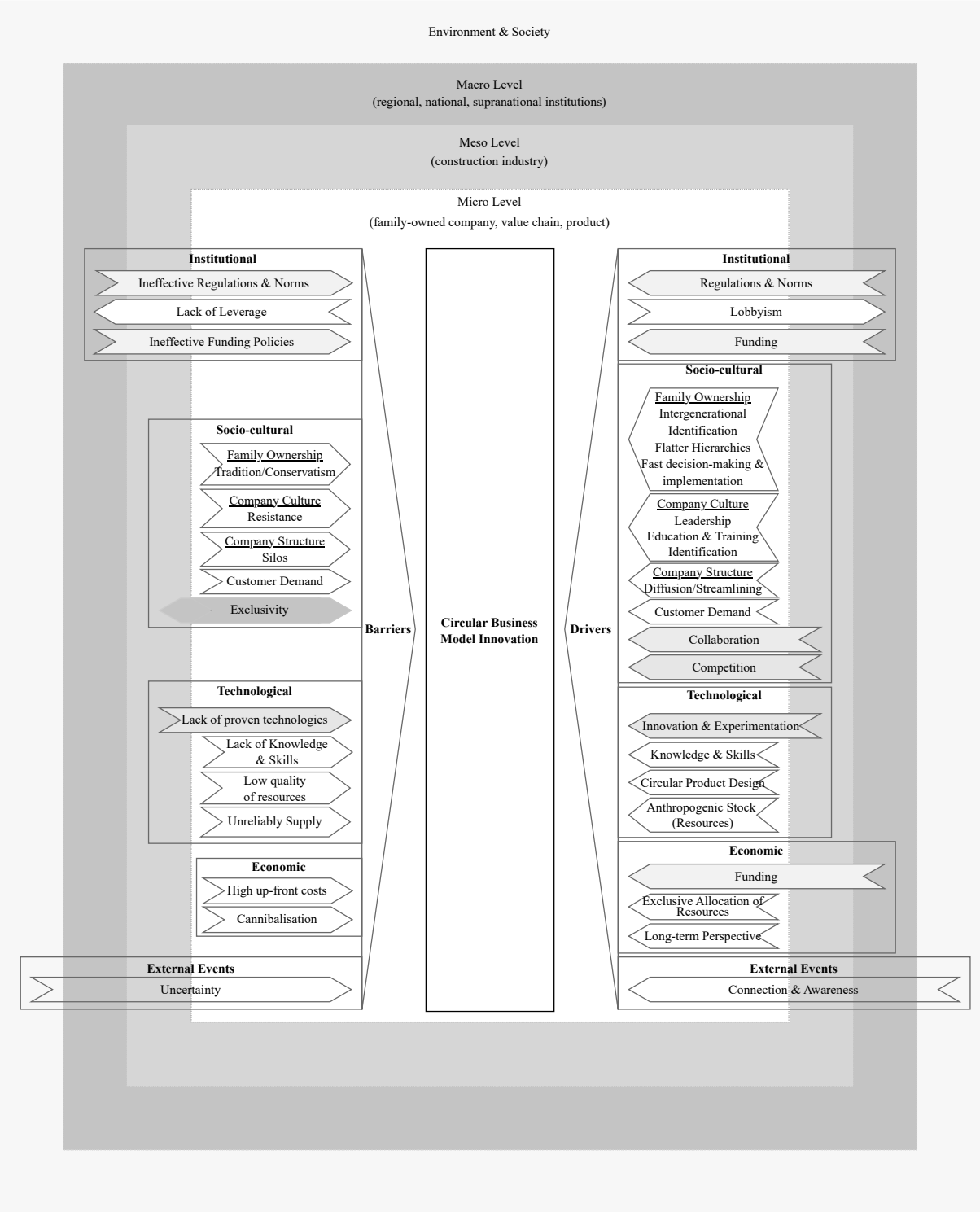
- I declare that I have thoroughly informed the research participant about the research study and answered any remaining questions to the best of my knowledge.
- I agree that this person participates in the research study.

Date

Signature

Appendix H: Refined Theoretical Model

Figure 2 – Refined Theoretical Model



Note. Figure created by the researcher based on results and discussion