A circular business model for non-residential buildings

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A CIRCULAR BUSINESS MODEL FOR NON-RESIDENTIAL BUILDINGS

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I. ACKNOWLEDGEMENT

This document presents the last project of my master education at the Eindhoven University of Technology. At the same time it marks the end of my life as a student but I will never stop learning. The research project has been conducted at the MOB department of the Royal BAM Group located in Veenendaal and focuses on modular buildings. This graduation project was not possible without the help of some people and therefore I would like to express my gratitude to them.

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Sven van Eldik

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II. EXECUTIVE SUMMARY

This study has followed a design science methodology in order to learn more about a circular business model for the construction industry for non-residential buildings. This study focusses on the supporting structure of the building as there is no innovative solution discovered for this component of the building. A circular business model is a set of assumptions about how a company will create and capture value from the extension of useful life of products and parts and closing material loops (Nußholz, 2017).

In the Netherlands, the construction industry accounts for roughly 50 percent of national material usage and 40 percent of the national waste (Lachmeijer, 2018; Landman, 2017). The energy required to extract natural resources is increasing (Christmann, 2018) and the worldwide population is projected to continue its growth which will increase the demand for natural resources. Therefore, material and resource efficiencies have become the centre of attention for many constructional firms.

The Royal BAM Group is looking at innovating ways to solve the material and resource problems within the sector. In particular, the Royal BAM Group is in seek of a business model innovation as investments for a product innovations are no longer promising. Business model innovation is the discovery of fundamentally different modes of value proposition, value creation and value capture for an existing business (Teece, 2010). Business model innovations have a more significant effect on the profit margins over a five year period compared to alternative forms of innovation years (BCG analysis, 2018; Pohle & Chapman, 2006). Therefore, the Royal BAM Group has approached me to develop a circular business model to solve the problem.

First, an overview of the best methods or approaches for circular business model innovation is created from the existing literature. Subsequently, the current business model is analysed to create a starting position for the business model innovation and improvements of the business model are researched. Therefore, two sub-research questions have been drafted to support the research on how a circular business model can be designed to profit from the supporting structure of non-residential buildings:

1. *From the previous literature, what are the best methods or approaches to innovate a circular business model?*

2. *In practice, how is the business model for the supporting structure of non-residential buildings organized within the focal company?*

Methodology

A design process approach based on Van Aken et al (2007) has been embraced to innovate the business model. A literature review has been conducted to research the best methods or approaches known to the existing literature for innovating a circular business model. An empirical analysis was conducted by means of a case study to investigate the current business model. Thereafter, the concept solution was designed by means of design science methodology (Van Aken et al., 2007). A set of requirements have been created followed by a set of design parameters. Multiple iterations of the synthesis step with the design process have resulted in the final solution. The solution has been tested through feedback sessions of the complete solution with company experts with knowledge on the important aspects of the business model. Additionally, validations of the separate assumptions on which the solution is based have been tested with relevant experts.

Results

As a result from the literature review, the business model framework proposed by Richardson (2008) is the most appropriate framework for mapping and designing business models. For the development of a circular business model, the business model framework has been adapted for circular business models by embracing the sustainable business model framework of Bocken & Short (2016) as a guide. Additionally, a take-back system is added to the sub-categories. Furthermore, the literature proposes to create a thorough understanding of the current business model before innovating the business model. The literature also suggests that a circular business model innovation will benefit from cooperation between the focal company and third parties. Furthermore, the literature on sustainable and circular business model innovations proposes to use pattern theory as a means to ideate different solutions for the business model innovation. Pattern theory consists of combining existing business models or elements of existing business models. An overview of useful patterns for a circular business model innovation has been created and embraced for the solution of this research.

The current business model illustrates that the company is in an integrator role within the industry. An integrator is in command of the bulk of the steps in a value-adding process. The Royal BAM Group acts as the connection between the customer and the necessary partners and suppliers to create the building. The Royal BAM Group are currently focussing on customers for large buildings within the non-residential sector. The average gross floor surface area of the customers is

18.514m2 and 80% of the non-residential buildings are included in the interval of 3000m2 to 55.000m2 gross floor space area. The revenue model is based on project specific cost calculations with a fixed added surcharge to account for profits. The constructional costs of a building make up roughly 17% of the total costs devoted to the building over its lifetime. The largest total costs are devoted to the service and maintenance, roughly 45% of the total building costs, followed by costs devoted for renovations of the building, which account for roughly 38% of the total building costs.

The solution

The solution proposes an innovation of the business model according to the switchboard business model. A switchboard business model connects buyers and sellers within their own business. The proposed solution will link and further develop the circular building platform and the BAM MEC to connect products and suppliers with customers through the design team employed by the Royal BAM Group. The business model solution will target a new customer segment of smaller buildings and embrace a fixed pricing model based on the costs of materials and a fixed surcharge for the engineering time. The solution highly recommends to add service and maintenance contracts to the deal.

Conclusion

This research has designed a circular business model as a solution for the focal company to create, deliver and capture value from a circular supporting structure for non-residential buildings. The solution shows that cooperation is key for the focal company to capitalize on opportunities for the circular economy. Additionally, the solution shows that an increase of the revenue will be beneficial to adopt the suggested solution. Finally, the solution shows the importance of understanding the current business model by embracing the most profitable phase within the current business model, the service and maintenance phase. Overall, the switch to a circular economy for non-residential buildings seems promising but there is still a long way to go.

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1 INTRODUCTION

The Royal BAM group NV is one of the largest firms within the Dutch construction industry based on their revenue and their full time equivalent employees. It is the Royal BAM group NV's mission to enhance the sustainability of buildings. They are doing this by permitting the proper individuals to access the foremost pioneering knowledge, resources and digital technologies (Royal BAM Group NV, 2017).

The Royal BAM group NV has set up a separate department for the development and construction of modular products. This department is titled the "MOB" department which stands for Modular development and building. The MOB department has developed products for the installations of non-residential buildings. Non-residential buildings are buildings that are used mainly for working space, business purposes, nursing purposes, recreational purposes and residential purposes. The MOB department consists of a development team and a manufacturing team. The manufacturing team focusses on the manufacturing of the ordered modular installation products. While the development team focusses on developing modular installation products.

BAM MOB has successfully introduced modular installation products for non-residential buildings. One example of a modular installation product introduced by BAM MOB is the "Distribution-track". The distribution-track is a distribution system for climate ceilings which consists of modules and is reusable after it is taken out of the building. The reusability of the product makes the distribution-track suitable for the circular economy. Additionally, the Distribution-track decreases the time spent on designing the distribution system. Because of the success of the installation products, the MOB department is now seeking new opportunities to expand their catalogue of products for non-residential buildings.

The next product that the department wishes to develop belongs to the structural components of the building; the supporting structure. The supporting structure is a collective term for all the constructional supporting elements of the superstructure of the building. For example, the supporting outer and inner walls, roofs and floors are part of the supporting structure. The supporting structure of a non-residential building contains the most material within the building, namely 70% and 66% when measured in weight and volume respectively. ("Sloop kantoorpand - Kosten en gegevenstabellen," n.d.).

The large amount of material devoted to the supporting structure creates possibilities for a circular solution to the supporting structure. In the Netherlands, the construction industry accounts for roughly 50 percent of national material usage and 40 percent of the national waste (Lachmeijer, 2018; Landman, 2017). It is therefore meaningful to take material and resource efficiency into consideration within the construction industry. A circular supporting structure should significantly reduce the material usage and waste generated by non-residential buildings.

Solely, innovating the product might not be sufficient for the supporting structure to be a success. Business model innovations can help a product innovation to a higher level of success as business model innovation typically have more competitive potential (Geissdoerfer, Vladimirova, Fossen, & Evans, 2018). A business model innovation searches for new ways for the firm to create, deliver and capture value for its stakeholders. The combination of a business model innovation together with a product innovation will most likely increase the chances of success for a circular supporting structure. To develop a circular supporting structure, BAM MOB is seeking a business model innovation to enhance the chances of success for a circular supporting structure. Which leads to the practical goal of this thesis, designing a circular business model for the creation of modular non-residential buildings.

Based on the assumption that the traditional business model will not generate sufficient earnings when transitioning to circular products, the MOB department is especially interested in a business model which can generate profits from the supporting structure of a circular non-residential building. The Royal BAM Group NV MOB department currently focusses only on non-residential buildings and therefore this thesis will focus on non-residential buildings. From the problem diagnosis the following research question has been derived:

"How can BAM MOB innovate its business model to create, deliver and capture value from a circular supporting structure for non-residential buildings?"

The main research question will provide the focal company with a business model to profit from a supporting structure which will enhance the circular economy. Therefore, a circular business model will be designed by the researcher to profit from the supporting structure of non-residential buildings.

A number of sub research questions have been formulated which will provide valuable information to better answer the main research question. To innovate the business model in a proper manner it is important to create an understanding of the best methods or approaches for innovating a business model. Furthermore, this research is interested in the best methods or approaches of a circular business model innovation. The research fields of business model innovation and sustainable business model innovation will also be researched to enrich the data obtained from literature. The findings from the literature can guide the business model innovation process. The first research question is formulated as:

1. *From the previous literature, what are the best methods or approaches for innovating a circular business model?*

To innovate the business model it is important to create an understanding of the current situation of the focal company (Giesen, Berman, Bell, & Blitz, 2007; Mitchell & Bruckner Coles, 2004; Sathananthan, Hoetker, Gamrad, Katterbach, & Myrzik, 2018). Herein the current business model(s) and further understanding of the focal company will be created. The second sub-research question is formulated as:

2. *In practice, how is the business model for the supporting structure of non-residential buildings organized within the focal company?*

The second research question will create an understanding of the current business for the supporting structure. A business model will help to explain how and why the business functions. Additionally, this research is interested in how the business model can be improved. In conclusion, the goal of this research is to design a business model for the supporting structure of circular non-residential buildings.

The goal of this thesis is to design a business model for the creation of circular non-residential buildings. To achieve this, an appropriate research method is desired. Since the aim is to provide the focal company with an appropriate solution to their problem, the regulative cycle by Van Strien (1997) is followed since this cycle is designed for problem solving. A further elaboration of the regulative cycle and its function for this thesis is given in paragraph 3.1, Research design – The regulative cycle. A solution design should be based on the use of literature (Van Aken et al., 2007). Therefore the literature review of business model innovations, sustainable business models and circular business models has been conducted. Subsequently, the problem-solving approach is followed to analyse and diagnose the findings for the solution and finally, a solution is designed, implemented and evaluated.

As a result, this report has the following structure. Chapter 2 presents the methodology. Chapter 3 presents the literature findings of the first sub-research question. In chapter 4 the findings to the second sub research question are presented. Chapter 5 presents the process involved in designing the solution, the design requirements and the design parameters. Chapter 6 covers the implementation of the solution and chapter 7 presents the evaluation of the solution. Chapter 8 presents the final solution designed in this research. Chapter 9 finalizes the report by presenting the conclusions, recommendations, implications, limitations and further research.

2 THEORY

Theoretical research has the advantage of the information being readily available. Therefore, a large part of the theoretical research has been conducted in advance of the empirical research. This literature analysis aims to answer the first research question: What are the best methods or approaches for innovating a circular business model?

During the literature research, relevant definitions will be analysed. The definitions are: business model, business model innovation, sustainable business model innovation and circular business model innovation. Subsequently, the literature review analyses the frameworks embraced by the literature to map the sustainable and circular business model innovation. This section will explain the mapping tools or frameworks embraced throughout the literature. In the conclusion a choice is made for a mapping tool or framework to embrace during this research. Successively, the literature is analysed on the processes frameworks for circular business model innovation. This knowledge has shown to be useful to direct the empirical analysis of this research. Lastly, the literature is researched to gather knowledge on the options to innovate a circular business model. The options for innovating a circular business model have been used to innovate the business model.

2.1 Definitions

2.1.1 Business model and business model innovation

The concept of a business model has skyrocketed since the year 2000 (Ghaziani & Ventresca, 2005) but in 2001 the concept of the business model was criticized for missing a well-defined concept. This has resulted in a confusion of the terminology of the business model concept (Morris, Schindehutte, & Allen, 2005). In 2011, Zott et al. (2011) state that the business model concept is moving towards conceptual consolidation and reaffirm that the consolidation is necessary for more cumulative research on business models. As of 2018, Fjeldstad & Snow perceive there remain two discourses of the business model concept within the literature. The first focuses on the operations of the business and the second deals with the dynamics of modifying the business model over time.

Additionally, Fjeldstad & Snow (2018) conclude that the business model concept consists of the following five elements: *"customers, value propositions, product/service offerings, value creation mechanisms, and value appropriation mechanisms.*" These five elements are linked to the description of the business model by a practitioner of business models; Osterwalder & Pigneur (2010) as *"the rationale of how an organization creates, delivers, and captures value."* In the literature, most definitions are close or consistent with the definition given by Teece (2010, p. 173):

"A business model articulates the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers."

According to Chesbrough & Rosenbloom (2002): "A successful business model creates the heuristic logic that connects technical potential with the realization of economic value." This definition contains two different domains, the technical and the economic domain, which are mediated by the business model. The connection of the two domains is conducted through the following elements of the business model: the value proposition, value creation and delivery and value capture (Richardson, 2008).

Research on business model innovation presents the added element of innovation compared to the research on business models. Innovation is defined as "the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order" (Van De Ven, 1986). Thus, the term innovation complements the element of new ideas to the definition of a business model. Business model innovation is characterized by changes to the core elements of a firm and its business logic (Bucherer, Eisert, & Gassmann, 2012). Additionally, (Pohle & Chapman, 2006) add that a business model innovation is an innovation in the structure and/or financial model of the business. The most elaborate definition of a business model innovation is given by Casadesus-Masanell & Zhu (2013, p 1):

"Business model innovation refers to the search for new logics of the firm and new ways to create and capture value for its stakeholders; it focuses primarily on finding new ways to generate revenues and define value propositions for customers, suppliers, and partners."

2.1.2 Sustainable business model innovation

Circular business model innovations are similar to sustainable business model innovations. Figure 1 presents the quantity of documents published to the Scopus database for the keywords on sustainable business model innovations and circular business model innovation. The search phrase used to obtain the documents on the sustainable business model was "title-abs-key ("business model innovation" and sustainable)" and the search phrase used to obtain the documents on the circular business model innovation was "title-abs-key ("business model innovation" and circular)". Both searches have been conducted on the 25th of September 2018. The large difference between the two search terms indicates that the literature on sustainable business model innovation is further developed. As the material on sustainable business model innovations is more extensive than the research on circular business model innovations, research on the existing models and performance indicators of sustainable business models innovations will also be used to guide this research.

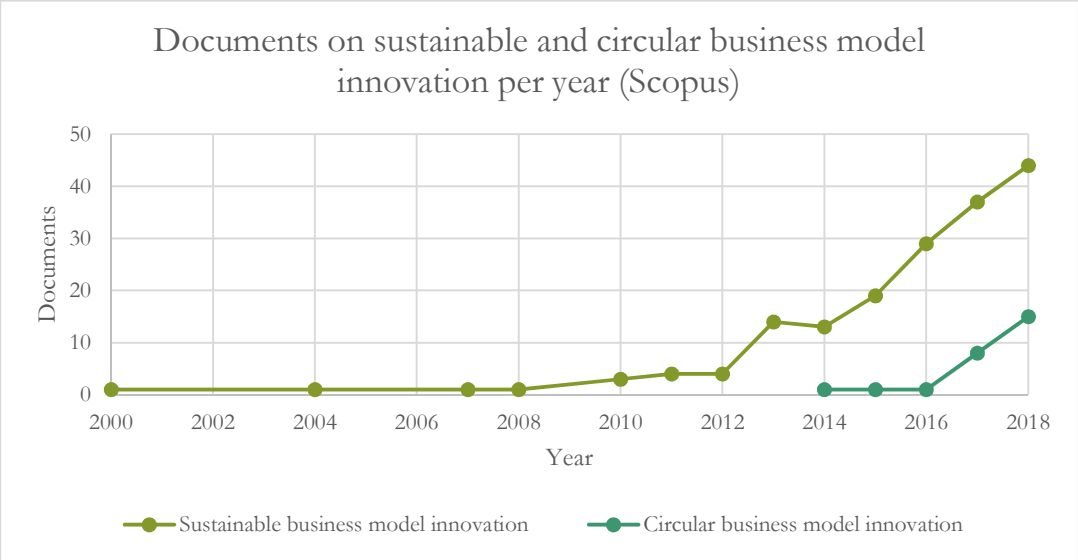

FIGURE 1 - DOCUMENTS ON SUSTAINABLE AND CIRCULAR BUSINESS MODEL INNOVATION IN THE SCOPUS DATABASE

As there is no consensus found on the definition of a sustainable business model innovation, the definition of a business model innovation for sustainability is used:

"Business model innovations for sustainability are innovations that create significant positive and/or significantly reduced negative impacts for the environment and/or society, through changes in the way the organisation and its value-network create, deliver value and capture value (i.e. create economic value) or change their value propositions" (N. M. P. Bocken, Short, Rana, & Evans, 2014, p. 44).

The difference between circular business model innovations and sustainable business model innovations is an additional focus within the environmental component. A sustainable business model innovations focusses on solutions for sustainability while a circular business model innovation also reduces, reuses and/or recycles resource loops. Circular business model innovations will improve the impact on sustainability and resource efficiency while sustainable business model innovations do not per se improve resource efficiency. Therefore, circular business model innovations are a sub-category of sustainable business model innovations. The comparison of traditional, sustainable and circular business models has been illustrated in Figure 2.

2.1.3 Circular business model innovation

The most used concept of resource efficiency within the construction sector is the circular economy. Generally, a circular economy is described as a system in which restoration and regeneration are fundamental by intention and design. The definition of the Ellen MacArthur Foundation, who works to inspire a generation to re-think, re-design and build a positive future circular economy, is most recognized by the firm. The definition of the Ellen MacArthur foundation has been widely adopted throughout the literature and by

practitioners, including the focal company (Lewandowski, 2016; Royal BAM Group NV, 2017). Their definition of the circular economy follows:

"The circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." (The Ellen MacArthur Foundation, 2012, p. 7)

The intention of the circular economy is to replace the 'end-of-life' concept, which puts forward reuse and aims to eliminate waste by better designing materials, products systems and business models (Ellen MacArthur Foundation, 2013). Furthermore, the Ellen MacArthur Foundation (2013) implies that closed material loops are inevitably connected to the circular economy. The government of the Netherlands has added to their transitional agenda that in 2050, zero waste and energy should be generated.

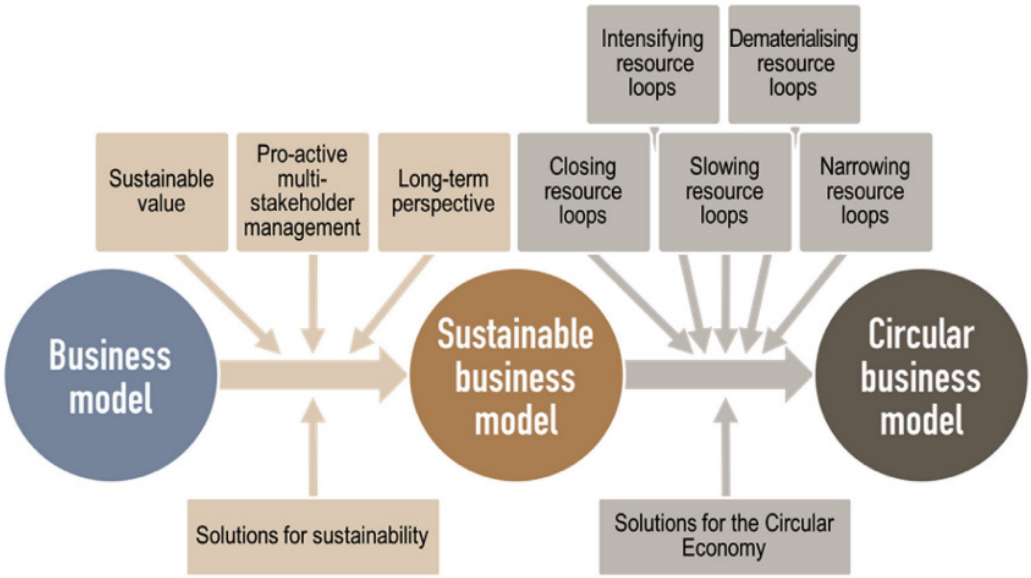

FIGURE 2 – COMPARISON OF TRADITIONAL, SUSTAINABLE, AND CIRCULAR BUSINESS MODELS (Geissdoerfer, Morioka, de Carvalho, & Evans, 2018).

Besides this definition from a practitioner-oriented institute, numerous different definitions within the academic literature can be found, contributing to the blurriness of the concept (Kirchherr, Reike, & Hekkert, 2017). Therefore, Kirchherr, Reike, & Hekkert (2017) have conducted an analysis of the definitions used throughout the literature. They found that the majority of the authors within the literature (90-97%) and practitioners (89%) embody a system that is regenerative or restorative in their definition of the circular economy as the core principle of the circular economy. Most commonly the 3R-framework is employed as a 'how to' for the Circular economy, concerning the Reduce, Reuse and Recycle principles. In addition, the aims and goals of a circular economy are enclosed within the definition. Economic prosperity (44-53%)

and environmental quality (28-42%) are the foremost common aims incorporated within the definition. Finally, enablers of the circular economy are enclosed within the definitions. Business models (9-14%) and customers (18-22%) are the foremost common enablers utilized in the definition of the circular economy.

This section will connect business model innovations with the concept of the circular economy in circular business model innovations. A definition of circular business model innovations will be given and the connection with sustainable business model innovations will be given.

The concept of the circular economy and the concept of business models are connected in the field of circular business models. The definition of a circular business model according to (Nußholz, 2017, p. 12):

"A circular business model is how a company creates and captures value with a value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts and closing material loops."

The definition of a circular business model differentiates from the definition of a business model on the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts and closing material loops. In other words, a circular business model requires a value creation logic to circulate material flows.

Circular business model innovations are a combination of circular business models and business model innovation. When combining the two definitions the following definition for a circular business model innovation is retrieved:

"Circular business model innovation refers to the search for new logics of the firm and new ways to create and capture value to improve resource efficiency through contributing to extending useful life of products and parts and closing material loops."

2.2 Mapping sustainable and circular business model innovation

This section will describe the frameworks which have been found in the literature on sustainable business model innovation. The frameworks have been categorized by author and are presented in the sections below. In the conclusion of this chapter, a combination of a selection of the framework will be made for the presentations of business models and the process of innovating the business model.

2.2.1 Richardson (2008)

Richardson (2008) has researched how the business model framework can be used in the strategy process of designing or checking how the firm is executing the given strategy. In this research a consolidated business model framework has been developed which includes the essential components from the business model frameworks mentioned by other business model frameworks. The resulting framework consists of

three major components: value proposition, value creation & delivery and value capture. The value proposition component includes what the firm delivers to its customers, why they are willing to pay for it, and the firm's basic approach to competitive advantage. The value creation and delivery system include how the firm will create and deliver that value to its customers and the source of its competitive advantage. The value capture component includes how the firm generates revenue and profit. The framework of these three components has been widely adopted by the sustainable business model innovation literature (Table 1). Bocken & Short (2016) have adopted the framework of Richardson (2008) to a sustainable business model framework by refining the sub-components. A representation of the framework is presented in Figure 3. The result is a consolidated framework embracing the essential components for the explanation of a sustainable business model based on the framework of Richardson (2008).

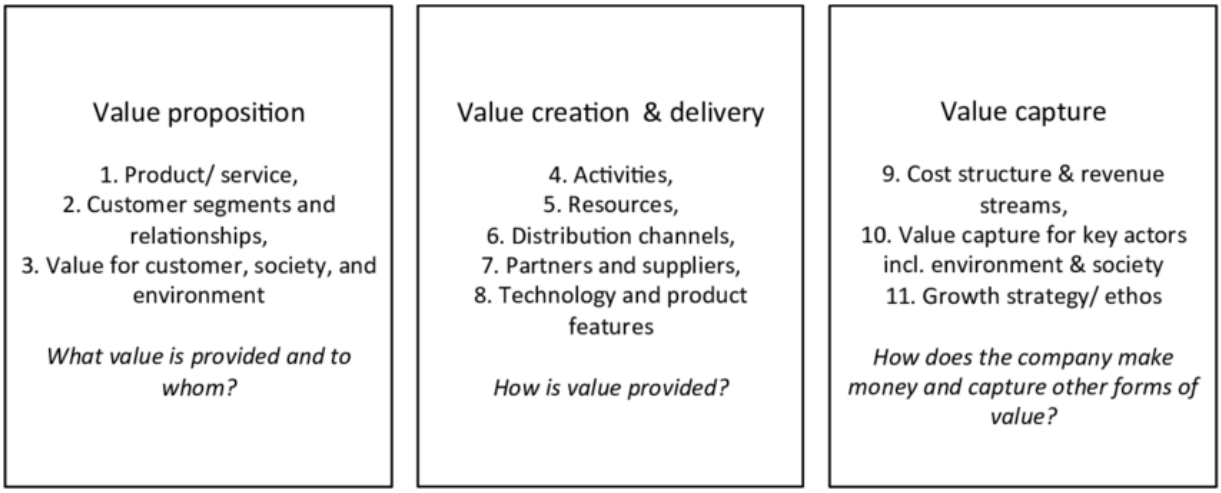

FIGURE 3- BUSINESS MODEL INNOVATION FRAMEWORK (N. M. P. Bocken & Short, 2016)

2.2.2 Osterwalder & Pigneur (2005, 2010)

Osterwalder & Pigneur (2010) have presented the business model canvas in their practical book: business model generation. The business model canvas is based on the categorization of a business model created in the work of Osterwalder, Pigneur, & Tucci (2005). The business model canvas is built up of nine business model elements which are presented in Figure 4. The business model elements consist of the value proposition, the customer segment, the customer relationships, the distribution channels, the key activities, the key resources, the key partners, the cost structure and the revenue streams. The business model elements are presented by a canvas which creates the business model canvas. The business model canvas can be split into four categories. The value proposition, the customer, the infrastructure and the financial model.

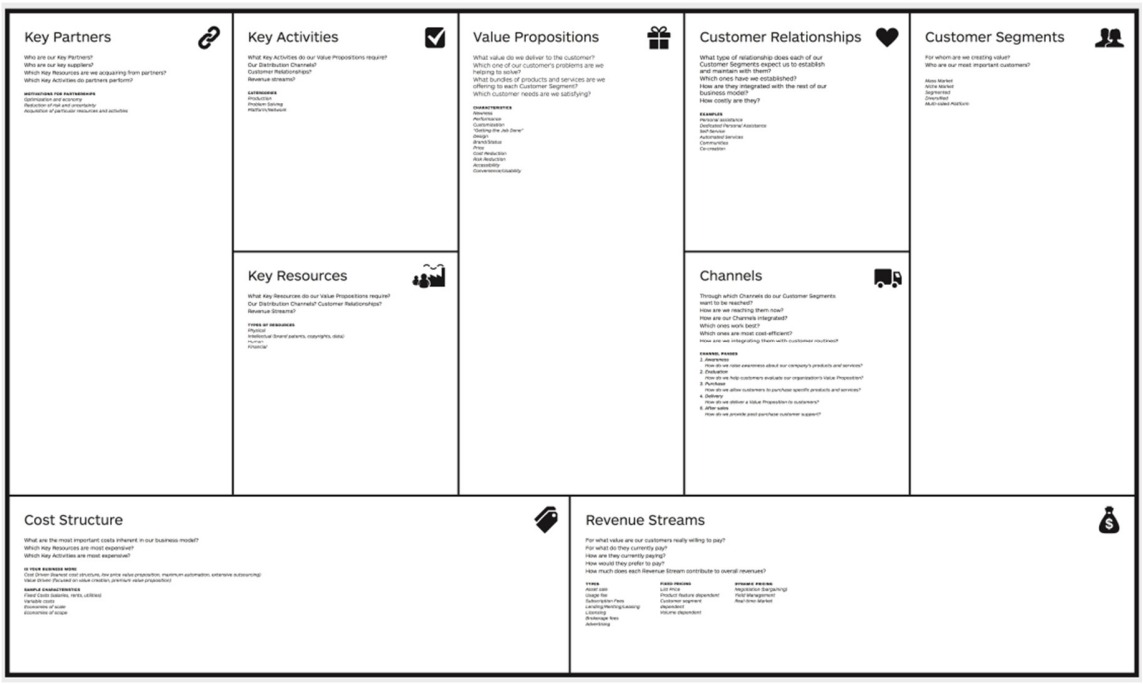

FIGURE 4- THE BUSINESS MODEL CANVAS (Osterwalder & Pigneur, 2010)

2.2.3 Lewandowski (2016)

Lewandowski (2016) proposes to use the business model canvas of Osterwalder & Pigneur (2010) as a foundation for circular business model design. The framework of Lewandowski (2016) is therefore counted as a framework originating from Osterwalder & Pigneur (2005, 2010). Two elements are added to the business model canvas to take the circular aspects into account, resulting in the circular business model canvas, see Figure 5. A take back system is added on the right side (customer side) of the business model canvas and an adoption factors box is added to the bottom of the business model canvas resulting in the circular business model canvas (Lewandowski, 2016).

2.2.4 Zott & Amit (2010a)

Zott & Amit (2010a) acknowledge that it is important to conceptualize a business model as an integrated system. They have used design themes to characterize the business models dominant value drivers. For the design themes, Zott & Amit (2010a) propose the 'NICE' framework – Novelty, lock-In, Complementarities, and Efficiency. Novelty involves introducing new elements to the business model. Lock-in refers to the power to keep third parties attracted as business model participants. Complementarities involve the bundling of activities such that the system provides more value than running activities separately. Efficiency refers to how firms aim at achieving greater efficiency.

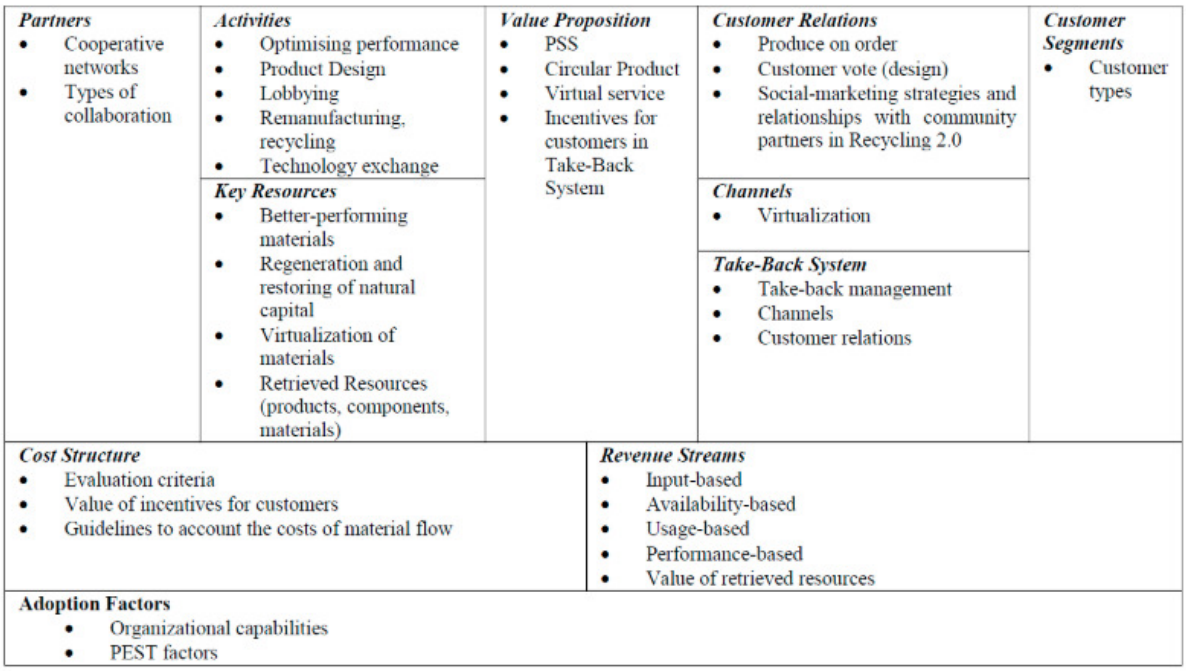

FIGURE 5 - THE CIRCULAR BUSINESS MODEL CANVAS BY (Lewandowski, 2016)

2.2.5 Abdelkafi, Makhotin, & Posselt (2013)

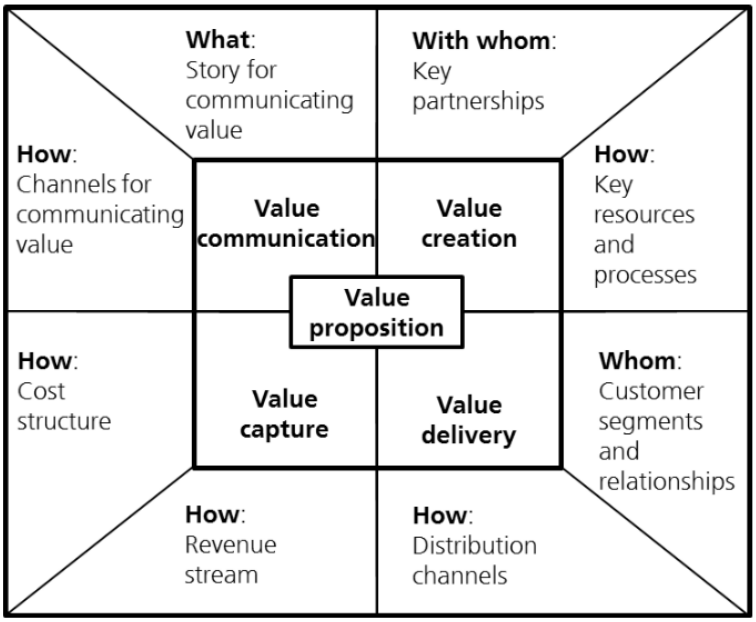

FIGURE 6 - THE BUSINESS MODEL FRAMEWORK PROPOSED BY Abdelkafi et al. (2013)

Abdelkafi et al. (2013) propose a business model framework in which the value proposition is central. They describe the value proposition as an overall view of a company's bundle of products and services that are of value to the customer. Surrounding the value proposition are the value creation, value delivery, value

capture and value communication categories which are divided into two sub-categories each. The framework is depicted in Figure 6.

Based on the literature, a framework will be selected. This framework will be used throughout the research as a structure to research the business model and to present the solution created during the research. An analysis of the frameworks has been conducted to select a framework from the existing literature. An overview of the frameworks has been created and the results of the framework analysis is presented in Table 1. The table shows the number of documents that have adopted the framework in the first row. The number of documents will give an indication of the prevalence of the framework. The second row contains the sum of the citations of the documents which have applied the according framework. The sum of the citations gives an indication on the popularity of the documents which have applied the framework. The third row shows the average publishing year of the documents which have adopted the framework. The average publishing year gives an indication on the novelty of the documents which have adopted the frameworks. Some frameworks were found to be a mix of multiple other frameworks presented in the table. These have been categorized under the term: mixed.

In the conclusion section of this chapter a selection is made for the framework of this research. Furthermore, this chapter will elaborate on the process to innovate a circular business model and the options which exist to innovate a circular business model. This will be explained in the next sections.

	Abdelkafi (2013)	**Zott & Amit (2010)**	**Mixed**	**Osterwalder (2005, 2010)**	**Richardson (2007)**
Number of documents	1	1	2	5	**8**
Sum of citations	40	138	305	622	**967**
Average publishing year	**2015**	2011	2013	2014	**2015**

TABLE 1 - RESULTS OF THE SUSTAINABLE BUSINESS MODEL FRAMEWORK ANALYSIS

2.3 The process of circular business model innovation

The previous section has researched the frameworks proposed by the literature to innovate a business model. This section will research the process needed to innovate a circular business model. Based on the literature, a process will be selected to innovate the business model. Therefore, an analysis of process oriented literature has been conducted.

A large part of the literature on the topic of business model innovation suggests that business model innovation seems rather chaotic and iterative (Bucherer et al., 2012). Stated in other words, business model innovation is at its very heart a process of experimentation and learning (Wittig, Kulins, Weber, & Models, 2017). Nonetheless, business model innovations happen along a logical sequence of process steps and one subset of the literature has shaped high-level or abstract process models (Bucherer et al., 2012; Frankenberger, Weiblen, Csik, & Gassmann, 2013; Wittig et al., 2017). Additionally, literature suggests

that there is a lack of in-depth structure to innovate business models (Frankenberger et al., 2013). Literature tends to describe the high-level process models for business model innovation but do not address the specific steps in order to innovate the business model (Wittig et al., 2017). The lack of structure may be due to the rather chaotic and iterative nature of business model innovation which would make it difficult to structure the process. Overall, the literature suggests to use a high-level process structure with iterations to derive promising new business models. Therefore, this research will adopt a high level process structure to innovate the business model.

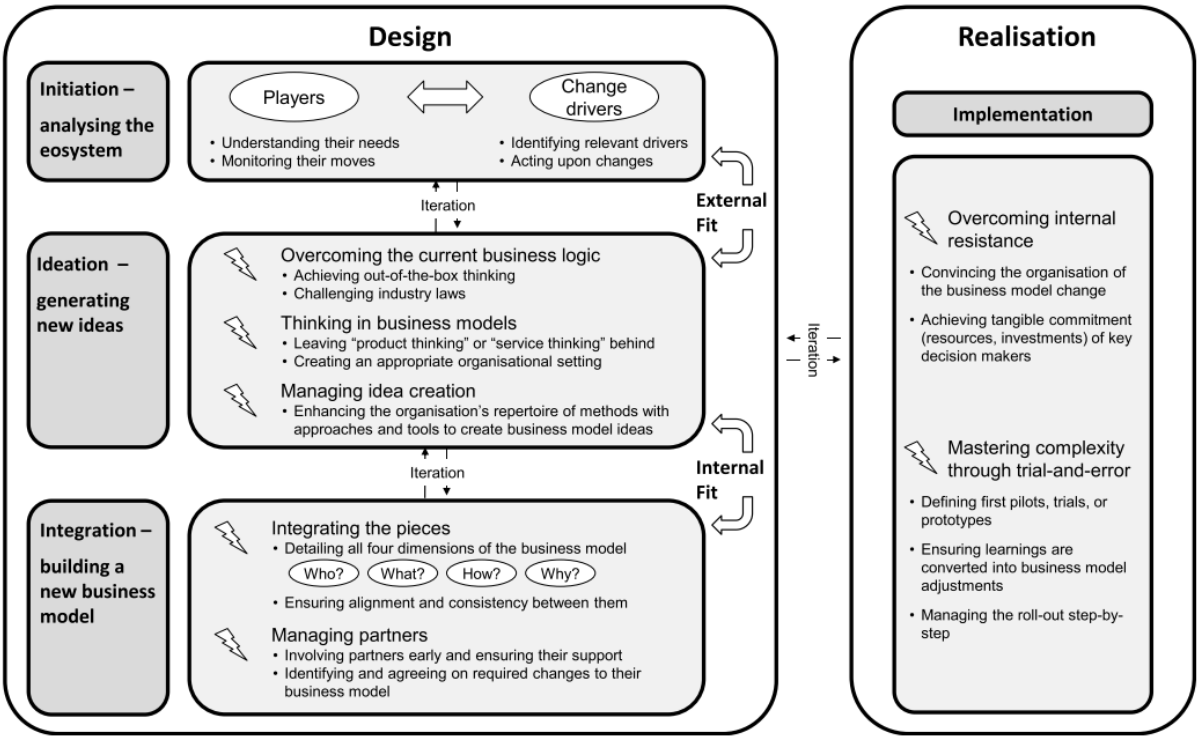

FIGURE 7 - THE 4I-FRAMEWORK (Frankenberger et al., 2013)

Frankenberger et al. (2013) proposes to structure the business model innovation process by means of four steps referred to as initiation, ideation, integration and implementation. The four steps make up the 4I-framework. The initiation phase in business model innovation processes can be described by activities which focus on the understanding and monitoring of the surrounding ecosystem of the innovating firm (Frankenberger et al., 2013). The ideation phase is concerned with the transformation of opportunities, which are identified in the initiation phase, into concrete ideas for new business models (Frankenberger et al., 2013). The activities within the integration phase focus on the development of a new business model based on promising ideas identified in the ideation phase (Frankenberger et al., 2013). The implementation stage of the newly designed business model includes implementing the business model. This typically involves huge investments to be made and risks to be taken by the focal firm (Frankenberger et al., 2013). The initiation phase is linked to the analysis and diagnosis step of the regulative cycle because both steps

focus on creating an understanding of a phenomenon. The ideation and integration phase are linked to the design solution phase of the regulative cycle because all phases are concerned with the transformation of ideas and opportunities into a concrete solutions. The last phase of the 4I-framework is the implementation phase and it is linked to the implementation of the solution phase of the regulative cycle. The framework is presented in Figure 7.

The work of Mendoza et al. (2017) proposes a more specific process compared to Frankenberger et al. (2013). The proposed consists of ten steps compared to the four of Frankenberger et al. (2013) and the proposed process is based on backcasting. Backcasting is a method which starts by defining a desirable future and then works backwards to identify policies and programs which will connect the desired future to the present. The ten steps proposed by the framework are depicted in Figure 8. The approach based on backcasting is unique in the literature on business model innovation. The success of this approach is largely dependent on the ability to specify the desired future. This forms a challenge when little is known about the desired future but creates opportunities as new and more knowledge is gained about the circular economy.

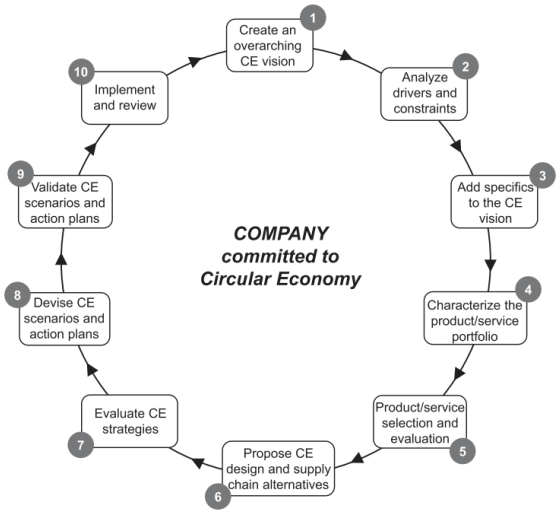

FIGURE 8 - THE BECE FRAMEWORK BY Mendoza et al. (2017)

The previous sections have explained high-level processes towards business model innovation. Based on the literature, a more detailed process has been selected for the ideation of new business models. This process will be used to generate ideas for the solution in this research. The work of Wittig et al. (2017), which also adopt the 4I-framework for their analysis, propose 'brainstorming along the business model canvas' and 'pattern adaption' as methods for the ideation phase.

The brainstorming along the business model canvas method embraces the business model canvas as a visual template to improve collaboration when brainstorming for new ideas for the business model. However, the brainstorming along the business model canvas method had a negative impact on the novelty of the generated solutions (Wittig et al., 2017).

The second method for the ideation phase is pattern adaption. A pattern describes a reoccurring problem and then describes the core of the solution. The pattern can then be used to solve similar problems. In other words, patterns are understood to be generalized problem-solution combinations (Lüdeke-Freund, Gold, & Bocken, 2018). Pattern adaption is a method in which existing patterns are adapted, transferred or combined, to generate a solution. Pattern adaption is a common method to generate new business models (N. M. P. Bocken et al., 2014; Osterwalder et al., 2005). Additionally, the method has been applied to wide variety of sustainable business models (Lüdeke-Freund, Carroux, Joyce, Massa, & Breuer, 2018; Stubbs & Cocklin, 2008). The method has been applied in many works because the gross of all business model innovations are not entirely new. They are rather a transfer or recombination of existing business model patterns or analogies (Gassmann, Frankenberger, & Csik, 2014; Wittig et al., 2017). Mixing and combining patterns or analogies can lead to impossible solutions. Therefore, managers should evaluate the generated business models as a consistency check (Abdelkafi et al., 2013).

2.3.1 The current business model

The literature suggests to create a thorough understanding of the current business model before business model innovation is undertaken (Giesen et al., 2007; Mitchell & Bruckner Coles, 2004; Sathananthan et al., 2018). The required depth of understanding the current business model seems to differ between the authors. While Giesen et al. (2007) and Mitchell & Bruckner Coles (2004) argue that the current business model or the industry should be fully understood, Sathananthan et al. (2018) conclude that a description of the current business model should be sufficient. Additionally, Frankenberger et al., (2013) states that it is important to understand the needs of players which can be seen as an element of understanding the business model. Overall, the innovation of the business model will benefit if the current situation is understood.

The articles on the process for business model innovation differ in their approach on how to research the current business model. Sathananthan et al. (2018) propose to describe the current business model through a business model framework and analysing the strengths, weaknesses, opportunities and threats of the current business model. Mitchell & Bruckner Coles (2004) suggests to optimize the current business model by informing stakeholders on all the needs and receive the most benefits while Giesen et al. (2007) proposes to analyse the industry in which the business model is operating with a future-oriented focus. Additionally, the research of Frankenberger et al. (2013) argues to analyse the change drivers which can initiate business model changes. Overall, the authors agree that the business model should be researched but no consensus is created on the method to analyse the current business model.

2.4 The options for the circular business model

The previous section has researched the process methods proposed by the literature to innovate a business model. This section will research the options available by pattern theory or analogies to innovate a circular

business model. The appropriate options discussed in this section will be used to innovate the business model and a further selection is not needed as they are only options.

In 2014, Bocken et al. (2014) have developed eight sustainable business model typologies called the archetypes. The sustainable business model archetypes describe the grouping of mechanisms and solutions that may contribute to building up a business model for sustainability. More recently, Ritala (2018) has synthesised the sustainable business model strategies into nine archetypes which are depicted in Figure 9. Three differences have been made to the sustainable business model archetypes. The differences are in the addition of the inclusive value creation archetype, the change of name of the create value from waste archetype to the closing resource loops and the categorization of the sustainable business model archetypes. The archetypes were first categorized by dominant innovation orientations and adapted to categories based of the major impacts of those innovations. Not all archetypes are relevant for a circular business model and therefore a selection has been made of the archetypes based on the definition of a circular business model. The explanations of the archetypes have been compared to the definition of a circular business model to extract the archetypes which match the definition of a circular business model. To repeat, a circular business model is how a company creates and captures value with a value creation logic designed to *improve resource efficiency* through contributing to *extending useful life of products and parts and closing material loops*. The two archetypes, maximize material and energy efficiency and closing resource loops, match the definition of a circular business model embraced by this research. For explanatory purposes the matching archetypes will be compared to the definition of a circular business model. The maximise material and energy efficiency is concerned with optimizing the resources used (Ritala et al., 2018). The optimization of the resources used will improve the resource efficiency and therefore the archetype matches the definition of a circular business model. The closing resource loops archetype is concerned with reusing products and materials (Ritala et al., 2018). The reusing of products and materials will extend the useful life of products and therefore the archetype matches the definition of a circular business model. These business model archetypes and their corresponding examples have been used during the ideation phase to test their applicability for the researched problem.

More specific business model patterns or analogies for sustainable and circular business models have been introduced by Mendoza et al. (2017), Lüdeke-Freund, Gold, & Bocken (2018) and Lüdeke-Freund et al. (2018). The work of Mendoza et al. (2017) introduces the BECE framework which provides support to ensure that businesses can implement the circular economy requirements more readily. The BECE framework is created by combining relevant steps from backcasting and eco-design for the circular economy.

The BECE framework starts with the application of backcasting to help formulate a vision for the circular economy through the consideration of the ReSOLVE actions. The ReSOLVE actions consist of six actions. These actions are: regenerate, share, optimize, loop, virtualize, and exchange. Each action represents a major circular business opportunity. Next, the eco- design analysis is applied aiming to achieve the vision for

the circular economy through strategic (re)design of products, services, and supply chains. Finally, the framework implements the vision by defining and validating scenarios and action plans. In this way, the BECE empowers organizations to tackle the circular economy holistically and create concrete solutions. The research analyses frameworks from sustainable business model innovation, closed loop systems, product-service systems and has matched the frameworks to the principles of the circular economy and the ReSOLVE actions. The circular economy principles embraced by the research are: 1. Preserve and enhance natural capital, 2. Optimize resource yields by circulating products, components, and materials, 3. Foster system effectiveness by revealing and designing out negative externalities. The work concludes that all of the reviewed frameworks have the potential to include all the ReSOLVE actions but no frameworks have been found that have included all the ReSOLVE actions. The ReSOLVE actions, which can be used to build a circular business model, will be adopted by this research as a means to identify opportunities to innovate the business model of the focal company.

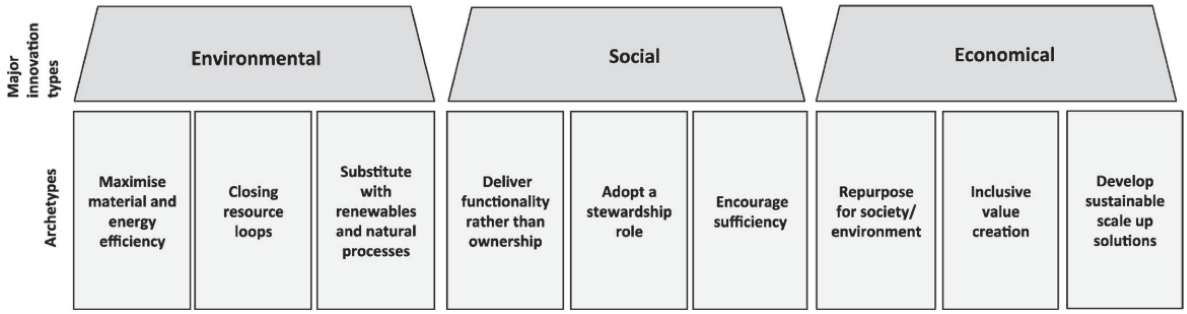

FIGURE 9 - SUSTAINABLE BUSINESS MODEL ARCHETYPES (Ritala et al., 2018)

The work of Lüdeke-Freund, Gold, et al., (2018) has conducted a morphological analysis of Circular business models from the literature. A morphological analysis can be used for exploring all possible solutions to a multi-dimensional, non-quantified problem. In the morphological analysis the major business model dimensions are defined and the specific characteristics of these dimensions identified. From their analysis a broad range of business model design options have been identified. The proposed design options provide an overview for the options which can be embraced for the solution to this research. Therefore, the circular business model design options will be embraced in the design parameters of the solution creation.

The work of Lüdeke-Freund et al. (2018) offers a synthesis and consolidation of the available knowledge about sustainable business models and presents an overview of the sustainable business model analogies used in practice as problem–solution combinations. The article sorts the analogies by the associated value creation which can be economic, social or ecological or a combination of the three. As the definition of a circular business model innovation does not include the social aspect of sustainable business models, the analogies can be adopted based on the associated value creation. The analogies with a primary associated value creation group of mainly economical, mainly ecological and integrative have been adopted for the

synthesis phase of this research to match a business model solution to the encountered problem. An overview of the analogies used during the synthesis phase of this research can be found in Appendix L – Overview of consulted analogies.

2.4.1 Job-to-be-done

Additionally to the works on business model analogies, the literature proposes guidelines to innovate a circular or sustainable business model. The renown work of Boons & Lüdeke-Freund (2013) proposes that financial models should shift to a pricing system for a "job-to-be-done" instead of a "price-per-unit" pricing system. A "job-to-be-done" pricing system focuses on the fulfilment of needs instead of selling products. On the contrary, a price-per-unit pricing system focusses on the selling of a number of products. The reason a job-to-be-done pricing model fits better for sustainable business models is that it is in line with approaches such as de-materialization through product-service-systems. The design of the business model for this research will consider and evaluate a job-to-be-done pricing models like a leasing model.

2.4.2 Collaboration

The literature also strongly suggests to use collaboration for the realization of a sustainable business model. Collaboration allows a firm to receive advantages from its key partners to benefit from and in return the partner will receive advantages back. Lewandowski (2016) states that "without collaboration, achieving circularity is hardly possible", emphasising that collaboration is essential for the success of a circular business model. The essence of collaboration is due to the nature of the circularity principle as an organization is dependent on a network of collaborating organizations to fulfil the concept of circularity (Bechtel, Bojko, & Völkel, 2013). A business model which embraces collaboration is therefore seen as superior (N. Bocken, Short, Rana, & Evans, 2013; De Pádua Pieroni, Pigosso, & McAloone, 2018).

2.5 Conclusion

In the theory section, the relevant definitions have been elaborated, an overview of the proposed frameworks has been given, the process for circular business model innovation has been presented and an overview of design options has been given. This section will discuss which framework will be embraced for this research, how the process will be incorporated in the research and which design options will be embraced for the solution generation.

Based on the literature, a framework has been selected. This framework will be used throughout the research as a structure to research the business model and to present the solution created during the research. For the selection of the framework, it is important to facilitate the presentation of the current business model and the different solutions for circular business models. For clarity purposes, this research will embrace one framework but the sub-categories for the framework will be adopted based on the type of business model

described, a traditional or a circular business model. From the literature review can be concluded that most of the literature on sustainable business model innovation embrace a framework which originates from Richardson (2008). This result is verified by Geissdoerfer et al. (2018) in their recent review on sustainable business model innovation. Additionally, to the high level of adaption by peer-reviewed literature, the framework of Richardson (2008) has good explanatory power and therefore the framework of Richardson (2008) will be embraced for this research. For the current business model, which is nor sustainable or circular, the sub categories of Richardson (2008) fit best. Nonetheless, the original framework of Richardson (2008) does not imply the sustainable or circular aspect of a business model. For example, the value proposition is described by the offering, the target customer and the basic strategy to win customers and gain competitive advantage. The lack of circular business model frameworks based on the framework of Richardson (2008) have substantiated the choice for an adoption of a sustainable business model framework. The framework of Bocken & Short (2016) contains appropriate adoptions to the framework of Richardson (2008) by adapting the subcomponents for sustainable business models. To adopt the framework to the circular business model definition, the society aspect will be omitted. For example, Bocken & Short (2016) describe the value proposition as the product/service, the customer segment and relationships and the value for customer, society and environment. However, the society aspect will be omitted. The sub-categories with numbers three and ten have been adapted to fit the sub-categories to the definition of a circular business model. The take-back system from Lewandowski (2016) is also added to the framework because taking back a product is essential for a circular business model. For the circular business model presentations, the adapted sub-categories of Bocken & Short (2016) for circular business models fit best and are illustrated in Figure 10.

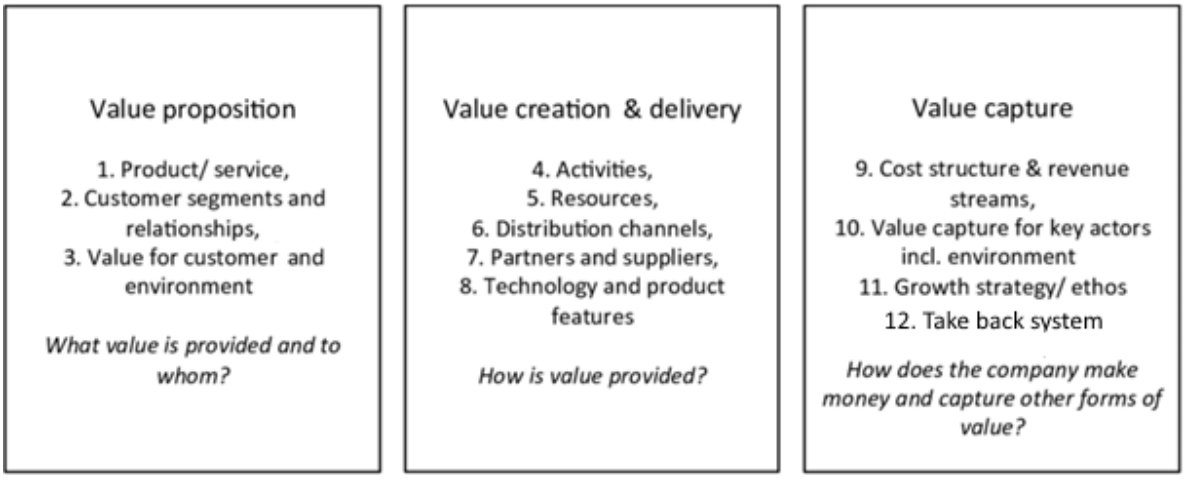

FIGURE 10 - THE FRAMEWORK OF BOCKEN & SHORT (2016) ADAPTED FOR CIRCULAR BUSINESS MODELS

Based on the literature, a high-level process has been selected. This process will be embraced to structure the innovation process of the business model. Besides the challenge of describing the desired future paired

to the BECE method, the work has received little citations from fellow researchers at the time of this research. So, the backcasting process proposed by the work of Mendoza et al. (2017) does not seem promising at this moment, but might be promising for future works. On the other hand, the 4I-framework of Frankenberger et al. (2013) matches closely to the regulative cycle which is embraced by this research. Additionally, the framework seems applicable for this research and has received better citations from fellow researchers at the time of this research. Therefore, this research will adopt the high-level process steps proposed by the 4I-framework of Frankenberger et al. (2013) illustrated in Figure 7.

Based on the literature, a more detailed process, named pattern adaption, has been selected for the ideation of new business models. This process will be used to generate ideas for solutions in this research. This research will use pattern adoption to ideate solutions for a new business model as it provides a structure for the researcher to investigate new opportunities. The pattern adaption method is preferred as it is more likely to generate novel ideas. The drawback of this method is that the mixing and combining of patterns may lead to impossible solutions. Therefore, the generated solutions will be carefully evaluated by managers.

Based on the literature, this research will study the current business model as it is recommended to fully understand the current business model of the business before innovating the business model (Giesen et al., 2007; Mitchell & Bruckner Coles, 2004; Sathananthan et al., 2018). This research will conduct an analysis on how the business model for the supporting structure of non-residential buildings is organized within the focal company as the second research question (Frankenberger et al., 2013; Giesen et al., 2007; Mitchell & Bruckner Coles, 2004; Sathananthan et al., 2018).

3 METHODOLOGY

This chapter will explain the methodology which is used to research the problem and to design an appropriate solution. First, the overall research design is explained. Next, the different methods of analysis are explained. Finally, an overview of the actions needed to answer a research question are explained in the plan of action section.

3.1 Research design – The regulative cycle

The research design refers to the overall strategy chosen to integrate the different components of the research and ensures that the problem is effectively addressed in an unambiguously and logical manner. The research design constitutes a blueprint for the collection, measurement and analysis of the data (de Vaus, 2001). This research will follow the regulative cycle to integrate the different components of the research. This section will explain what the regulative cycle is and the procedure used in each step of the regulative cycle to effectively address the problem.

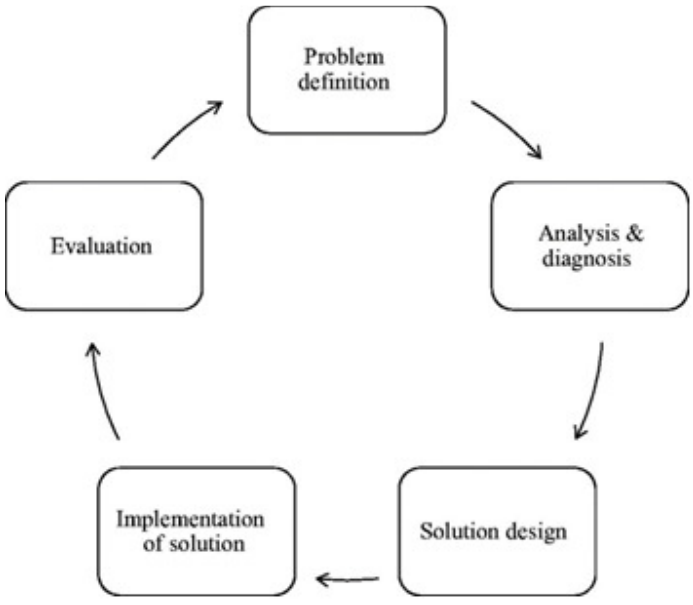

FIGURE 11 - THE REGULATIVE CYCLE ADAPTED FOR PROBLEM SOLVING

For the method of this research the regulative cycle of Van Strien (1997) will be used. The regulative cycle incorporates the steps needed to solve a business problem and is therefore referred to as the classic problem-solving cycle (Van Aken et al., 2007). Figure 11 depicts a representation of the regulative cycle adapted for solution design. The regulative cycle consists of five process steps: problem identification, diagnosis of the problem, plan of action, intervention, and evaluation of the new situation. This thesis will use the regulative

cycle adapted for problem solving since it is aimed at designing a solution to a problem. The problem solving cycle consists of a problem definition in which the problem is given. Next, an analysis and diagnosis of the causes of the problem and possible remedies are made. Thereafter, a solution is designed and is further elaborated. Once a solution is designed it is then implemented, aimed to bring about a change in the desired direction. Finally the solution is evaluated in the new situation. The order in which the process steps are executed depends on the progress of the project. This results in iterations and exploration of subsequent steps (Van Aken et al., 2007).

The application of the regulative cycle is favourable when the research is aimed at problem solving and taking decisions. The regulative cycle is also favourable when the research is focussed on one specific situation and therefore the solution generated by this research is not generalizable. In contrast, the process of synthesizing the solution can bring findings which are generalizable. An additional drawback of the regulative cycle includes the researcher being a participant in the research because of the interventions made by the researcher. For this research the generalizability of the solution is not a problem because the firm addressing the problem is not in favour of a solution which is generalizable to their competitors. The researcher is aware of participating in the research by the interventions and will therefore be cautious to act as neutral as possible.

In the following sub-sections, the method of analysis used in this research are elaborated by means of the steps of the regulative cycle.

3.2 Problem definition

The initial problem definition has been drafted by the principal of the project. This problem statement was dynamic, meaning that during further analysis and design, the problem statement was adjusted and modified to better represent the problem faced by the focal company. Changes to the problem definition have been agreed upon by the principal of the project and university supervisor. An example of a modification to the problem definition was the narrowing of the scope of the project towards the supporting structure of the building.

3.3 Analysis & Diagnosis

The analysis and diagnosis step is the analytical part of the regulative cycle. Objective knowledge about the type of problem should be used to interpret the results of the analysis and to support the diagnosis of the causes of the problem (Van Aken et al., 2007). The output of the analysis and diagnosis phase produces specific knowledge about the business context and the nature of the problem (Van Aken et al., 2007). The information gathered in the analysis and diagnosis should provide sufficient knowledge on the problem encountered to design the business model. This research has used qualitative methods of analysis to gain

knowledge on the research subject to gain an understanding of the underlying reasons and motivations of the problem encountered. As for the qualitative research method, the case study research has been chosen for this research. The case study research design is an in-depth study of a specific research problem. A case study design should be considered when the focus of the study is to answer "how" and "why" questions and the research wants to cover contextual conditions they are believed to be relevant to the phenomenon under study (Yin, 2006). Additional to the empirical data gather, this research has also embraced literature as a source of data. The analysis & diagnosis step will generate the information needed to develop the specifications for the solution.

The following sections will explain the methods of analysis used for the sub-research questions. The analysis and diagnosis has been split into two sections corresponding to the two sub-research questions. The first part corresponds to the first sub-research question and the second part corresponds to the second research question.

3.3.1 Theory

Creating a good overview of the existing literature requires a structured approach. The process of reviewing literature consists of five steps: problem formulation, data collection, data evaluation, analysis and interpretation and public presentation (Randolph, 1996). The problem of the first research question, what are the best methods or approaches for innovating a circular business model, has been formulated in the introduction. The next section will explain why literature is chosen to research the problem formulated. Subsequently the data collection and evaluation methods will be explained for each part if the research and thereafter the analysis and interpretation of the data will be elaborated. The public presentation of the data can be found in chapter 2 - THEORY.

Unit of analysis

The unit of analysis is the type of object that is the focus of interest (Van Aken et al., 2007). It is important to create an overview of the information readily available within the subject (Randolph, 1996). Therefore, the unit of analysis for this sub-research question is academic literature available to the researcher. Academic literate has the advantage of being readily available and peer-reviewed literature enhances data validation due to the peer-reviewing process.

The review of literature can be split into three sections. The first section creates an overview of the definitions used for this research which are business models, business model innovation, sustainable business model innovation, circular economy and circular business model innovation. The second section will select mapping tools or frameworks which will be used to design and present the business model. The last section creates an overview of the process approaches and options to innovate a circular business model. The framework selection has been presented separately in this section.

Definitions, process approaches and options

This section will explain the data collection and data analysis methods used to gather the required information and create an overview of the information.

Data collection

This paragraph will explain the methods used to collect the data from the literature. The first step is to identify relevant keywords. A short review of the Journal of Cleaner Production and google scholar has been conducted to create an overview of the keywords used within the relevant research fields. The list of relevant keywords has been updated as new articles were discovered to enhance the relevance of the findings related to the keywords.

The TU Eindhoven university library, multiple scientific databases and search engines have been reviewed for their ability to trigger relevant literature. The database of Elsevier's Scopus appeared to be most appropriate because of its level of accessibility and restriction to peer-reviewed literature. Additionally, the databases of ScienceDirect and the search engine of google scholar appeared appropriate for secondary searches because of their level of accessibility and filtering options.

	Search phrases	Results	Included
1	"business models"	24259	3
2	"circular economy"	2963	1
3	"review" AND "business model innovation"	113	8
4	"best practices" AND "business model innovation"	17	6
5	“business model innovation" AND circular	26	2
6	"business model" AND design AND circular	64	1
7	“business model innovation" AND sustainable”	246	1
8	Snowballing	-	11

TABLE 2 - OVERVIEW OF SEARCH PHRASES

Subsequently, the search quotes have been created to trigger the relevant articles. Due to the scarcity of the available literature, see Figure 1, precautions are taken not to exclude literature which contains valuable information. Therefore, the search terms are designed to not exclude important data. From a short analysis, the term “business model” shows in all relevant papers and therefore the search quote will require this term to be in the search phrase. Two terms are used to target reviews and literature on best methods or approaches. Multiple terms and combinations are used to target the innovation aspect, sustainability and circularity of business models. The resulting search phrases are presented in Table 2 - Overview of search phrases. The results column presents the number of results given by the Scopus database. The search results have then been sorted by number of citations and the first 40 results have been reviewed by a screening of their title, keywords and abstract to determine if the document is relevant for the review. The included column presents the number of documents included from the search.

The documents resulting from the search have then been used to identify further relevant literature. Thus, the method of concentric circles (Mark Saunders, Philip Lewis, 2011) was applied with backward- and forward-oriented literature searches in order to reduce the risk of overlooking prominent and important sources. The documents selected through concentric circles are indicated by their cited source in Appendix A – Overview of documents for literature analysis which presents the documents used for the analysis.

To assure the quality of the literature, a set of requirements for the documents to be included in the review has been made. A first selection is made based on the topic relevance of the article. The topic relevance has been evaluated by means of reading the article's title and abstract. If the article is considered valuable, the rest of the article was read to evaluate the relevance of the research for this review. If the article fits in the review and the remaining inclusion criteria were met, the article was included in the analysis. Furthermore, the literature had to be peer-reviewed and in case of a large number of search results, sufficiently cited. To include relatively new literature, an exception has been made for the citation criteria if the article was published in 2018. The inclusion criteria are presented in Table 3 including the search phrases to which they apply indicated in Table 2.

Search phrase	Inclusion criteria
All	Peer-reviewed
1,2,3,4,7	Citations of more than 9 OR Publish year: 2018
All	Topic on BMI with interesting information for Circular business models
3,4,5,6,7	Topic on Circular/sustainable business model innovation

TABLE 3 - CRITERIA FOR LITERATURE INCLUSION

Data analysis

According to Randolph (1996) it is important to classify the documents and to create summary databases. For this review the documents have been classified by their topic of interest. Business models, Business model innovation, sustainable business model innovation and circular business model innovation. The key findings from each documents have been grouped and ordered to create an overview of the relevant findings within the field. Subsequently, the key findings have been presented in the chapter Literature review.

The mapping framework selection

Multiple business model mapping frameworks are applied to present a business model in the reviewed literature (Morris et al., 2005). A literature review has been performed to create an overview of the frameworks embraced in the literature which has been used to select the frameworks for this research. The literature review is recommended for students and researchers new to the field (Pickering & Byrne, 2014). The other reasons to support the selection of the framework are the appropriateness, the ease of application and the explanatory power of the framework. The overview of the frameworks used in the literature have been created through the analysis of the framework embraced in 40 peer-reviewed documents.

Data collection

The literature documents have been collected through a search of the Scopus database. The analysis towards the framework has used two search strings and were adopted from the literature review of Geissdoerfer, et al. (2018) of sustainable business model innovations which can be found in Table 4. These search phrases have been chosen because the results best resemble the topic of interest. The first search strings used for the data collection is "sustainable business model*" and the second search string is "business model innovation" AND sustainab*. The * search operator is included in the search strings to represent any number of characters, even zero. For example, the search string sustainab* will return sustainable and sustainability. For both search phrases the documents have been sorted on "cited by (highest)" and the first 20 literature documents for each search string have been selected for a review. In total 38 unique documents have been selected for this review.

Search string	Search field	Number of results	Last updated
"sustainable business model*"	Topic/Article title, Abstract, Keywords	511	19/10/2018
"business model innovation" AND sustainab*	Topic/Article title, Abstract, Keywords	204	19/10/2018

TABLE 4 - LITERATURE SEARCH STRINGS

Data analysis

The selected documents have been analysed to identify the framework embraced by the author. An overview of the selected documents and the embraced frameworks can be found in Appendix B – Overview of documents for framework analysis. 17 of the 38 documents have been found to embrace a framework. When analysing the embraced frameworks the researcher has found that there is a wide variety of frameworks used in the literature. Therefore each framework has been analysed to identify the primary work on which the framework is based. The sustainable business model frameworks originate from business model frameworks and have been identified for each document. Four distinctive frameworks have been identified originating from the works of Richardson (2008), Osterwalder & Pigneur (2005, 2010), referred to as business model canvas or BMC, Zott & Amit (2010) and Abdelkafi (2013). The literature has been grouped based on the embraced framework and the data has been analysed for number of documents embracing the framework, sum of the citations, average number of citations, average publishing year. The results of the analysis are depicted in Table 1 - Results of the sustainable business model framework analysis.

3.3.2 Case study

This section will provide the unit of analysis, data collection and data analysis methods for the second research question. The second research question desires to create an understanding of the current business model for the supporting structure of non-residential buildings.

A qualitative case study methodology will be required to create an understanding of the current business model as a qualitative case study methodology contributes uniquely to our knowledge of organizational

phenomena (Yin, 2006). The next section will explain which unit of analysis is chosen to research the problem formulated. Subsequently the data collection and evaluation methods will be explained. The results of the research can be found in chapter 4, analysis & diagnosis.

Unit of analysis

The unit of analysis is the type of object that is the focus of interest. Several types of objects can be the unit of analysis, such as units of production, organizational units or process units (Van Aken et al., 2007). For this research question, the unit of analysis are the actors involved in the process of creating a non-residential building and have knowledge or interest in the circular development within the focal company. The literature on business model innovation suggests to create an enhanced understanding of the current business model when engaging in the innovation of the business model (Giesen et al., 2007; Lewandowski, 2016; Mitchell & Bruckner Coles, 2004; Sathananthan et al., 2018). The stakeholders and actors in the business practice the business model on a daily basis and will therefore be able to provide the required information.

One of the most important actors involved in the business model is the customer. For this sub-research question the customer has been analysed indirectly, by means of the interpretations of other actors involved in the business model. This method has been chosen as the focal firm was not willing to cooperate in the direct data collection from the customers.

One of downsides of analysing people is that people are by definition biased. According Power & Huber (1985), biases of respondents can be offset by interviewing respondents with unique biases or lack of knowledge. Therefore, respondents with different job functions have been interviewed within and outside of the organization.

Data collection

This paragraph will explain the methods used to collect the data for the research. From the variety of data collection methods, interviewing has been chosen as the main method for data collection as interviewing provides rich and detailed data for the understanding of the respondent's experiences (Rubin & Rubin, 2005). Rich and detailed data is desired to provide sufficient in-depth information for this research. A worthy alternative to interviews are focus groups as focus groups spark interaction between research participants. Focus groups are especially effective when debate is required. Focus groups have not been chosen as the data collection method for this research because debate is not required for the data collection and interviews provide a better method to gain more detailed answers per question (Harrell & Bradley, 2009). Surveys have not been chosen as a data collection method for this research as surveys do not provide the in-depth information needed (Harrell & Bradley, 2009). Interviews provide the in depth information needed for this research and match the practical limitations of the research (Harrell & Bradley, 2009).

Interviews can take various forms of control, varying from unstructured to semi-structured to structured interviews. The different forms of control have different benefits to them. Structured interviews have a

fixed set of questions which are asked in a specific order (Harrell & Bradley, 2009). Semi-structured interviews have an open structure allowing the interviewer to convey from the pre-determined structure to gain useful information which was not anticipated for in advance (Harrell & Bradley, 2009). In unstructured interviews the interviewer has a clear plan, but minimum control over how the respondent answers (Harrell & Bradley, 2009). The structured interviewing method does not allow the interviewer to deviate from the structure and is therefore less applicable to understand the reasoning behind the answers (Harrell & Bradley, 2009). Semi-structured interviews are used to delve deeply into the research topic and to understand the reasoning behind the answers provided (Harrell & Bradley, 2009). An unstructured interview is most appropriate when the researcher has a great deal of time to spend with the respondent (Harrell & Bradley, 2009). For this research there is not a great deal of time to spend with the respondents as this research has a deadline. Concluding, the semi structured interview seems most applicable for this research and has been used as the main method of analysis for this research. This allows for divergence of the interview topic to explore innovative ideas to problems.

Besides researching, the researcher has also worked at the focal company in a team of innovators. The researcher has worked on a project which aimed to develop a product innovation solution for the supporting structure. During this project, weekly meetings were held with experts from the field and discussions have taken place about the current business and activities. This has given the researcher insight into the working of the current business model. As this is not sufficient, additional research is performed to substantiate the findings on the current business model.

Internal documents

As a starting point for the collection of data, internal documents have been analysed to create an initial understanding of the current business model. Internal documents are documents used to share knowledge and to make decisions within the company. The internal documents are specifically tailored to the company's needs. Therefore, they give an enhanced understanding of the operations and organisation of the company. Internal documents are the preferred choice for data collection in the initial stage as the information is readily available. Furthermore, the analysis of the internal documents is aimed to triangulate the data gained for the second sub-research question. The internal documents have been collected and selected based on advice from the supervisors at the focal company and a list of documents can be found in Table 5. The findings of the current business model based on the internal documents have been verified with experts before the interviews or separate consultations. The position in the value network is an example of retrieved data from internal documents which has been verified with experts within the focal company.

Title	Contents	Pages
01022018_BC1_V2.1.docx	business case for a Modular product	15
2017-10-24_Totale modulaire potentie BC Concept.xlsx	Top down cost analysis of a modular product of MOB	

Afnemers- & stakeholdersanalyse (1).docx	Stakeholder analysis for MOB	14
Data analyze hoofddraagconstructie.xlsx	Data on buildings created by BAM	
Manifesto opzet a2 v2.pdf	Manifesto for designing modular products at MOB	1
Notulen sessie 10 Bouwkundige Modulariteit.docx	writings of meeting 10 on modular construction	7
Notulen sessie 7 Bouwkundige Modulariteit.docx	writings of meeting 7 on modular construction	8
Notulen sessie 8 Bouwkundige Modulariteit.docx	writings of meeting 8 on modular construction	11
Notulen sessie 9 Bouwkundige Modulariteit.docx	writings of meeting 9 on modular construction	6
O01_00_ACQUISITIE.pdf	Process flowchart and explanation of acquisition step	3
O02_00_SO.pdf	Process flowchart and explanation of sketch design step	4
O03_00_VODOONTWERP.pdf	Process flowchart and explanation of pre and definitive design step	3
O04_00_CALCULEREN.pdf	Process flowchart and explanation of calculation step	5
P01_00_ENGINEERING.pdf	Process flowchart and explanation of engineering step	5
P02_00_WERKVOORBEREIDING.pdf	Process flowchart and explanation of work preparation step	5
P03_00_UITVOERING.pdf	Process flowchart and explanation of execution step	3
P04_00_INBEDRIJFSTELLEN.pdf	Process flowchart and explanation of start-up step	5
P05_00_PROJECTAFRONDING.pdf	Process flowchart and explanation of finalization step	5
S01_00_BUDGETTEREN.pdf	Process flowchart and explanation of budgeting step	3
S02_00_CONTRACTEREN.pdf	Process flowchart and explanation of contracting step	3
S03_00_INKOOP.pdf	Process flowchart and explanation of procurement step	5
S04_00_FINANCIELE PROJECTBEHEERSING.pdf	Process flowchart and explanation of financial management step	7
Scriptie Distributiebaan Circulair conceptversie 2.docx	Research for the distibutiebaan	107
Stakeholder analyse invulmodel.xlsx	Overview of the stakeholders for modular product MOB	
Visio-Opzet processchema-versie9.pdf	Process flowchart of the MOB process	7

TABLE 5 - OVERVIEW OF INTERNAL DOCUMENTS USED FOR TRIANGULATION PURPOSES

Semi-structured interviews

Jacob & Furgerson (2012) highly recommend unexperienced qualitative researchers to use an interview protocol. An interview protocol is an instrument for asking questions to gain specific information related to the aims of a study (Patton, 2015). An interview protocol has been developed to ensure that all the information needed was extracted from the interviews and to give structure to the interview (Jacob & Furgerson, 2012). The insights given by the first research question and the analysed internal documents have been used as an input to design the interview protocol.

The guides of Jacob & Furgerson (2012), Castillo-Montoya (2016) and the University of Michigan (n.d.) have been used to develop the interview protocol as well as the scripts for the opening and finishing of the interview. According to the guide of the University of Michigan (n.d.) it is important to evoke stories before emotions are explored. This has determined the sequence of the interview protocol. The definitive version of the interview protocol can be found in Appendix C – The interview protocol. Trial interviews with the supervisor were conducted to improve the protocol which is recommended by Castillo-Montoya (2016).

Job role	Years of experience	Connection with the circular economy
Architect	18	Involved in the development of a modular product
Constructional consultant	42	Involved in the development of a modular product
Constructional engineer	16	Involved in the development of a modular product
Developer	11	Connected to the circl building
Manager of plan development	5	Involved in the development of the circular building platform
Director BAM Business developers - Governments	10	Promotor of circular building for governments
Counsellor	17	Promotor of circular building within municipal

TABLE 6 - DATA ON INTERVIEWEES

The respondents of the interviews have been selected based on their connection with the development of the circular economy within the focal company. The respondents of the interviews fulfil different job roles within the organization and therefore the respondents have knowledge on different topics. An overview of the interviewees can be found in Table 6. Ideally, interviews would take place until data saturation, the point when no new appropriate data is forthcoming, is achieved (Galvin, 2015). This was not the case for the interviews conducted for the second sub-research question. An interview matrix has been accustomed to match interview questions to the elements of the business model. The interview matrix provides an outline of the research topic which is linked to each interview question (Castillo-Montoya, 2016). The interview matrix can be found in Appendix D – The interview matrix.

Consultations

Due to the fact that not all the information required on the business model was known to the respondents, further consultations were needed. The missing information has therefore been retrieved through consultations with experts in the field. For this research, information was missing on the link between the cost and the revenue model. An informal meeting with a calculation expert, someone who is experienced in making offers for the sector, was held to collect the relevant data. The consultations tend to a narrative survey form of data collection. The results of this meeting can be found in the chapter analysis & diagnosis.

Data Analysis

This paragraph will explain the methods used to analyse the data obtained in this research.

Internal documents

The internal documents have been analysed and combined to create an initial understanding of the value chain of the business model. This initial understanding has been used as a starting point to formulate questions for the interviews which will give a deeper understanding of the value chain. The overview of the information gained from the internal documents has been presented to experts within the company for a confirmation of their correctness. Additionally, internal documents have been used for triangulation purposes. The triangulation of data increases the validation of the data through cross verification.

Semi-structured interviews

The interviews have been recorded and transcribed, on approval of the respondents, to allow for further analysis of the data obtained from the interviews. The transcripts have been checked by the respondents and the opportunity was given to provide additional information afterwards. Anonymity was provided during the interview through a confidentiality agreement to enhance the honesty of the results (Rubin & Rubin, 2005). The obtained transcripts have been coded for the further analysis of the data.

The data has been analysed according to a directed approach as a directed approach is useful when existing theory exists about a phenomenon that is incomplete or would benefit from further description (Hsieh & Shannon, 2005). Existing theory on business models is known and information is known about the business model of the supporting structure for non-residential buildings. The semi-structured interviews will be used to extend the information on the business model of the supporting structure for non-residential buildings (Hsieh & Shannon, 2005).

A directed content analysis approach starts with a theory or relevant research findings as guidance for initial codes (Hsieh & Shannon, 2005). The business model framework of Richardson (2007) has been used as the guidance for the initial coding of the data. For coding purposes the transcripts have been transferred to Microsoft Excel. Each saying has been placed in a separate row. Each row is separated into columns for information on who is speaking, the spoken text or transcript, the question and sub question linked to the interview protocol and summative text. The interview matrix provides an outline of the research topic which is linked to each interview question (Castillo-Montoya, 2016). For this analysis the interview matrix helps to link the interview questions to the business model framework. Microsoft Excel allows the researcher to filter text belonging to one or multiple interview questions or sub-questions. This allows for a great overview of the data per interview subject. The researcher has labelled relevant information based on its novelty. Novel information was then summarized in the summative column of the Excel sheet and transferred to a separate sheet containing only the novel information. The data per business model framework element has then been placed into groups and categories where created. These categories have been labelled creating the final codes. An overview of the codes, categories and counting scheme can be found in Appendix E – The interview codes and categories. The transcription and coding process have been conducted by the researcher.

After the coding was completed, an overview of the key findings of each of the interviews has been sent to the respondents for verification purposes as it is not expected that all respondents will thoroughly read the full transcript. The results of the semi-structured interview analysis can be found in the chapter of analysis and diagnosis.

Consultations

The consultations with experts have been setup to collect very specific pieces of information which can be summarized in numbers. Therefore the conversations have not been recorded or transcribed. Alternatively, the narratives have been summarized in an overview in an Excel sheet. A top down analysis has been used to create an overview of the costs of building the supporting structure.

Actor-linkage matrix

An actor linkage matrix has been accustomed to map the relationships between the actors (Reed et al., 2009). The actor linage matrix has been chosen as it is a relative easy process and requires few resources (Reed et al., 2009). To create the actor–linkage matrix first the stakeholders have been identified. This has been done through one-on-one sessions with employees of the focal company (Reed et al., 2009). An overview of the stakeholders can be found in Appendix G - Overview of stakeholders. Subsequently, the stakeholders have been differentiated and categorised by means of an interest- influence matrix (Reed et al., 2009). The influence-interest matrix can be found in Appendix H – Influence-interest matrix. The empirical findings have been combined with the interest-influence matrix to create the actor-linkage matrix which maps the relationships between stakeholders (Reed et al., 2009).

3.4 Designing the solution

Designing is the process of determining the required function of an object to be designed, combined with making a model of it. In the 'solution design' step, of the regulative cycle, the solution to the problem has been designed. This solution design translates the findings from the analysis & diagnosis step into a design to solve the encountered problem. This is done by means of specifications for the design. The design process is followed to design a solution for the problem since this method is driven by field problems and seeks to design a solution to the stated problem (Van Aken et al., 2007).

The design process incorporates the steps needed to design a solution for the problem encountered (Van Aken et al., 2007). For this research the synthesis-evaluation iterations and specification-design iterations from Van Aken et al. (2007) has been used as a foundation for the design process. The design process consists of five process steps to design a solution: problem analysis, developing specifications, synthesis, implementation and the evaluation. The problem analysis step of the design process are linked to the analysis and diagnosis step of the regulative cycle which is explained in the previous paragraph. The develop specifications step and synthesis step of the design process are linked to the solution design step of the

regulative cycle and will be explained in this paragraph. The develop specifications step has been placed in the design solution step of the regulative cycle because the design specifications are mainly created by the iterations of the solution design instead of by the problem analysis. Finally, the implementation step and evaluation step of the design process is linked to the implementation of the solution step and the evaluation step of the regulative cycle respectively. Figure 12 depicts a representation of the design process adapted for this research. The design process steps are linked to the regulative cycle by means of the dotted rectangles. The arrows depict the iteration process which will be further elaborated in paragraph 3.4.3.

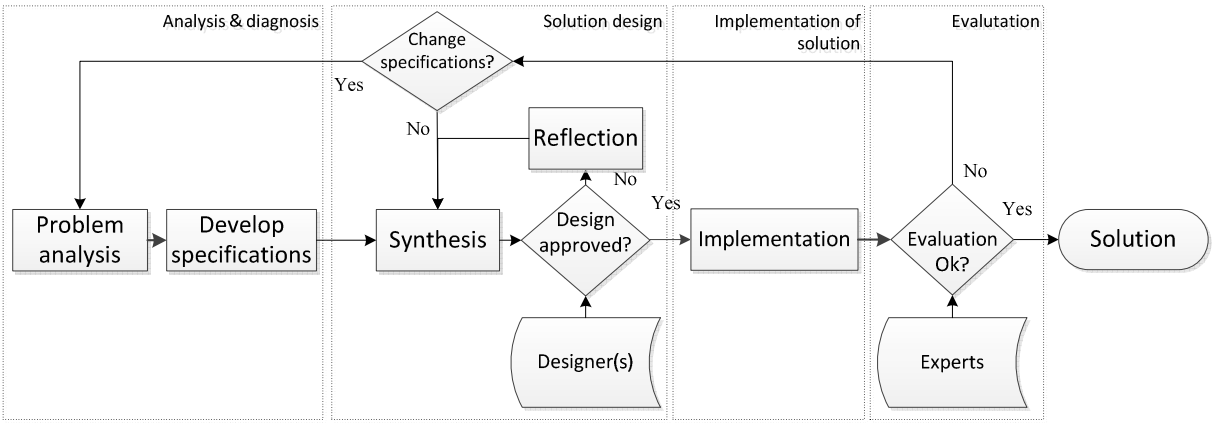

FIGURE 12 - THE DESIGN PROCESS ADAPTED FROM AKEN ET AL. (2007)

3.4.1 Develop specifications

The specifications, or design specifications, are detailed descriptions of the design which are used to design the business model. The design specifications are based on the findings from the problem specification, the literature review, the analysis of the business models and by iterations of the solution with experts of the focal company. The design specifications can be divided into functional requirements, user requirements, boundary conditions and design restrictions. The functional requirements form the fundamental requirements and describe the performance demands for the designed solution to fulfil. The user requirements are explicit requirements from the viewpoint of the user. Boundary conditions are requirements which should be met unconditionally. The design restrictions contain the requirements which are preferred for the design.

A solution can be broken down into different properties of which the design consists. These properties are the design parameters of the solution. Each design parameter or property can take on different possibilities and the combination of possibilities creates the solution. The design parameters create an overview of the possibilities available to create a solution to solve the problem. Therefore, the design parameters facilitate the process of playing with the alternatives. As mentioned by Van Aken et al. (2007), a good design is playing with alternatives.

3.4.2 Synthesis

The synthesis step is the creative leap. In the synthesis step multiple ideas are created and combined to form a connected whole based on the design specifications. For the synthesis of the business model the ideation and integration phases from the 4I-framework of Frankenberger et al. (2013) are used to generate ideas for potential new business models. The ideation phase is concerned with the transformation of design specifications into concrete ideas for a new business model and the integration phase focuses on the development of a new business model.

For the ideation phase, multiple analogies and a morphology for circular business models have been used to generate potential ideas for the synthesis of the business model. Analogies provide a fundamental method to support business model innovation (Lüdeke-Freund, Carroux, et al., 2018). The analogies contain a variety of existing business model patterns or innovations. Analogies provide an overview of patterns taken to innovate business models. Combining different patterns can lead to the generation of business model innovations (Abdelkafi et al., 2013). Therefore, the analogies will provide a fundamental base to ideate solutions for the business model. The embraced analogies have been further elaborated in the literature review.

3.4.3 The iteration process

The order in which the design process steps are executed is dependent on the progress of a project. This results in iterations and exploration of subsequent steps of the design process (Van Aken et al., 2007). The arrows in Figure 12 depict the iterations, or loops, made to design the final solution. The first design iteration loop starts in the design approved decision. This decision is made by the designer(s) and judges if the design meets all the design specifications. If the outcome is ‘yes’ then the process proceeds to the implementation step. If the outcome of the decision is ‘no’ then a process is started to reflect why the design does not meet all the specifications. The designer(s) then repeat the synthesis process with the accumulated knowledge of the reflection process. The second design iteration loop starts at the evaluation decision. After the design is implemented, the various actors/stakeholders determine if the design solves the problem. If the outcome is ‘yes’ then the problem is solved and the process is finished. If the outcome is ‘No’, then a decision is made if the specifications need changing and the design process restarts from the corresponding process step.

3.5 Implementation

The designed solution should be validated to ascertain the correctness of the solution (Van Aken et al., 2007). The implementation step acts as the organizational section to solve a business problem. The most reliable approach to validate a business model is through the practical implementation of the business model

(Frankenberger et al., 2013). This allows for a validation of the requirements confirmation of the correctness of the business model design. The implementation of a business model often involves huge investments and risks to be taken by the company of interest (Frankenberger et al., 2013) which do not seem to be obtainable for this research. For this reason, the real implementation of the business model will not take place during this research.

Alternatively to the practical implementation of the business model, MaRS Discovery District (2012) suggest a different approach to validate a business model. They suggest to test the assumptions on which the business model is built. The first step within the validation process is to explain the most important assumptions of the business model. Subsequently, the assumptions will be validated by means of checking the assumption with experts within the focal company. The focal company is already active in the construction of non-residential buildings and therefore sufficient knowledge should be available for the validation of the key assumptions by means of expert consultations. Finally, the overall business model will be tested with employees with knowledge on all three dimensions of the business model elements (Richardson, 2008).

To enable a correct validation of the individual assumptions and the complete business model, it is important to provide a presentation of the assumptions and business model which is sufficiently explanatory power. The individual assumptions are presented by means of statements. The complete business model is presented by means of the circular business model canvas as it is based on the business model canvas which has worthy explanatory power. The implementation of the assumptions and business models will be used to evaluate the correctness of the assumptions and the business model.

3.6 Evaluation

The last step, the *evaluation*, serves as the learning section. In the evaluation section, reflections on the design are made to enhance the potential of the solution. The evaluation can result in a ‘yes’ or a ‘no’. An approval of the evaluation of the solution will result in the definitive solution. A disapproval of the solution will result in further synthesis of the solution, excluding or including a further analysis of the problem. The solution has not passed the evaluation stage with an approval and is therefore in development.

Due to the expected resources needed to fully implement the model and no availability of these resources, an alternative approach is required. MaRS Discovery District (2012) suggest a different approach to validate a business model. They suggest to test the assumptions on which the business model is built. The first step within the evaluation is to explain the most important assumptions of the business model. Subsequently, the assumptions will be validated by means of checking the assumption with experts within the focal company. Finally, the overall business model will be tested with employees with knowledge on all three dimensions of the business model elements (Richardson, 2008). The evaluation is therefore split into two parts, the evaluation of the assumptions and the evaluation of the business model.

Data collection

For the evaluation of the assumptions, the researcher has identified experts with relevant knowledge on the topic. A one-on-one consultation meeting was planned in which the assumption of the business model was presented and feedback was given by the expert.

For the business model evaluations, experts have been consulted to evaluate the proposed business models. Focus groups seem to be better for the evaluation of the solution as focus groups create a debate. Nonetheless, focus groups have not been chosen for the evaluation of the solution because of scheduling difficulties. The selected experts to evaluate the business models have varied as the evaluation sessions have taken place at different periods of time. According to the handbook of Osterwalder & Pigneur (2010), the evaluation of the business model design can best take place with a SWOT analysis. A SWOT analysis allows experts to analyse the business model organization's Strengths and Weaknesses and identify potential Opportunities and Threats. The SWOT analysis provides a snapshot of the business model's development, the strengths and weaknesses, and it suggests future trajectories, opportunities and threats. Additionally, the SWOT analysis is a well-known tool to business people and has therefore been used in the last evaluation of the business model.

Experts have been chosen based on their capabilities to assess the assumptions on which the solution is designed and their availability. The purpose of the sessions was to present the solution to the experts, thereafter the experts were invited to comment on the assumptions underlying the solution. In all cases the solution was not approved and therefore the solution is in development. The first evaluation session invited ten experts to evaluate the solution. The second and third evaluation sessions have invited single experts to comment on the solution. During the final evaluation session a SWOT analysis has been conducted to collect the data provided whilst the first and second sessions were more of a consultation approach with the researcher taking notes of the data provided.

Data analysis

After the data collection, the provided data has been linked to assumptions on which the solution was built. Thereafter, the researcher judged the correctness of the specifications and conducted adjustments through the problem analysis and develop specifications process if necessary. Based on the judgement of the assumptions the researcher has determined the course of action for the further development of the solution. This varies between complete terminations of the solution to small adaptions of the solutions based on the correctness of the assumptions which have been evaluated in the session. The findings from the evaluation sessions are presented in the chapter evaluation of the solution.

3.7 Overview of methods of analysis

This chapter has explained the methodology of this research. Concluding, the design science methodology is most appropriate for the overall research design. To enhance the research outcome, two sub-research questions have been analysed. Different methods of analysis were required for both sub-research questions and therefore an overview is created of the methods of analysis for each sub-research question and its interpretations. This overview can be found in Table 7. The current business model has been analysed by means of the framework of Richardson (2008) the framework categorizes the business model by three categories. The value proposition, the value chain and value delivery and value capture. To add more detail to the data collection sources used, the business model is split into the three categories created by Richardson (2008).

(Sub-) research questions	1	2	Designing the solution
Literature	X	X	X
Internal documents		X	
Semi-structured interviews		X	
Consultations with calculation experts		X	
Group / One-on-one evaluation sessions			X

TABLE 7 - OVERVIEW OF METHODS OF ANALYSIS

4 FINDINGS

In this chapter, the findings of the analysis towards the current business model for the supporting structure and possible improvements are presented. A qualitative case study methodology will be required to create an understanding of the current business model as a qualitative case study methodology contributes uniquely to our knowledge of organizational phenomena (Yin, 2006). The findings of the case study will serve as an input for the design process of the solution and the findings are presented by means of the business model framework from Richardson (2008).

The findings that have been retrieved from internal documents, semi-structured interviews and consultations with experts. Findings based on the use of internal documents will be indicated by a reference to the source document. Findings based on the semi-structured interviews will be indicated by a numerical code which can be traced to the transcription paragraph. The translation of the numerical code to the transcript line and the translation from the transcript line to the numerical code are given by the following formulas:

Translation from the transcript line and sheet number in the excel file to the coding number:

$$Coding\ number = Sheet\ number\ *\ 500\ +\ line\ number$$

Translation from the coding number to the transcript line and sheet number in the excel file:

$$Sheet\ number\ = Divisor\ (coding\ number, 500)$$
$$Line\ number\ = Modulo\ (coding\ number, 500)$$

Findings based on consultations will be specified and the job role of the consulted expert will be mentioned.

4.1 The current business model

This section explains the current business model of the focal company for the creation of traditionally built non-residential buildings. The business model is presented by means of the framework of Richardson (2008) as explained in chapter 3.3.1.

4.1.1 Value proposition

The value proposition of a business model includes what the firm will deliver to its customers, why the customer will be willing to pay for it, and the firm's basic approach to competitive advantage. The value proposition can be presented by means of the offering delivered to the customer, the target customer and the basic strategy to win customers and gain competitive advantage (Richardson, 2008).

The offering

The focal company offers to create non-residential buildings tailored to the wishes of their customers ("BAM voor de kantoren | BAM Bouw en Techniek," 2018, 1003). They offer an integral solution and a high quality of working to create a solution that fits the unique customer's needs ("BAM voor de kantoren | BAM Bouw en Techniek", 84, 1001, 2108). This statement is backed up by a director within the focal company. The focal company enables themselves to create the best solutions through the facilitation of knowledge for the right expert employees ("Bedrijfsprofiel | Koninklijke BAM Groep / Royal BAM Group," 2018). The focal company is often not the least expensive in the market (2505) although customers often wish the cheapest option (328, 1113, 2006, and 2571). The focal company does not sell the supporting structure separately because the supporting structure is a sub-part of the whole building.

The target customer

In this section the current customer segment of non-residential buildings of the focal company is analysed.

The customer segment of the focal company consists of customers wishing to create non-residential buildings from 2000m2 floor space area. The empirical data suggests that the customers of non-residential buildings are demanding larger than average buildings. This is due to a larger amount of customers within the larger customer categories (2103). Consequently, a market analysis has been performed to analyse on the size of non-residential buildings created by the company. The floor space area of the building has been used as the size parameter to compare the distribution of the size of non-residential buildings. Two data sets have been created, the first for the non-residential buildings created by the company within the Netherlands and the second for the entire Dutch market of newly built non-residential buildings which has been retrieved from Olthof (2012). To identify if the focal company is in the upper end of the market in terms of floor space area, the relative distribution of the floor space area of non-residential buildings has been used as a parameter. The average floor space area is 18.514m2 and 80% of the non-residential buildings are included in the interval of 3000m2 gross floor space area to 55.000m2 gross floor space area. The data on the distribution of non-residential building floor space area is represented in Figure 13. This analysis suggests that the focal company is involved in creating larger non-residential buildings than the market average.

This analysis is limited due to the fact that the floor space area of the data collected for the focal firm is represented in the gross floor space area whilst the data retrieved from the entire Dutch market is represented in usable floor space area. Olthof (2012) suggests to convert the gross floor space area to usable floor space area for non-residential buildings larger than 1000 m^2 by the following formula:

$$\text{Usable floor space area} = 0{,}95 \times \text{Gross floor space area}$$

This conversion will not affect the conclusion of the analysis as the difference between the floor space area of the datasets is large than the conversion rate.

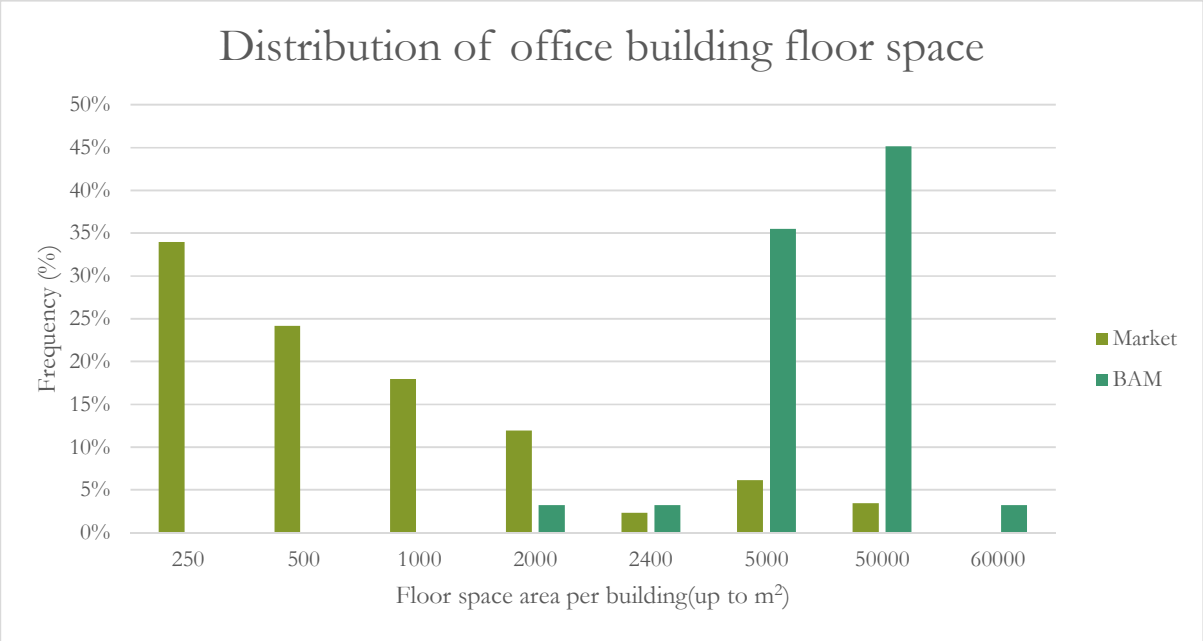

FIGURE 13 - DISTRIBUTION OF NON-RESIDENTIAL BUILDINGS BY FLOOR SPACE

Note that the horizontal axis of Figure 13 is not linearly distributed. The distribution has been determined by the data presentation of Olthof (2012).

Customer needs

In the current business model, the focal company serves four different customer groups, the government, large institutional investors, smaller risk-taking investors and small businesses (194, 2003, 2009, 2015, 2019, and 2103). Small businesses are owners of a company with the desire to provide their employees with workspace. The customers share the desire to create a non-residential building to provide workplaces but differ in their basic and social needs. A real-estate developer working at the focal firm mentioned that: "The last one [risk-taking investors] really focusses on the yield, risk and finding a good balance in those factors. They are willing to take more risk against a higher return. Sustainability plays a smaller role for them. For large institutional investors, sustainability plays a much bigger role. (2015)" An overview of the needs of the different customer segments is presented in Table 8.

Customer segments	**Small risk-taking investors**	**large institutional investors**	**Governments**	**Small business owners**
Functional needs	Provide a non-residential building	Provide a non-residential building	Provide a non-residential building	Provide a non-residential building
Basic needs	Profit	Profit	Provide workplaces	Provide workplaces
Social needs	No focus on sustainability	High focus on sustainability	High focus on sustainability	Medium focus on sustainability

TABLE 8 - CUSTOMER NEEDS

The basic strategy to win customers and gain competitive advantage

The focal company tends to focus on quality to gain a competitive advantage (2108). The added value of the focal company lies within their expertise of generating solutions to customer problems in the constructional sector ("BAM voor de kantoren | BAM Bouw en Techniek," 2018). This has become clear from a consultation with a director within the focal company. The customer does not always desire the added value of the company as four of the interview respondents who work at the focal firm have mentioned that the least expensive proposal for creating the non-residential building is often the most desirable and mostly chosen option (328, 1113, 2006, and 2571). A real-estate developer of the focal firm has mentioned that the financial yields of a real estate investment are extremely important for customers with an investing perspective and the yield of a building is directly linked to the initial building costs of the building (2015).

4.1.2 Value creation and delivery

The value creation and delivery of a business model consist of the activities, resources, distribution channels, partners and suppliers and the technology and product features.

Position in the value network

The position in the value network illustrates the position of the company compared to its suppliers, partners and customers. The value network of the focal company is comparable to other firms active in the industry. The focal company provides the service of connecting all parties required to create the non-residential building. In other words, the focal company is the main contractor and they are in command of the bulk of the steps in the creation of a non-residential building. The value network is elaborated by means of the process and the supply chain for the focal company. The process of creating a non-residential building starts with the raw material. The raw material is then manufactured into products. Subsequently, multiple designs are sketched to match the desires of the customer. When the final design is approved, the physical construction of the building is conducted. Once the construction is finished, the building is released and the operations and maintenance phase starts. The operations and maintenance phase is also referred to as the service and maintenance phase. Thereafter, two routes can be taken. The building can be renovated or the building can be demolished to raw materials. The actors involved in each phase of the construction varies for each project. Figure 14 depicts an overview of the process with the partners, suppliers and customers depicted for each phase of the process.

The supply chain for creating a non-residential building is divided over the focal company, subcontractors, manufacturers and the customer/end user. The focal company is the main contractor within the supply chain. They are responsible for the financials of the project and the project manager paired with the design team. The design team can vary but at least consists of the architect, quantity surveyor, structural engineer and mechanical and electrical engineer. The main contractor is the connection between the subcontractors and the customer. On the other side of the supply chain, the material flow starts with raw materials and the raw

material is converted into components. The conversion of raw materials to components is done by manufacturers who are classified as a supplier of the focal company. Partners of the focal company, or subcontractors, connect the manufacturers with the main contractor through deliveries and/or construction of the components. An overview of the construction supply chain is given in Figure 15.

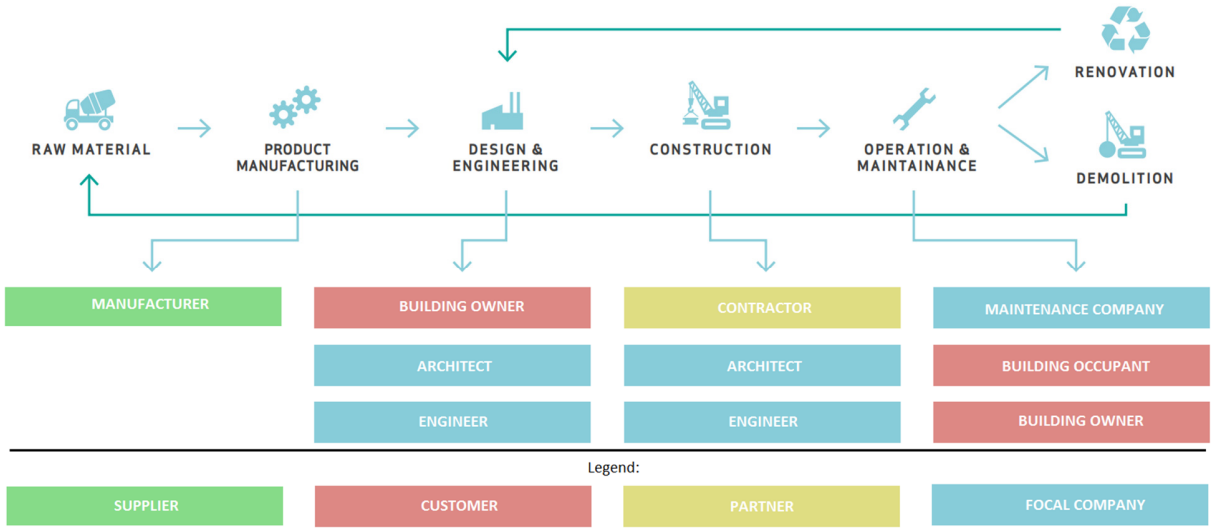

FIGURE 14 - HIGH-LEVEL OVERVIEW OF THE PROCESS WITHIN THE CONSTRUCTION SECTOR (De Groote & Lefever, 2016)

Organization, resources and capabilities

An actor linkage matrix has been accustomed to map the relationships between the actors (Reed et al., 2009). An actor linkage matrix tabulates the stakeholder in a two-dimensional matrix and their relationships described.

The organization explains the activity system and business processes within the focal company. From the previous section it has become clear that the focal company is mainly involved in the information flow of process corresponding to the creation of a non-residential building. To create an enhanced understanding of the activity system and the business processes linked to the focal company, an actor linkage matrix is created to describe the relationships between the most influential stakeholders. The actor linkage matrix, which can be found in Table 9, shows the most important actors, the most important relationships between the actors and what information or knowledge is transferred between the stakeholders to finalize the project.

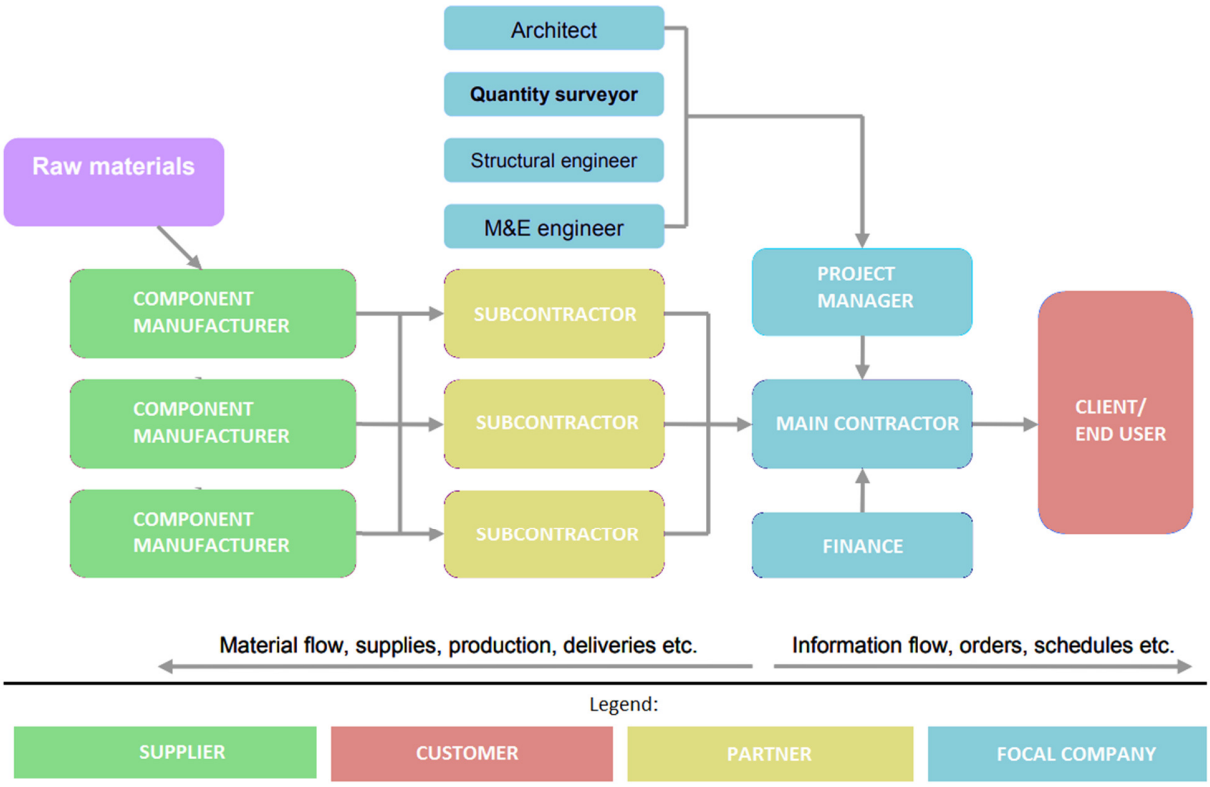

FIGURE 15 - THE CONSTRUCTION SUPPLY CHAIN (Barawas et al., 2013)

The actor linkage matrix shows that the tender manager and developer are the linking parties between the engineers, who create the design, and the owner of the building, who pays for the building. The tender manager and the developer therefore seem most appropriate for a consultation to verify the complete business model as they are the connecting links with the process and therefore have the required knowledge on the important components of the business model.

The expertise of the project managers, the financial experts and the design team are the valuable resources which enable the focal company to deliver their value proposition. The wide variety of knowledge and expertise available within the focal company creates a competitive advantage. Besides the information flow, the focal company is often the main builder present on the construction site. This creates an input for practical and new knowledge to the experts working at the focal company.

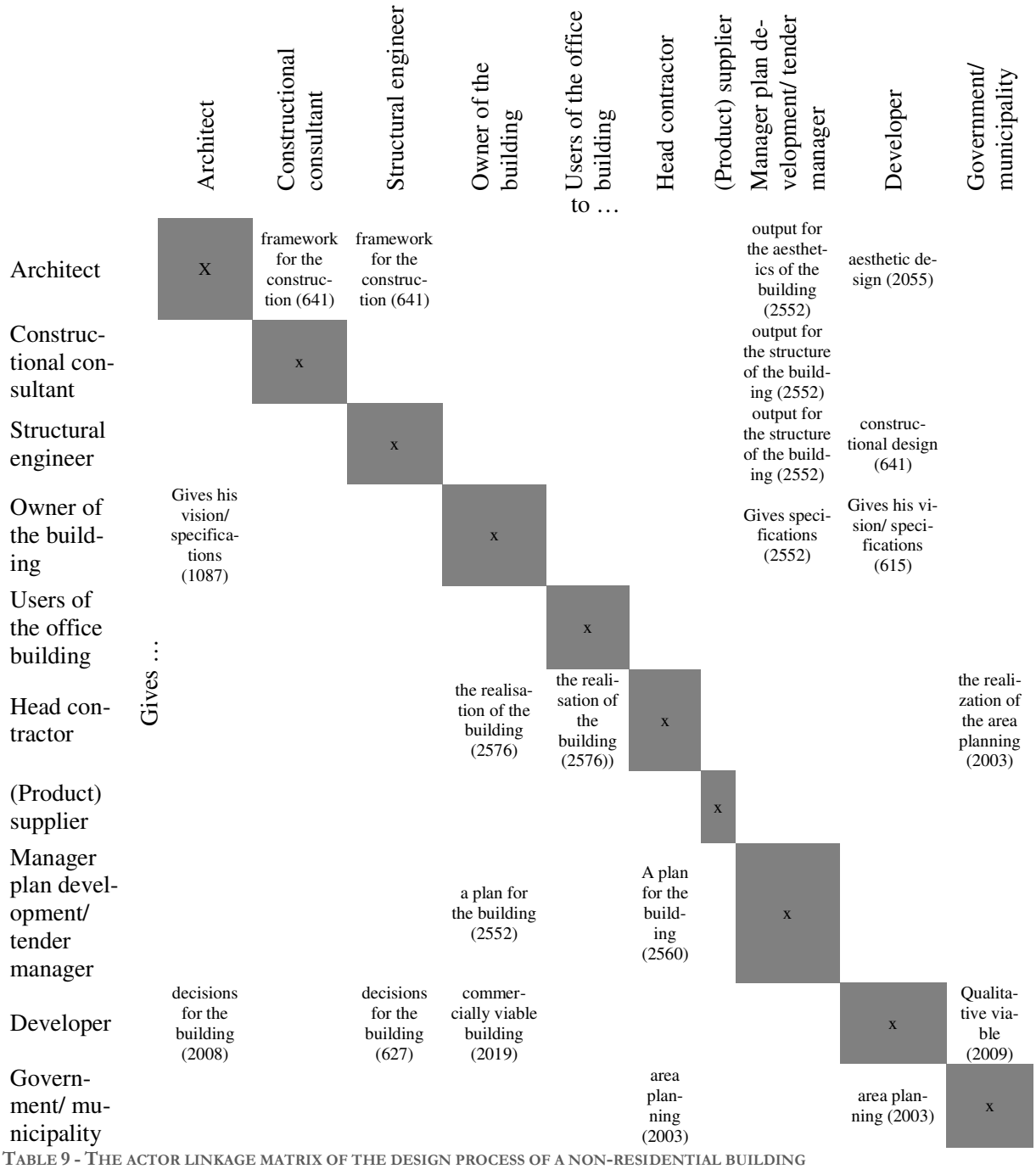

TABLE 9 - THE ACTOR LINKAGE MATRIX OF THE DESIGN PROCESS OF A NON-RESIDENTIAL BUILDING

4.1.3 Value capture

The costs of the focal company consists of consultations with the experts of the focal company, purchasing of construction materials and the hiring of sub-contractors. Revenue is created by forwarding the costs to the customers with an additional surcharge. The surcharge is used to generate a profit. This has been found

from a meeting with a cost calculator. Additionally to the surcharges, profit is also generated by decreasing the required resources after the offer is agreed upon.

Revenue sources and the economics of the business

To get a better understanding of the value capture aspect of the business model, the revenue sources and the economics of the business are analysed. The revenue model describes the sources of revenue or different ways that the firm receives money in exchange for its services (Richardson, 2008). The economic model covers the costs, margins, and various financial aspects of the firm (Richardson, 2008).

To create an enhanced understanding of the division of costs in the creation process of a non-residential building, this section will present the findings of two financial analyses. The first section analyses the distribution of costs per constructional element. This analysis will indicate how much money is accounted for each constructional element. The second section analyses the temporal distribution of costs accompanied by the creation and ownership of a non-residential building. This analysis will specify how much money is spent in each year/phase of the building.

Distribution of cost per constructional element

To create an understanding of the costs which are associated with the supporting structure an interview has been conducted with a cost calculating expert from the focal firm. Sequentially, the gained data was gathered to conduct a top down analysis to calculate the costs associated with the material for the supporting structure and how much costs are devoted to engineering of the supporting structure.

The top-down analysis indicates that 6.9% of the building costs are devoted to the materials of the supporting structure and 0.83% of the costs for the supporting structure are devoted to engineering costs. Together the total costs for the supporting structure add up to 7.73% of the total building costs. The top down analysis is depicted in Appendix F – Top-down analysis of the supporting structure.

Temporal distribution of revenue of a non-residential building

An analysis of the temporal distribution of costs of a non-residential building is made to understand which costs are associated with each phase of a non-residential building. The analysis will show how much money is spent by the owner of a non-residential building over the lifetime of the building. The empirical data suggests that most of the earnings are generated by the service and maintenance of the buildings (171). If this is the case then it is important to leverage the earnings from service and maintenance in the new business model.

The temporal cost analysis has been conducted to analyse the costs of a non-residential building associated with the different phases of construction, usage, renovation and deconstruction. The temporal cost analysis will give an indication of the market size of the service and maintenance of non-residential buildings compared to the construction of non-residential buildings. Based on the fact that the profit margins are based

on the calculated costs and the assumption that the calculated costs are correct, the relative revenue generated in the different phases of the non-residential building are linked to the relative profits of the phases. The building analysed in the breakdown has a floor space area of 4000 m^2, which is the most common building space area for the focal company, has a lifecycle of 60 years until deconstruction and the building is renovated three times during its lifecycle. An overview of the costs per phase of a non-residential building can be found in Table 10. Appendix I presents the costs of each phase per floor space area including the sources used for the model. Figure 16 displays the graph of the temporal costs analysis of the non-residential building over time.

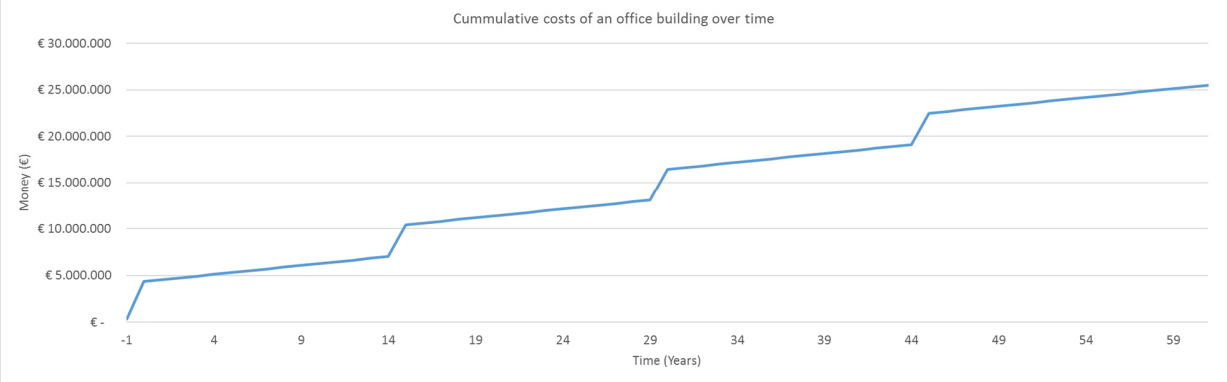

FIGURE 16 - CUMULATIVE COSTS OF A NON-RESIDENTIAL BUILDING OVER THE LIFECYCLE

Phases	**Costs (€)**	**Costs (%)**
Constructional costs	€ 4.364.360,00	17,1%
General execution costs	€ 360.360,00	1,4%
Construction costs	€ 4.004.000,00	15,7%
Annual costs	€ 11.400.000,00	44,7%
Service and management (60 years)	€ 11.400.000,00	44,7%
Renovation costs	€ 9.565.800,00	37,5%
3x renovation – Demolition costs	€ 606.000,00	2,4%
3x renovation – Execution costs	€ 739.800,00	2,9%
3x renovation – Construction costs	€ 8.220.000,00	32,3%
Deconstruction costs	€ 156.000,00	0,6%
Total cost over the lifetime of the building	€ 25.481.800,00	100,0%

TABLE 10 - DISTRIBUTION OF COSTS OVER THE LIFETIME OF THE BUILDING

The results of the temporal cost analysis indicate that the majority of costs of a non-residential building are allocated to the service and management of the building. This finding indicates that the service and maintenance market is substantially larger than the constructional market.

This analysis indicates that the service and maintenance is an important part of the profits for the focal company. Therefore, profits will be larger if the solution includes service and maintenance. Additionally, the supporting structure has a small direct impact on the service and maintenance costs (Dukers, 2004a).

4.2 Recent developments

This section will elaborate on the developments taking place at the focal company. The overview of the recent developments will help to create an overview of the current innovations taking place at the focal company which can be benefited from.

4.2.1 Circular Building Platform

The focal company has started the development of the circular building platform. The circular building platform is a virtual marketplace for reusable products within the construction industry. Owners of construction products can offer their products in the marketplace and buyers can bid on the construction products to buy reusable products. The tool has been devised during the building of Circl, a circular building built in Amsterdam. It became clear that no marketplace existed specialized for construction products which is essential when creating a circular solution based on circular products. This has motivated the company to develop their own marketplace to resell the products from the Circl building in the future. In the circular building platform every product gets its own product passport containing essential information. The circular building platform is still in development and currently no available products are offered on the platform (2628). The circular building platform can facilitate the sales of reusable and used products for the supporting structure.

(“BAM ontwikkelt circulaire marktplaats voor de bouw - Cobouw.nl,” 2017).

4.2.2 BAM MEC

The focal company has started development of the software tool BAM MEC at the start of 2018. The BAM MEC offers the ability to configure custom built modular products for the corresponding building. This is possible due to the availability of the required information in a building information system. The result is a more efficient and effective process in the design, engineering, construction and operation & maintenance phases of the building. The circularity of the building is stimulated through the BAM MEC because the ease of reusing components is increased.

The software tool offers engineers a platform in which they can design the installation products of the building. The new process decreases faults and decreases the amount of labour required to design the products and therefore decreases the costs of the products. The BAM MEC is being developed to add more modular products with the ultimate goal being to design a complete building in the BAM MEC ("BAM voegt met configuratie platform dimensie toe aan digitalisering bouwproces | BAM Bouw en Techniek," 2018).

4.3 Designing the solutions

Previously, the results of the literature review and the results of the analysis towards the current business models have been presented. These results serve as an input the for design process of the solution. This chapter presents the process of developing the concept solution based on the iteration process explained in section 3.4.3. This chapter is presented by means of the following sections; design specifications and design parameters. The design specifications are different from the design parameters. The design specifications specify a condition which the solution should meet while the design parameters consist of a set of factors forming the solution. A design parameter can take several options. For explanation purposes an example is given. The realization of the solution should decrease net material waste and decrease net energy waste. This is a requirement which the solution should meet but how it can be met is not specified. The design parameter, circular material use proposes several options for the factor. The specification is not necessarily linked to a parameter like in this case. The design specification together with the design parameters will lead to the design of the concept solution.

4.3.1 Design specifications

The design of a good solution starts from the specifications for the design (Van Aken et al., 2007). The design specifications are detailed descriptions of the design which the solution should fulfil. The design specifications are based on the findings from the problem specification, the literature review, the analysis of the business models and by design iteration loops of the solution with experts of the focal company. The source of the information used to generate the specification has been indicated in-between brackets. The solution should meet four types of specifications; functional requirements, user requirements, boundary conditions and design restrictions (Van Aken et al., 2007). These requirements are explained in the following section.

Functional requirements

Functional requirements are the core of the design specification in the form of performance demands on the object to be designed and the functional requirements for the solution are:

- The realization of the business model should generate profit from a circular supporting structure. (Problem specification)
- The realization of the solution should decrease net material waste and decrease net energy waste. (Definition of circular business model)

User requirements

User requirements are specific requirements from the viewpoint of the users and the user requirements for the solution are:

- Employees currently working in the business system should have the competences needed to work in the new business system and to use the new procedures. (Amit & Zott, 2009)

Boundary conditions

Boundary conditions are conditions which should be met unconditionally and the boundary conditions for the solution are:

- The business model should enable the creation of non-residential buildings. (Problem specification)

Design restrictions

Design restrictions are restrictions which incorporate the preferred solution space and the design restrictions for the solution are:

- The business model should be applicable within the coming 2 years. (Design iteration loop)
- The business model should increase the long term profits of the company (Problem specification)

4.3.2 Design parameters

Design parameters are the properties of which a design or solution consists. Each design parameter or property can take on different possibilities and the combination of possibilities creates the solution. According to Van Aken et al. (2007), a good design is playing with alternatives. The design parameters can vary throughout the design process and changing the design parameters facilitates the process of playing with the alternatives. Therefore, the design parameters are the foundation of a design and this chapter will elaborate on the design parameters for the business model.

The work of Lüdeke-Freund, Gold, et al., (2018) has created an overview of design options which can be embraced for the solution to this research. The circular business model design options will be embraced in the design parameters of the solution creation. The circular business model design options are presented in Figure 17 - The circular business model design options (Lüdeke-Freund, Gold, et al., 2018). The business model dimensions embraced by Lüdeke-Freund, Gold, et al., (2018) do not correspond to the dimensions embraced for this research. Therefore, a mapping tool has been created to map the business model dimensions of Lüdeke-Freund, Gold, et al., (2018) to the dimensions embraced by this framework. This tool is

presented in Table 11 - Business model dimension mapping. The table presents the dimensions embraced by Lüdeke-Freund, Gold, et al., (2018), on the right, and the dimension embraced by this research, on the left. The dimensions of Lüdeke-Freund, Gold, et al., (2018) are linked to the dimensions by the numbers which are assigned to the embraced dimension.

BM Dimensions		CEBM design options derived from reviewing 26 CEBMs (the number of CEBMs that mention the respective design option is indicated in parentheses)[a]								
Value proposition	Products	Repaired, refurbished, remanufactured, or recycled products (3)	Reusable or recyclable products (3)	Products based on recycled waste (3)	Long-lasting products (3)	Used products, components, materials, or waste as production inputs (5)	Reusable or recyclable production inputs (1)			
	Services	Facilitating collaboration (3)	Take-back management (4)	Customer education (3)	Waste handling, processing (3)	Product-/service-based functions (2)	Maintenance, repair, control (4)	Product-/service-based results (1)	Upgrading (2)	Auxiliary services (2)
Value delivery	Target customers	Quality-conscious customers (1)	Cost-conscious customers (1)	Green customers (2)	B2B customers (4)	B2C suppliers (1)	B2B suppliers (2)	C2C suppliers (1)		
	Value delivery processes	Connecting suppliers and customers (5)	Providing access to a product's functionality (2)	Providing (product-based) services and results (2)	Providing used products, components, materials, or waste (4)	Taking back used products, components, materials, or waste (4)	Sharing products, components, materials, or waste (2)			
Value creation	Partners and stakeholders	Suppliers (1)	Manufacturers (5)	Retailers (2)	Service providers (2)	Public institutions (2)	Collectors of products, components, materials, waste (2)	Others (e.g., researchers) (1)		
	Value creation processes	Maintaining or repairing products, components (6)	Refurbishing or remanufacturing products, components (5)	Recycling of products, components, materials, waste (3)	Upgrading or upcycling of products, components, materials, waste (3)	Reselling products, components, materials, waste (3)	Taking back or recapturing products, components, materials, waste (7)	Winning back base materials (4)	Using used products, components, materials, waste as input (8)	Matching over- and under-capacities (4)	Designing products, components, materials (4)
Value capture	Revenues	Additional product revenues (3)	Payments per unit of service (5)	Payments for functions or results (1)	Price premiums (6)					
	Costs	Labor (1)	Repair, maintenance, control (3)	Waste handling, processing (7)	Manufacturing (1)	Resource inputs (13)	Transportation, logistics (1)	Supply risks (1)		

FIGURE 17 - THE CIRCULAR BUSINESS MODEL DESIGN OPTIONS (Lüdeke-Freund, Gold, et al., 2018)

4.3.3 The solutions and evaluations

In this section the outcomes of the design cycle are presented. The methodology section has covered how the solution have been designed and therefore this section will only explain which solutions have been created and why certain choices have been made resulting in these solutions. To indicate the origins of the building blocks, the building blocks of the solution are coloured. The building blocks with text coloured in black originate from the original business model for the supporting structure. The building blocks with text coloured in blue originate from the business model of BAM MOB. The building blocks with text coloured in green originate from the given problem statement or research findings and the building blocks with text coloured in red originate from the literature findings.

This section will also present the evaluations of the designed solutions. Throughout the research, solutions have been presented to experts within the company and feedback on the solutions was provided by the experts. Additionally, key assumptions on which the solutions are based have been tested through consultations with experts within the focal company. This chapter will elaborate on the evaluation of the solutions.

#	Embraced dimensions	Lüdeke's Dimensions	Linked to embraced dimensions
1	Product/services	Product	1
2	Customer segment and relationships	Services	1
3	Value for customer and environment	Target customers	2
4	Activities	Value delivery processes	4,5,6
5	Resources	Partners and stakeholders	7
6	Distribution channels	Value creation processes	8
7	Partners and suppliers	Revenues	9
8	Technology and product features	Costs	9
9	Cost structure and revenue streams		
10	Value capture for key actors incl. environment		
11	Growth strategy / ethos		

TABLE 11 - BUSINESS MODEL DIMENSION MAPPING

The first solution presents a business model based on the "job-to-be-done" pricing system for the supporting structure of non-residential buildings. The solution has been generated early in the research project based on academic literature proposing the job-to-be-done pricing systems and product-service systems (Boons & Lüdeke-Freund, 2013; Johnson, 2010; Moreno, De los Rios, Rowe, & Charnley, 2016; Nasiri, Rantala, Saunila, Ukko, & Rantanen, 2018; Schaltegger, Lüdeke-Freund, & Hansen, 2016). Additionally, Mitsubishi is well known within the industry for their conversion to the product as a service model. The Job-to-be-done solution is based on the current business model of BAM MOB and extended with the literature findings on a job-to-be-done pricing model. For the cost and revenue streams of the proposed solution, the job-to-be-done pricing model has been adopted. The payments for functions or results and the payments per unit of service option meet the job-to-be-done pricing model. The payments for functions or results will create a stable revenue flow as the function of the product is more predictable. Therefore the solution has adopted the payments for functions or results revenue model. For the products/service offered by the company, the reusable products and product service based functions are chosen. The BAM MOB department is specialized in the development and manufacturing of reusable products which matches the reusable products option from the design parameters. Additionally, the product service based results has been chosen because the result oriented service will offer a job-to-be-done service. The business model solution is presented in Figure 18 – Solution 1, The Job-to-be-done solution.

The first solution has been presented to the employees as an exploration step in the regulative cycle (Van Aken et al., 2007). The presentation of the first business model has taken place during an exhibition for BAM employees. This exhibition has taken place in the BAM MOB department and three 20 minute sessions with three or four employees have taken place to provide feedback on the first exploratory solution.

Zero experts approved the solution to be promising and two employees were in doubt of the success of the business model. The main concerns are on the inseparability of a single component without the removal of other components and on the value adding potential of the solution compared to the already existing business models of investors. The supporting structure of a building is inseparable as the supporting structure cannot be removed without the removal of other components of the building. The supporting structure provides the support of the building and other components depend on the supporting structure to stay in place and therefore removing the supporting structure will require the removal of a substantial part of the building. This makes the supporting structure inseparable without the removal of other components. Inseparability of a single component is seen as key for the success of the business model as removal of the product, for example due to payment issues, will lead to high costs and legal problems. The objections of the solution are based on the job-to-be-done pricing model and therefore this solution has been put aside.

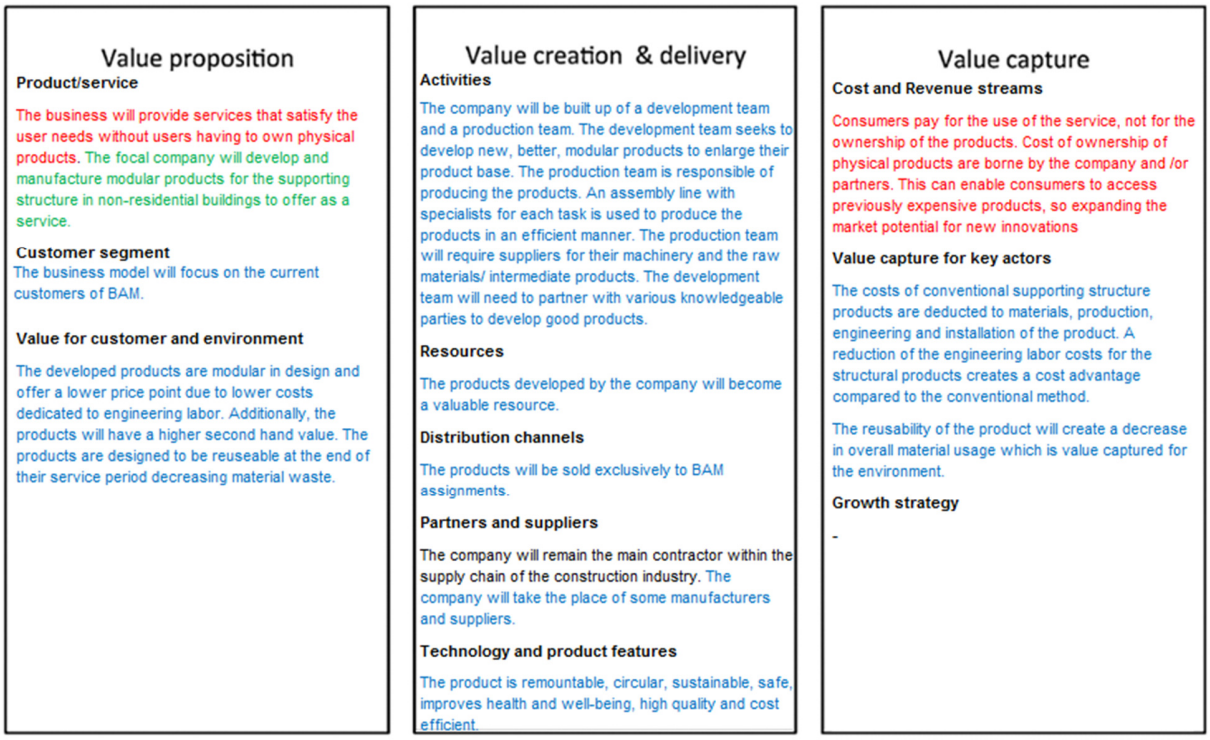

FIGURE 18 – SOLUTION 1, THE JOB-TO-BE-DONE SOLUTION

The second solution presents a business model based on the business model of BAM MOB. The business model has been adapted to fit the problem of creating a solution for a circular supporting structure for non-residential buildings. The current business model of BAM MOB has successfully developed, introduced and manufactured circular products for installations of a non-residential building. The current business model of BAM MOB matches multiple options within the dimension of the design parameters. These are: the reusable or recyclable products from the products dimension, the providing (product-based) services and results option from the value delivery processes dimension and the designing products, components,

materials option from the value creation processes. Therefore a solution has been based on the current business model of BAM MOB and has been adapted for a circular supporting structure. The business model is focussed on the supporting structure of non-residential buildings and therefore the product/service offering is different to the current business model of BAM MOB. The product which will be offered by the modular components solution matches the reusable products options. Furthermore, the solution matches the maintenance, repair and control option from the services dimension, the quality-conscious customers' option from the target customers' dimension and the providing (product-based) services and results from the value delivery processes dimension as the company will remain the main contractor. The suppliers of raw materials will become an important partner and stakeholder and the designing products option from the value creation processes dimension will be matched by the solution. The price premium option from the revenues dimension and the labour, manufacturing, resource inputs, transportation, logistics and supply risks options from the costs dimension match the modular components solution. This business model solution is presented in Figure 19 – Solution 2, the modular components solution.

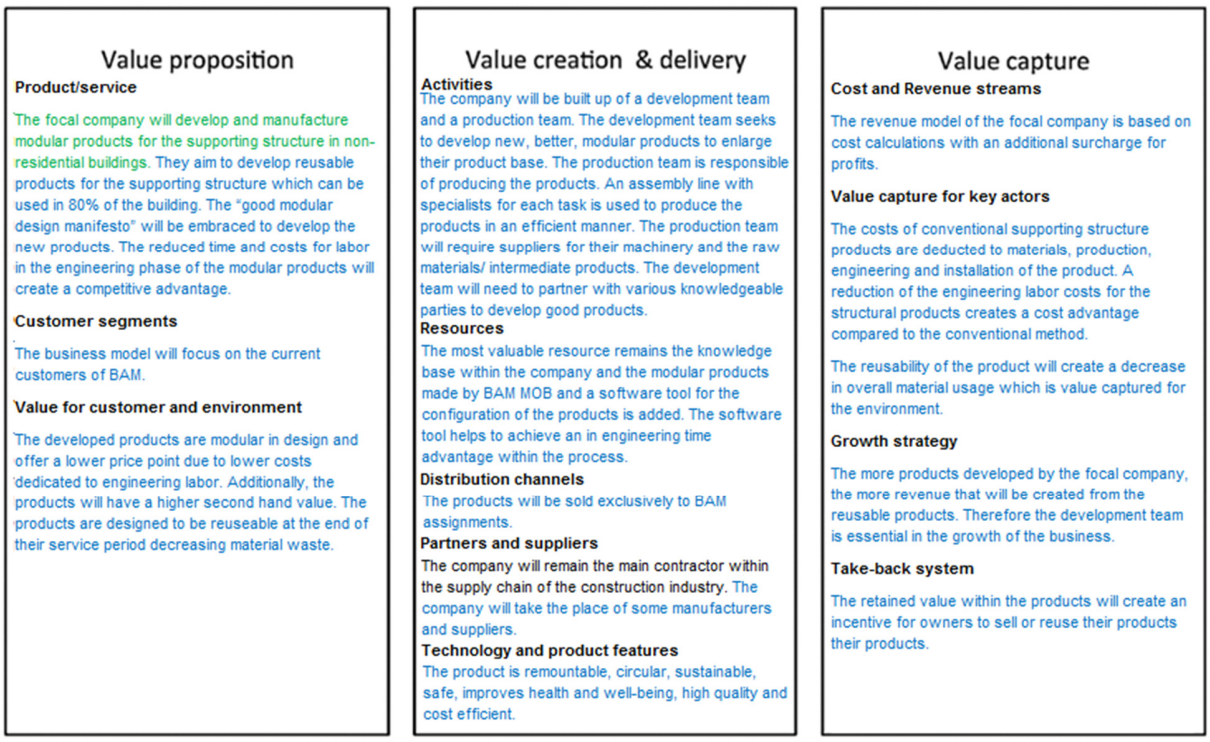

FIGURE 19 – SOLUTION 2, THE MODULAR COMPONENTS SOLUTION

The evaluation of the second solution was held with an employee of the BAM MOB development team. This was a one-on-one evaluation session in which the solution was presented to the employee and thereafter the employee was free to comment on the solution. The complete solution was discussed and the main concerns were summarized at the end of the meeting.

The main concern of the second solution is the development of a wide spectrum of reusable products for supporting structure. A wide variety of products seems needed for engineers to create a promising design for a non-residential building because each customer has different needs which requires different products to design a solution for their needs. Creating a wide spectrum of products for the supporting structure will require development time and financial resources. An evaluation of the assumption that a wide variety of products is needed for the engineers has been tested by a group of twelve employee engineers. This was done after a presentation of a reusable product for the supporting structure. The engineers were asked if this product, or a similar product, would be able to replace current products for the supporting structure. The engineers indicated that a wider variety of products would be needed for the solution to be promising. Three engineers indicated that a minimum of ten products would be needed to be successful. Additionally to the wider variety of products, the company has ceased their attempt to develop a reusable product because no further investments towards the development of a modular supporting structure are desirable or cost worthy. The combination of these two evaluation findings has resulted in the avoidance of the internal development of elements for a supporting structure.

The feedback from the evaluation has been discussed with a member of the development team to adapt the requirements of the solution. The proposed solution would not be possible within the foreseeable future as resources will be required in the form of financial and development labour which are not available at the moment. Therefore, one addition to the design specifications has been made caused by this evaluation loop: The business model should be applicable within the coming 2 years. The 2 year time frame has been chosen as the company desires to create a solution within the coming 2 years.

Based on the evaluation of the second solution, an additional synthesis loop has been conducted to create the final solution. The final solution has been inspired by the original business model in which the company is in the business of the main contractor, who is in command of connecting sub parties and by the literature suggestion to embrace collaboration for circular business models. The final solution proposes to connect multiple sellers and buyers together and therefore the final solution is called a switchboard. A switchboard is a system which connects multiple sellers and buyers. The final solution is presented in chapter 5 – Solution and only the evaluation of the final solution will be presented in this chapter.

A developer and a manager plan development are most suitable to evaluate the business model for the following reasons: They are influential stakeholders within the process, they are the connecting elements between the customer and the engineers and they have insight in the costs and revenue of the project.

The third and final evaluation has taken place with a manager of plan development who has helped in the development of the circular building platform, a platform designed to assist the transition towards a circular economy within the construction sector. Throughout the session with the manager plan development, the technical feasibility and the novelty of the designed solution have been confirmed by the manager plan development. Additionally, the manager plan development mentions that a platform which facilitates the

trade of used circular elements is already in development, the circular building platform, but not yet in operational service. A small number of essential technical changes are required to incorporate new products to the existing platform, making it suitable for the designed business model. Further integration with a design tool, or the BAM MEC, will be required to facilitate the engineers in the design process. The manager of plan development has expressed his concerns about the parties willing to develop new products for the business model. Therefore, the assumption that suppliers are willing to develop new products for the focal company, has been tested by phone calls with relevant companies. The openness to cooperate in the design and manufacturing of products has been evaluated thru cold phone calls to the customer desk of a potential key supplier/partner. A series of phone calls with one company has resulted in the confirmation of a collaboration by means of the designed business model by Stora Enso, who is a leading provider of renewable solutions for wooden constructions.

One final assumption remains unverified. The assumption that the reusable products will maintain financial value after their service life has not been verified. Proven methods to determine the second hand value of construction products or circular products seem to be unknown.

5 SOLUTION

The goal of this research is to design a circular business model for the creation of non-residential buildings. To design the circular business model, the design requirements, design parameters, research findings and evaluation findings are combined. After the completion of the iteration processes a final business model has been designed. This design is called the Switchboard for circular building.

A circular business model should be designed which will provide a supporting structure for circular non-residential buildings. A switchboard is a system which connects multiple sellers and buyers. A switchboard has the characteristic of becoming more valuable as more buyers and sellers join the switchboard. The focal company will be in command of the bulk of the steps in the value adding process, the construction of the building, as the focal company will be the integrator within the value chain. An integrator is in command of the bulk of the steps in a value-adding process.

In the switchboard for circular buildings solution the focal company will provide the service of designing and constructing a non-residential building with the use of reusable products which can be sold on the software platform to gain a second life. The solution matches the reusable or recyclable products option from the product dimension. The reusable or recyclable products option has been chosen because this option has been proven to work for BAM MOB. Furthermore, the take-back management, the service of maintenance, repair and control of the products and product/service based results options from the service dimension are matched. The take-back management of the products has been chosen because it fits the circular building platform that has been developed by the company. The empirical research suggests that the service of maintenance, repair and control of the products is highly profitable within the industry. Therefore, this option has also been embraced by the solution. Finally, the product/service based results option has been chosen because this matches the expertise of the current business model of the supporting structure (Dimension: Product/Service).

The business model will require a link or combination of the circular building platform with the BAM MEC. The combination of the platforms will allow people to buy, design and reuse the products of the supporting structure. The solution should increase the profits to the current business of the focal company. Therefore a new market will be targeted. The focal company should target smaller buildings than currently targeted because smaller buildings require less complex products than larger buildings which are therefore easier to develop. This is due to the high and weight of the building which increases for larger buildings. This will result in a target customer wishing to create a building with a floor space area ranging from 1000$m^2$to 3000m^2. Within this segment small risk-taking investors and small businesses are mostly active. This solution will target the small businesses as the small businesses are more demanding on the performance and desires of the buildings while small risk-taking investors are more demanding in the price point.

Therefore, the small business customers fit the quality conscious customers from the design options. The small business customers have been chosen because they are active within the smaller building segment and quality conscious. The benefit of the smaller buildings segment is that smaller buildings with less stories will require less complex products for the supporting structure. Furthermore, the smaller buildings segment has lots of potential for new customers to create new revenue streams (Dimension: Target customer).

The company will be delivering its value by connecting suppliers and buyers through their platform and design services. This matches the connecting suppliers and buyers' option and the providing product-based services and results option from the value delivery dimension. The connecting supplier and buyer option and the providing product-based services and results option have been chosen because this is what the company does best in their current business model for the supporting structure (Dimension: Value delivery processes)

Currently, the focal company does not wish to make further investments in the development of constructional elements. A wide variety of products is required for the engineers to design a building according to the desires of the customer. The evaluation of the second solution has resulted in the finding that the business model should not place the focal company in the position to develop and manufacture the products. The switchboard solution suggests that the focal company should target other companies, suppliers and/or manufacturers, to develop and manufacture the products needed for the building. The suppliers and/or manufacturers option has been chosen as the development of reusable products for the supporting structure is creating difficulties for the company. The theory suggests to use collaboration for the realization of a sustainable business model. Collaborating with the suppliers and/or manufacturers will allow the focal company to benefit from the product development from their partners. In return, the suppliers and/or manufacturers will benefit from the large network of customers of BAM (Dimension: Partners and stakeholders).

The solution will require multiple partners to develop different products to enable the focal company to design the building. The focal company will become the reseller of new and second hand products through their software platform. This matches the reselling products, components, materials and waste option. The reselling products, components, materials and waste option has been chosen because it fits the use of the circular building platform (Dimension: Value creation processes).

The new business model will use fixed margin. The fixed margin financial architecture works best for the current customers of the company due to its simplicity. The first evaluation has resulted in no further consideration of other value capture options. The fixed margins model matches the price premiums option from the revenue dimension. The fixed margins model is chosen as it has proven to work within the industry (Dimension: Revenues).

The revenue model of the focal company is based on cost calculations with an additional surcharge for profits. The focal company will provide an overall solution, including a service and maintenance contract.

Insufficient data on the maintenance contracts is available to further analyse the profitability of the maintenance contracts but there is a strong indication that the focal company thrives on service and maintenance contracts. The presented solution matches the labour option and the repair, maintenance and control option. The cost of labour is required to provide for the knowledge and expertise needed to create a non-residential building. The repair, maintenance and control option has been chosen because there is a strong indication that it is very profitable (Dimension: Costs).

The focal company will provide a platform, which facilitates the trade of reusable products for the supporting structure. The products of which the buildings consist will be incorporated in the system which allows for an easy resell and reuse process. The stored financial value will incentivize users to offer their products for reuse. The take-back system, in which the business provides the platform to resell the reusable products, has been chosen because it fits the current development of the circular building platform (Dimension: Take-back system)

The combination of the design options make up the circular business model for the focal company. The design options are integrated and presented in Figure 20 – Final solution, the switchboard for circular building.

Value proposition

Product/service

The focal company will develop and manufacture modular products for the supporting structure in non-residential buildings. They aim to develop reusable products for the supporting structure which can be used in 80% of the building. The "good modular design manifesto" will be embraced to develop the new products. The reduced time and costs for labor in the engineering phase of the modular products will create a competitive advantage.

The company will also develop a software platform which will facilitate the trade of reusable and used products. The platform will also enable and ease the design with reusable products.

Customer segments

Customers wishing to build a non-residential building with a floor space area varying between 1000m2 and 3000m2 and a maximum of 4 stories. Customers will have a value of approximately 1million to 4 million euros. The customer group targeted in this segment are business owners wishing to create a non-residential building.

The customer expects a relationship in which the construction company facilitates the design and building process to unburden the customer. Therefore a relationship manager or account manager will be appointed to relieve the customer.

Value for customer and environment

The developed products are modular in design and offer a lower price point due to lower costs dedicated to engineering labor. Additionally, the products will have a higher second hand value. The products are designed to be reuseable at the end of their service period decreasing material waste.

Value creation & delivery

Activities

The company will be built up of a development team and a production team. The development team seeks to develop new, better, modular products to enlarge their product base. The production team is responsible of producing the products. An assembly line with specialists for each task is used to produce the products in an efficient manner. The production team will require suppliers for their machinery and the raw materials/ intermediate products. The development team will need to partner with various knowledgeable parties to develop good products.

The company will need to extend the circular building platform to resell the reusable and used products. The company will need to integrate the circular building platform with the BAM MEC to facilitate in the design of the building.

Resources

The most valuable resource remains the knowledge base within the company and the modular products made by BAM MOB and a software tool for the configuration of the products is added. The software tool helps to achieve an advantage in engineering time within the process.

Distribution channels

The products will be sold exclusively to BAM assignments.

Partners and suppliers

The company will remain the main contractor within the supply chain of the construction industry. Manufacturers or suppliers, who are selling or willing to develop circular products for the supporting structure based on the BAM MOB design manifesto, will become close partners. Their products will be offered to the customers of BAM in return for their cooperation in develop circular products.

Technology and product features

The product is remountable, circular, sustainable, safe, improves health and well-being, high quality and cost efficient.

Value capture

Cost and Revenue streams

The revenue model of the focal company is based on cost calculations with an additional surcharge for profits. The focal company will provide an overall solution, including a service and maintenance contract. Insufficient data on the maintenance contracts is available to further analyse the profitability of the maintenance contracts but there is a strong indication that the focal company thrives on service and maintenance contracts. The presented solution matches the labour and repair, maintenance and control options

Value capture for key actors

The reusability of the product will give the product an increased financial value after its use. The reusability of the product will create a decrease in overall material usage which is value captured for the environment.

Growth strategy

The more products developed by the focal company, the more revenue that will be created from the reusable products. Therefore the development team is essential in the growth of the business.

Take back system

The focal company will provide a platform which facilitates the trade of reusable constructional components which have been bought through the platform. The products of which the buildings consist are incorporated in the system which allows for an easy resell and reuse process. The stored financial value will incentivize users to offer their products for reuse

FIGURE 20 – FINAL SOLUTION, THE SWITCHBOARD FOR CIRCULAR BUILDING

6 DISCUSSION

This final chapter will discuss the results of the study to answer the main research question: “How can BAM MOB innovate its business model to create, deliver and capture value from a circular supporting structure for non-residential buildings?" This research will attribute to the existing literature by getting to know more about the business model innovation of the supporting structure in the Netherlands. The sub-questions, main research question and the managerial implications are discussed in paragraph 6.1. This paragraph will show both the contribution to the literature and the practical relevance of the research. Subsequently, the limitations of the research are discussed and finally suggestions are made for further research.

6.1 Research relevance

This study contributes to existing literature through its findings. The findings of this research have been gained in three different ways: from the literature, from the empirical findings and from the solution design. This section will discuss the findings for each of these sections.

6.1.1 Findings from the literature

The research on the best methods or approaches for innovating a circular business model been guided by RQ 1. This paragraph will answer the first sub-research question. Overall, this research has studied three paths on the best methods and approaches in the literature: the frameworks for mapping circular business models, the process recommended for innovating a circular business model and lastly, the options for innovating a circular business model.

The framework of Richardson (2008) has been found to be the most adopted and the most appropriate framework to innovate a sustainable business model. However, the framework of Richardson (2008) lacks a circular focus as it does not emphasize the resource efficiency aspect (Nußholz, 2017). The framework of N. M. P. Bocken & Short (2016) has evolved the framework with corresponding attention for sustainable business models. The framework of N. M. P. Bocken & Short (2016) has been adopted for this research and the attention for the society has been left out to match the circular business model definition. Additionally, the take-back system has been added to the framework. A take-back system is crucial for the solution to fit the definition of a circular business model. Therefore, the take-back system has been added to the framework. This framework has proven to work when innovating a circular business model.

For the business model innovation process the 4I-framework proposed by Frankenberger et al. (2013) suggests four steps for the innovation of a business model: initiation, ideation, integration and implementation. The suggested process, fits the regulative cycle and suggests to study the current business model.

For the ideation process of innovating a circular business model, pattern adaptions or analogies are most suitable as they provide for a structured approach and offer a wide variety of options. Additionally, wide support from the literature has been found to incorporate collaboration and a job-to-be-done pricing model in the circular business model.

6.1.2 Findings from the empirical analysis

The research on the current business model has been conducted to answer the second research question: "In practice, how is the business model for the supporting structure of non-residential buildings organized within the focal company?" The research question originates from the literature proposal to create an enhanced understanding of the current business model when engaging in business model innovation. The supporting structure is not sold as a separate product and therefore a business model on which only a supporting structure if offered does not exist. The supporting structure is one part of the whole building and therefore the business model operated by the Royal BAM group for the creation of the whole non-residential building is researched.

The focal company is currently in the segment of creating larger buildings as their average building size is larger than the average non-residential building in the Netherlands, which is 955 m^2. This research finds that there is a strong indication that the focal company thrives from the service and maintenance phase of the non-residential building as the service and maintenance phase creates the largest amount of revenue from a non-residential building. The operations of the focal company are organized by a central contractor, or main contractor, who is in command of connecting sub parties. To differentiate themselves from their competitors, the focal company focusses on their expertise or knowledge for creating non-residential buildings. Finally, the focal company has based their revenue model on cost calculations with an added surcharge to account for profits. An overview of the current business model by means of the framework of Richardson (2008) is given in Appendix K – The current business model.

6.1.3 Findings from the solution design

This research has designed a circular business model as a solution for the focal company to create, deliver and capture value from a circular supporting structure for non-residential buildings. The designs and evaluation sessions have shown that the focal company can expand their customer base by targeting customers of smaller buildings. Additionally, smaller buildings require less complex products than larger buildings which are therefore easier to develop. Expanding their customer base will create an opportunity for additional revenue. The focal company should partner with material and product suppliers for the development of new products to decrease their investment costs. The suppliers will have a great opportunity when engaging in the product development as they will have access to the large customer base of the focal company. By developing the products, the suppliers will create a win situation for both the suppliers as for themselves from a financial point of view. Additionally, this solution will solve the large number of building products

problem, which is desired by the engineers to create a non-residential building to match the needs of their customers. The service and maintenance phase of the building provides the most revenue for the focal company and there is a strong indication that this phase is therefore most profitable. The incorporation of the service and maintenance phase in the new business model will lead to additional revenue and profits for the focal company.

These findings combined have resulted in the solution presented in the solution design chapter, the switchboard for circular building. The switchboard for circular building solution will enable the focal company to create circular buildings with a circular supporting structure.

6.1.4 Managerial implications

Innovating the business model is one of the challenges required to overcome to adapt to a circular economy within the construction industry. This research proposes a solution in the form of a business model but there are challenges ahead that will compromise the effectiveness of the business model if not solved. These implications are presented in this paragraph.

The management of the focal company should further research on the value determination of second-hand products. The success of the reusable products for the supporting structure depends on the second-hand value of the products for the supporting structure. In a follow up study the value of second-hand products of the supporting structure should be estimated. Based on those estimation, the business model can be better evaluated.

The management of the focal company should focus on a good strategy to implement the designed business model because solely "… a good business model is not enough" (Magretta, 2002). A good business model design will not guarantee the success of a business. To embrace the full potential of the business model design the focal company will be required to understand the opportunities and implications of the designed solution and create systems and processes to capitalize from the solution proposed by this research.

Additionally, the implementation of a business model requires continuous adaption and improvement of the strategy and the business model is required for the business model to succeed in the longer term (Osterwalder et al., 2005; Wittig et al., 2017). It is important for management to focus on the continuous improvement of the business model to assure the competitive advantage.

To finish, it is important for the company to create a wide foundation of partners willing to develop the products required for the success of the business model. The business model assumes a large base of products will be developed by suppliers and partners to facilitate the design and engineering of a non-residential building. This holds for the supporting structure products as well as for other products of the building.

6.2 Limitations

This research has designed a circular business model as a solution to the problem of the focal company providing insights which have not yet been described by the literature. Although the insights are valuable for companies within the construction industry, the research has some limitations which should be consider when studying the research.

This research had to compromise in the implementation of the solution due to the lack of resources required to implement a full business model. As a consequence, the designed solution has not yet been fully tested to the extent that it should have been to make a proper judgement about its effectiveness to solving the encountered problem.

The interviews conducted in this research have not gathered information from an important player, the customer. The focal firm was not willing to cooperate in the direct collection of data from their customers as the risks seemed too high for the focal company. A business model depends on the value added aspect for the customer and therefore it is important to research this aspect with care. This research has focussed on the value adding aspect for the customer but the data collected is secondary data as it is gathered from employees within the company. To fully understand the value proposition of the customer, it is important to assure the correctness of the value proposition and therefore this should be taken into consideration when interpreting the results of this study.

Another remark which has to be made is on the data collection of the semi-structured interviews. The literature on qualitative research methods states that data collection must not stop until the point of saturation (Galvin, 2015). For this research the point of saturation has not be reached and therefore important knowledge or information can be missing from the spectrum. To solve this limitation, more interviews should be conducted until the point of saturation is reached.

The researcher has conducted the coding solely and is inexperienced in the coding process. The research could have been enhanced by using a team of experienced coders for the data analysis phase of the research (Weston, Gandell, Beauchamp, Wiseman, & Beauchamp, 2001). The use of experienced coders for the data analysis phase will provide better data in the sense of unbiased data. Unfortunately, the resources were not on hand to outsource the coding process of the data and therefore the researcher has coded the data.

6.3 Suggestions for further research

Further research on the creation of circular business models should focus on the gaps identified in the literature. During this research a number of gaps have been identified and closing these gaps will offer future researchers to enhance their results. This section will discuss the gaps identified and suggest how they can be researched.

The first gap identified in the literature is decision making tools for business model innovations. To the knowledge of the researcher, no decision making tools exist to choose a path or option to innovate the business model. Designers navigate through a sequence of decisions to arrive at a solution. Therefore, the solution is highly dependent on the decisions taken to develop the solution. During this research, multiple options were available to innovate the business model. Some of the taken options have been evaluated as more promising than others. In future studies, researchers can support designers by providing decision making tools which will enable the generation of better business model innovations.

Furthermore, business model innovations would benefit from more systematic evaluation and validation methods. To thoroughly evaluate and validate the business model, it is required to fully implement the business model. In most cases, the full implementation of the business model can be extremely resource intensive. Alternatively, the literature proposes to embrace the knowledge of managers and let them evaluate and validate the correctness of a business model. In future studies, more research should be done towards quantifiable knowledge on the factors which determine the success rate of innovating a business model.

Lastly, knowledge is lacking on the financial valuation of reusable goods. The circular economy is dependent on goods or materials re-entering the marketplace. For businesses to adapt to the circular economy, it would be a safer decision if they would be able to estimate the financial value of the goods re-entering the marketplace. In the case of this research, the success of the final solution is dependent on the market value of the products after they are taken out of the building. This is because a higher second hand value of the products will make them more attractive than when their second hand value is unknown. In future studies, more research should be done towards the financial value of the products re-entering the marketplace. To the knowledge of the researcher, no quantitative tools exist to estimate the value of second-hand, circular products.

7 CONCLUSIONS

The goal of this research is to provide the focal company with a circular business model design to profit from the supporting structure of non-residential buildings. This research proposes a solution for a circular business model which solves the material problem.

The study is conducted by creating an understanding of the current business model for the supporting structure. Furthermore, literature has been consulted to develop options for the innovation of the business model and the design science methodology has been applied to create a solution for the encountered problem. Our results provide evidence that collaborating the partners to develop new reusable products could solve the problems encountered by the Royal BAM Group.

This research has designed a circular business model as a solution for the focal company to create, deliver and capture value from a circular supporting structure for non-residential buildings. The business model designs and evaluation sessions have shown that the focal company can expand their customer base by targeting customers of smaller buildings. By expanding their customer base, BAM will create an opportunity for additional revenue. The focal company should partner with material and product suppliers for the development of new products to decrease their investment costs. The suppliers will have a great opportunity when engaging in the product development, as they will have access to the large market of the focal company. By developing the products, the suppliers will create a win situation for both the suppliers as for themselves from a financial point of view. Additionally, this solution will solve the problem of the large number of building products, which is required for the engineers to create a non-residential building to match the needs of their customers. The service and maintenance phase of the building provides the most revenue for the focal company and there is a strong indication that this phase is therefore most profitable. The incorporation of the service and maintenance phase in the new business model will lead to additional revenue and profits for the focal company.

These findings combined have resulted in the solution presented in the solution design chapter, the switchboard for circular building. The switchboard for circular building solution will help the focal company to create circular buildings with a circular supporting structure.

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9 Appendix A – Overview of documents for literature analysis

Authors	Title	Year	Cited by	Search phrase or cited document
Bocken N., Short S., Rana P., Evans S.	A value mapping tool for sustainable business modelling	2013	102	"review" AND "business model innovation"
Bocken N.M.P., Short S.W., Rana P., Evans S.	A literature and practice review to develop sustainable business model archetypes	2014	406	"review" AND "business model innovation"
Bocken, N.M.P. & Short, S.W.	Towards a sufficiency-driven business model: Experiences and opportunities	2016	43	"Business model innovation" AND Sustainable
Boons, F. & Lüdeke-Freund, F.	Business models for sustainable innovation: State-of-the-art and steps towards a research agenda.	2013		N. M. P. Bocken et al., 2014
Bucherer E., Eisert U., Gassmann O.	Towards Systematic Business Model Innovation: Lessons from Product Innovation Management	2012	80	"best practices" AND "business model innovation"
Chesbrough, H. & Rosenbloom, R.S.	The role of the business model in capturing value from innovation : evidence from Xerox Corporation's technology spin-off companies.	2002	1373	"business models"
De Pádua Pieroni M., Pigosso D.C.A., McAloone T.C.	Sustainable Qualifying Criteria for Designing Circular Business Models	2018	1	"best practices" AND "business model innovation"
Ellen MacArthur Foundation	Towards the Circular Economy	2013	-	Internal report
Fjeldstad, Ø.D. & Snow, C.C.	Business models and organization design	2018		Zott et al., 2011
Foss N.J., Saebi T.	Fifteen Years of Research on Business Model Innovation: How Far Have We Come, and Where Should We Go?	2016	54	"review" AND "business model innovation"
Frankenberger K., Weiblen T., Csik M., Gassmann O.	The 4I-framework of business model innovation: A structured view on process phases and challenges	2013	61	"review" AND "business model innovation"
Gassmann, O., Frankenberger, K. & Csik, M.	St. Gallen Business Model Navigator. Management of the Fuzzy Front End of Innovation	2014		Wittig et al., 2017
Geissdoerfer M., Vladimirova D., Evans S.	Sustainable business model innovation: A review	2018	2	"review" AND "business model innovation"

Geissdoerfer, M. et al.,	Business models and supply chains for the circular economy.	2018	2	"BUSINESS MODEL INNOVATION" AND Circular
Ghaziani, A. & Ventresca, M.J.	Keywords and cultural change: Frame analysis of business model public talk	2005		Zott et al., 2011
Giesen E., Berman S.J., Bell R., Blitz A.	Three ways to successfully innovate your business model	2007	75	"best practices " AND "business model innovation"
Kirchherr, J., Reike, D. & Hekkert, M.	Conceptualizing the circular economy: An analysis of 114 definitions.	2017	69	"circular economy"
Lewandowski, M.	Designing the business models for circular economy-towards the conceptual framework	2016	71	"business model" AND design AND circular
Lüdeke-Freund F., Carroux S., Joyce A., Massa L., Breuer H.	The sustainable business model pattern taxonomy—45 patterns to support sustainability-oriented business model innovation	2018	2	"review" AND "business model innovation"
Mendoza J.M.F., Sharmina M., Gallego-Schmid A., Heyes G., Azapagic A.	Integrating Backcasting and Eco-Design for the Circular Economy: The BECE Framework	2017	10	"review" AND "business model innovation"
Mitchell D.W., Bruckner Coles C.	Establishing a continuing business model innovation process	2004	34	"best practices" AND "business model innovation"
Nußholz, J.L.K.	Circular business models: Defining a concept and framing an emerging research field.	2017	6	"BUSINESS MODEL INNOVATION" AND Circular
Osterwalder, A. & Pigneur, Y.	Business model generation: a handbook for visionaries, game changers, and challengers	2010		N. Bocken et al., 2013
Osterwalder, A., Pigneur, Y. & Tucci, C.L.	Clarifying business models: origins, present, and future of the concept.	2005		SCHNEIDER & SPIETH, 2013
Pohle, G. & Chapman, M.	IBM's global CEO report 2006: Business model innovation matters.	2006		Giesen et al., 2007
Richardson, J.E.	The Business Model: An Integrative Framework for Strategy Execution	2008		N. M. P. Bocken et al., 2014
Ritala, P. et al.	Sustainable business model adoption among S&P 500 firms: A longitudinal content analysis study.	2018		Geissdoerfer, Vladimirova, et al., 2018
Royal BAM Group NV,	Integrated report 2017,	2017		Internal report
Sathananthan S., Hoetker P., Gamrad D., Katterbach D., Myrzik J.	Realizing digital transformation through a digital business model design process	2018	1	"best practices" AND "business model innovation"

Schneider S., Spieth P.	Business model innovation: Towards an integrated future research agenda	2013	131	"review" AND "business model innovation"
Teece, D.J.,	Business models, business strategy and innovation.	2010	1634	"business models"
The Ellen MacArthur Foundation	Towards a Circular Economy - Economic and Business Rationale for an Accelerated Transition	2012	-	Internal report
Wittig A., Kulins C., Weber C.	Toward a best practice framework in business model innovation	2017	0	"best practices " AND "business model innovation"
Zott, C., Amit, R. & Massa, L.	The business model: Recent developments and future research.	2011	1027	"business models"

10 Appendix B – Overview of documents for framework analysis

Authors	Title	Year	Cited by Scopus	Framework
Bocken N.M.P., Short S.W., Rana P., Evans S.	A literature and practice review to develop sustainable business model archetypes	2014	402	Richardson
Boons F., Lüdeke-Freund F.	Business models for sustainable innovation: State-of-the-art and steps towards a research agenda	2013	381	Osterwalder
Stubbs W., Cocklin C.	Conceptualizing a "sustainability business model"	2008	242	-
Boons F., Montalvo C., Quist J., Wagner M.	Sustainable innovation, business models and economic performance: An overview	2013	213	Richardson
Schaltegger S., Lüdeke-Freund F., Hansen E.G.	Business cases for sustainability: The role of business model innovation for corporate sustainability	2012	204	Mixed
Visnjic Kastalli I., Van Looy B.	Servitization: Disentangling the impact of service business model innovation on manufacturing firm performance	2013	174	-
Sorescu A., Frambach R.T., Singh J., Rangaswamy A., Bridges C.	Innovations in retail business models	2011	138	Zott & Amit
Tseng M.-L., Chiu A.S.F., Tan R.R., Siriban-Manalang A.B.	Sustainable consumption and production for Asia: Sustainability through green design and practice	2013	120	-
Bohnsack R., Pinkse J., Kolk A.	Business models for sustainable technologies: Exploring business model evolution in the case of electric vehicles	2014	111	Richardson
Vaught J., Rogers J., Carolin T., Compton C.	Biobankonomics: Developing a sustainable business model approach for the formation of a human tissue Biobank	2011	101	-
Bocken N., Short S., Rana P., Evans S.	A value mapping tool for sustainable business modelling	2013	101	Mixed
Schindehutte M., Morris M.H., Kocak A.	Understanding market-driving behavior: The role of entrepreneurship	2008	100	-
Murray A., Skene K., Haynes K.	The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context	2017	97	-
Malhotra Y.	Knowledge Management and New Organization Forms: A Framework for Business Model Innovation	2000	94	-
Matos S., Silvestre B.S.	Managing stakeholder relations when developing sustainable business models: The case of the Brazilian energy sector	2013	90	-
Chen Z., Clements-Croome D., Hong J., Li H., Xu Q.	A multicriteria lifespan energy efficiency approach to intelligent building assessment	2006	90	-
Richter M.	Business model innovation for sustainable energy: German utilities and renewable energy	2013	80	Osterwalder

Overhage J.M., Evans L., Marchibroda J.	Communities' readiness for health information exchange: The national landscape in 2004	2005	76	-
Lewandowski M.	Designing the business models for circular economy-towards the conceptual framework	2016	71	Osterwalder
Adler-Milstein J., Bates D.W., Jha A.K.	Operational health information exchanges show substantial growth, but long-term funding remains a concern	2013	69	-
Witjes S., Lozano R.	Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models	2016	59	Richardson
Shrimali G., Slaski X., Thurber M.C., Zerriffi H.	Improved stoves in India: A study of sustainable business models	2011	52	-
Kastalli I.V., Van Looy B., Neely A.	Steering manufacturing firms towards service business model innovation	2013	49	-
Birkin F., Cashman A., Koh S.C.L., Liu Z.	New sustainable business models in China	2009	49	-
Schaltegger S., Lüdeke-Freund F., Hansen E.G.	Business Models for Sustainability: A Co-Evolutionary Analysis of Sustainable Entrepreneurship, Innovation, and Transformation	2016	49	Richardson
Upward A., Jones P.	An Ontology for Strongly Sustainable Business Models: Defining an Enterprise Framework Compatible With Natural and Social Science	2016	49	Richardson
Eppler M.J., Hoffmann F., Bresciani S.	New business models through collaborative idea generation	2011	47	-
Birkin F., Polesie T., Lewis L.	A new business model for sustainable development: An exploratory study using the theory of constraints in nordic organizations	2009	47	-
Saeed K.A., Hwang Y., Grover V.	Investigating the impact of web site value and advertising on firm performance in electronic commerce	2003	47	-
Richter M.	German utilities and distributed PV: How to overcome barriers to business model innovation	2013	46	Osterwalder
Zollo M., Cennamo C., Neumann K.	Beyond What and Why: Understanding Organizational Evolution Towards Sustainable Enterprise Models	2013	45	-
Joyce A., Paquin R.L.	The triple layered business model canvas: A tool to design more sustainable business models	2016	44	Osterwalder
Bocken N.M.P., Short S.W.	Towards a sufficiency-driven business model: Experiences and opportunities	2016	43	Richardson
Halme M., Korpela M.	Responsible innovation toward sustainable development in small and medium-sized enterprises: A resource perspective	2014	42	-
Bocken N.M.P., Rana P., Short S.W.	Value mapping for sustainable business thinking	2015	41	Richardson
Carayannis E.G., Sindakis S., Walter C.	Business Model Innovation as Lever of Organizational Sustainability	2015	40	Abdelkafi
Avci B., Girotra K., Netessine S.	Electric vehicles with a battery switching station: Adoption and environmental impact	2015	37	-

11 Appendix C – The interview protocol

Script before

Hello! My name is Sven van Eldik. I'm an engineering student from the University of Eindhoven. I'm here to learn about circular building of non-residential buildings. Thank you for taking the time to talk with me today. The purpose of this interview is to learn how a business model can me designed for the design and execution of circular non-residential buildings. There are no right or wrong answers, or desirable or undesirable answers. I would like you to feel comfortable saying what you really think and how you really feel. If it's okay with you, I will be recording our conversation since it is hard for me to write down everything while simultaneously carrying an attentive conversation with you. Ok?

Please let me know if at any point you want me to turn off the recorder or keep something you said off the record. Everything you say will remain confidential, meaning that only I will be aware of your answers. The purpose of that is only so we know whom to contact should we have further follow up questions after this interview.

Before we begin the interview, do you have any questions? [Discuss questions] If any questions (or other questions) arise at any point in this study, you can feel free to ask them at any time. I would be more than happy to answer your questions.

Interview questions + probes

1. RQ1: Verification of the process
    a. What are the key activities in the process of creating an non-residential building?
        i. Why are these activities the most important activities?
    b. In which of these activities are you involved?
        i. Why are you involved with these activities?
    c. What are your key activities?
        i. Why are these activities, important for your work?
    d. Is the process, as illustrated, correct?
        i. Do you use a process scheme to manage your work?
            1. Why do you use it/ why do you not use it?
        ii. Is, this process, the process of BAM MAP correct?
            1. Why is the process not correct?
        iii. Is the process always followed as illustrated?
            1. Why is the process not followed?
2. RQ1: Division of money and time?

a. What time is spent in each phase of the process?
    i. Why is the most time spent in X?
b. What money is spent in each step of the process?
    i. Why is the most money spent in X?
    ii. Why is this the same/not the same as for time?

3. RQ1: Who are the key partners?
    a. Who are the key stakeholders in creating a non-residential building?
        i. Why are these your key stakeholders?
        ii. What do these stakeholders do to be so important?
    b. What are their interests?
    c. Which activities do you do together?
        i. Why do you do these activities together?
    d. What do your key partners expect from you? What are your deliverables?
    e. What do you require from your key partners? What are their deliverables?
4. RQ1: What are the resistances to change the process?
    a. What changes have there been in the past to the process?
        i. Why has the process changed?
        ii. When has this change taken place?
        iii. Who were influenced by this change?
        iv. How was the change taken by the influenced people?
    b. Who want to cooperate in a process change in the future and who do not?
        i. Why would they want to change? Or not?
    c. What must happen for them to change?
5. RQ2: What are the pains in the current process?
    a. What causes the most frustrations in the creation of a non-residential building?
    b. What obstacles are hardest to overcome in the creation of a non-residential building?
    c. Which risks are the biggest in the creation of a non-residential building?
        i. What is the reason these pains exist?
        ii. Who causes the pain?
        iii. Who experience the pain?
        iv. Why aren't these pains relieved? What is the gain from these pains?
6. RQ 2: What are your gains?
    a. When do you feel you have done a good job?
    b. Which performance indicator do you try to improve?
    c. Which benefits do you get from your job?
7. Business model design requirements

a. What measures should be taken to facilitate circular options within the process?

12 Appendix D – The interview matrix

	Background information	Research question 2 – Value proposition	Research question 2 – Value creation & delivery	Research question 2 – Value capture
Interview Q0	X			
Interview Q1		X	X	
Interview Q2				X
Interview Q3			X	
Interview Q4		X	X	X
Interview Q5		X	X	X
Interview Q6		X	X	X
Interview Q7		X	X	X

13 Appendix E – The interview codes and categories

BM elements	Categories	Count
Improvement	Change initiation	10
Value proposition	Cause of pain	9
Customer	Customer wishes	8
Improvement	Changing aspects	5
Value chain	Key activity	5
Value chain	Key partners	5
Value proposition	Pain reliever	5
Improvement	Change restriction	4
Circular economy	Definition of circular	3
Value chain	Process	3
Improvement	Risk	3
Overall Business model	Business model	1
Customer	Customer acquisition	1
Customer	Customer profile	1
Value capture	Revenue model	1

14 Appendix F – Top-down analysis of the supporting structure

Total costs for new buildings	**€ 1099,00 /m2** (Dukers, 2004b, p33 average)
Total cost of structural elements	€ 200,00 /m2 (Chang & Blankestijn, 2016)
Supporting outer walls	€ - *
Supporting inner walls	€ - *
Supporting floors	€ 96,00 /m2*
Supporting roofs	€ 26,00 /m2*
Supporting structure	**€ 76,00** /m2****
Other structure	€ 2,00 /m2*

TABLE 12 - MATERIAL COSTS FOR THE SUPPORTING STRUCTURE

*Source: consultation with a cost calculation expert.

Total costs for new buildings	**100%**		**Source**
Construction costs	75%		Cost calculation expert
General construction costs	15%		Cost calculation expert
Engineering	**10%**		**Cost calculation expert**
Engineering installations	3,33%	33,3%	Cost calculation expert
Engineering constructional	5%	50%	Cost calculation expert
Engineering structure	**1,66%**	**16,6%**	**Cost calculation expert**
Engineering others structure	0,833%	50%	Constructional engineer
Engineering supporting structure	**0,833%**	**50%**	**Constructional engineer**

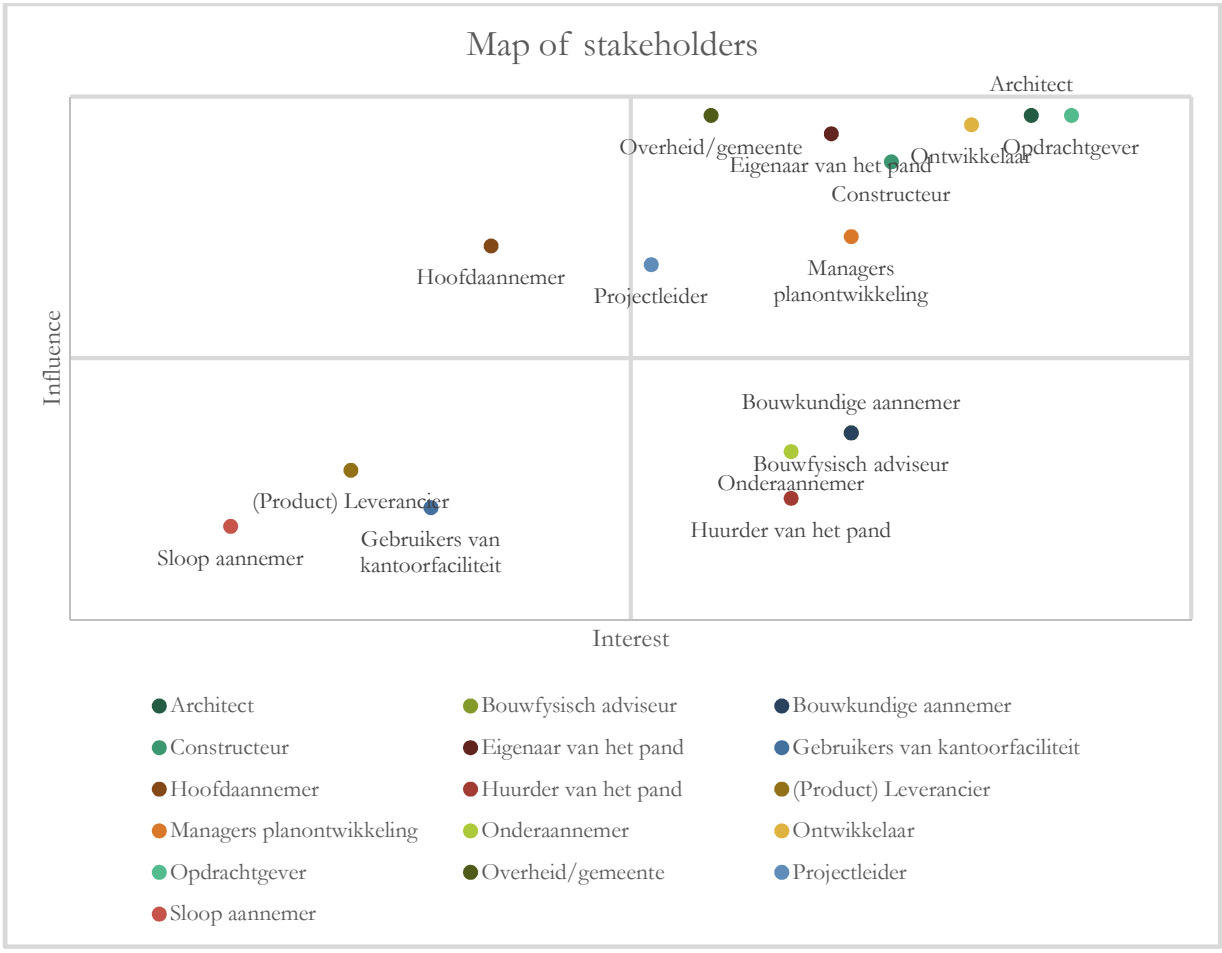
TABLE 13 - ENGINEERING COSTS FOR THE SUPPORTING STRUCTURE

15 Appendix G - Overview of stakeholders

	Stakeholder (NL)	Stakeholders
1	Architect	Architect
2	Bouwfysisch adviseur	Building physics consultant
3	Bouwkundige aannemer	Building engineering contractor
4	Constructeur	Structural engineer
5	Eigenaar van het pand	Owner of the building
6	Gebruikers van kantoorfaciliteit	Users of the non-residential building
7	Hoofdaannemer	Head contractor
8	Huurder van het pand	Tenant of the building
9	(Product) Leverancier	(Product) supplier
10	Managers planontwikkeling	Manager plan development
11	Onderaannemer	Subcontractor
12	Ontwikkelaar	Developer
13	Opdrachtgever	Bidder
14	Overheid/gemeente	Government/municipality
15	Projectleider	Project leader
16	Sloop aannemer	Demolition contractor

TABLE 14 - OVERVIEW OF STAKEHOLDERS

16 Appendix H – Influence-interest matrix



17 Appendix I – Costs of activities per floor space area

Expenses	€/m2	Source
Constructional costs		
General execution costs	€ 99,00	(Arcadis, 2016, p16, top)
Construction costs	€ 1.001,00	(Dukers, 2004b, p33, average)
Annual costs		
Service and management (60 years)	47,5/year	(Arcadis, 2016, p16, top)
Renovation costs		
Demolition costs	€ 50,50	(Arcadis, 2016, p11, top)
General execution costs	€ 61,65	(Arcadis, 2016, p16, top)
Construction costs	€ 685,00	(Arcadis, 2016, p16, top)
Demolition costs	€ 39,00	(Arcadis, 2016, p11, top)

TABLE 15 - COSTS OF ACTIVITIES ASSOCIATED WITH THE CREATION, SERVICING AND DEMOLITION OF A NON-RESIDENTIAL BUILDING

18 Appendix J – Company goals

Company goals for the Royal BAM Group:

- Increase return on capital employed (ROCE) >10%
- Increase corrected margin before taxes to 2 to 4%
- Decrease real estate portfolio, decrease working capital
- Net positive impact on the planet, incident frequency of < 3,5

19 Appendix K – The current business model

Value proposition

The offering
The focal company is in the business of creating non-residential buildings. They offer the service of connecting all parties required to create the non-residential building. The wide variety of knowledge and expertise within the focal company creates a competitive advantage.

The customer segment
The current business model focuses on customers wishing to create buildings upward of 2.000m2 gross surface space area. The average building is 18.514m2 gross surface space area and 80% of the buildings fall within the interval of 3.000m2 to 55.000m2 gross surface space area.
The segment can be categorized in the following customer groups:
- Large institutional investors
- Governments
- Small risk-taking investors
- Small businesses.

Strategy to win customers
The focal company tends to focus on quality and their reputation to win customers and gain a competitive advantage.

Value creation & delivery

Position in the value network
The focal company is predominantly involved as the main contractor within the supply chain of the construction industry. In most of the cases, the focal company is involved in the design, engineering, construction and operations and maintenance phase of the building.

Organization
The focal company is built up of experts with knowledge on different subjects. A team of experts combines forces to create the design of the building to match the desires of the customer.

Resources and capabilities
The most valuable resource of the focal company is their knowledge base of experts. This resource is sustained by the involvement of the company with the construction and operations and maintenance phase of the building.

Value capture

Revenue model
The revenue model of the focal company is based on cost calculations with an additional surcharge for profits.

Economics of the business
The largest costs of a building are deducted to the operations and maintenance phase (roughly 45%). The second largest costs of a building are deducted to the renovation phase of the building (roughly 38%). The material costs of the supporting structure are roughly 20% of the total costs of the building. The engineering costs of the supporting structure are roughly 1% of the total engineering costs.

FIGURE 21 - THE CURRENT BUSINESS MODEL PRESENTED BY MEANS OF THE FRAMEWORK OF Richardson (2008)

20 Appendix L – Overview of consulted analogies

Analogies	Citation
Maximise material and energy efficiency	**Ritala (2018)**
Closing resource loops	Ritala (2018)
Differential pricing	Lüdeke-Freund et al. (2018)
Freemium	Lüdeke-Freund et al. (2018)
Innovative product financing	Lüdeke-Freund et al. (2018)
Subscription model	Lüdeke-Freund et al. (2018)
Pay for success	Lüdeke-Freund et al. (2018)
Product-oriented services	Lüdeke-Freund et al. (2018)
Result-oriented services	Lüdeke-Freund et al. (2018)
Use-oriented services	Lüdeke-Freund et al. (2018)
Hybrid model / Gap-exploiter model	Lüdeke-Freund et al. (2018)
Maximise material productivity and energy efficiency	Lüdeke-Freund et al. (2018)
Product design	**Lüdeke-Freund et al. (2018)**
Substitute with renewables and natural processes	Lüdeke-Freund et al. (2018)
Co-product generation	Lüdeke-Freund et al. (2018)
Industrial symbiosis	Lüdeke-Freund et al. (2018)
Online waste exchange platform	Lüdeke-Freund et al. (2018)
Product recycling	Lüdeke-Freund et al. (2018)
Remanufacturing / Next life sales	Lüdeke-Freund et al. (2018)
Repair	Lüdeke-Freund et al. (2018)
Reuse	**Lüdeke-Freund et al. (2018)**
Take back management	Lüdeke-Freund et al. (2018)
Upgrading	Lüdeke-Freund et al. (2018)
Sharing business	Lüdeke-Freund et al. (2018)
Green supply chain management	Lüdeke-Freund et al. (2018)
Inclusive sourcing	Lüdeke-Freund et al. (2018)
Micro distribution and retail	Lüdeke-Freund et al. (2018)
Physical to virtual	Lüdeke-Freund et al. (2018)
Produce on demand	Lüdeke-Freund et al. (2018)
Shorter supply chains	Lüdeke-Freund et al. (2018)
A product-as-service	Mendoza et al. (2017)
Leasing, renting or sharing	Mendoza et al. (2017)
Take-back	Mendoza et al. (2017)
Use renewable materials	Mendoza et al. (2017)
Share assets	Mendoza et al. (2017)
Reuse	**Mendoza et al. (2017)**
Prolong product life	Mendoza et al. (2017)
Increase product performance and efficiency	Mendoza et al. (2017)
Remove waste in the supply chain	Mendoza et al. (2017)
Remanufacture	Mendoza et al. (2017)
Recycle	Mendoza et al. (2017)
Dematerialize	Mendoza et al. (2017)
Replace materials	Mendoza et al. (2017)
Choose new products/services	Mendoza et al. (2017)
Use new technologies	Mendoza et al. (2017)

Sell a service	Mendoza et al. (2017)
Rent and lease product	Mendoza et al. (2017)
Provide service of repair and maintenance	Mendoza et al. (2017)