# Master Thesis

## Collaboratively towards a circular building environment

A qualitative research of the relationship between supply chain collaboration and value retention options influenced by barriers and triggers for CE


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**Abstract**

The concept of circularity is still emerging. This research focuses on how supply chain collaboration impacts the implementation of value retention options when influenced by barriers and triggers for CE in the building environment. Documents are analysed and interviews are conducted among different actors involved in the construction of a new residential area, Ecowieck, in the municipality of Beuningen. Preventive options are present to a high extent while options concerning reutilization are lacking. Customer demand and governmental regulation are important triggers for the implementation of circular initiatives. Increasing costs acts as an important barrier to overcome for CE. Supply chain collaboration can contribute to the implementation of the value retention options when all components are present to a high extent. More collaborative goals concerning circularity should be made and communication and information sharing can improve. Governmental organizations have an important role in the improvement of collaboration among actors in the building environment.

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**Content**

# Chapter 1: Introduction

In recent years, the concept of the circular economy (CE) has gained interest among scholars and practitioners. Yet, the topic of CE is still emerging (Korhonen, Nuur, Feldmann & Birkie, 2018). According to the Dutch Ministry of Infrastructure and the Environment a circular economy is

*"an economic system based on the reusability of products and product components, recycling of materials, and on conservation of natural resources while pursuing the creation of added value in every link of the system"* (Potting, Hekkert, Worrell & Hanemaaijer, 2017).

There are various activities an organisation can implement to enable circularity. These activities are called R-strategies (van Boerdonk, Krikke & Lambrechts, 2021). The purpose of these strategies is to reduce the consumption of materials within the product chain and make the production process more circular (Potting et al., 2017). For decades, several R frameworks have been used in academic literature as a core principle of the circular economy (CE) (Kirchherr, Reike & Hekkert 2017). These frameworks differ from 3Rs (reduce, reuse and recycle) till up to 10Rs (Campbell-Johnston, Vermeulen, Reike & Brullot, 2020). The 10R framework described by Reike, Vermeulen and Witjes (2018) is the most elaborated (van Boerdonk et al. 2021). This framework consists of 10 strategies that an organisation can implement to enable circularity. Reike et al. (2018) conceptualizes these strategies as value retention options (RO's) in order to best cover all the strategies. When referring to resources, value retention means that resources stay closest to their original state. For finished goods it means that goods retain closest to their current state or are being reused with minimum adaptation. In contrast to other R strategies, these strategies consider differences between business-to-business (B2B), business-to-consumer (B2C) and consumer-to-consumer (C2C) (Campbell-Johnston et al. 2020). The 10R typology is applicable for the two product life cycles of produce and use and of concept and design (Reike et al. 2018).

The 10R typology framework of Reike et al. (2018) is shown schematically below in table 1. The framework consists of two preventive options (R0 and R1) and eight options concerning reutilization (R2, R3, R4, R5, R6, R7, R8 and R9). The first four RO´s (R0, R1, R2 and R3) are concerned with short loops, meaning that the product and materials stay close to its use and function. R4, R5 and R6 can be seen as medium loops where upgrades are made to the products and producers are reinvolved. The last three RO's (R7, R8 and R9) are concerned with long loops. Products are transformed such that they lose their original function. The options

higher in the framework are the most desirable options for organisations to implement circularity.

| **Resource value retention option (RO)** | **Description** |
|---|---|
| Refuse: R0 | For consumers and producers to buy less and or use less materials or designs. |
| Reduce: R1 | For consumers reducing the use of purchased products. For producers reducing the use of materials in production or product design. |
| Resell/Re-use: R2 | Second-hand buy or sell of products that hardly needs any adaptation. |
| Repair: R3 | Repairing or replacement of parts to make products workable again. |
| Refurbish: R4 | Upgrading of a multicomponent product by replacing parts with more new/advanced parts. |
| Remanufacture: R5 | Dismantling, checking, cleaning, and, if necessary, replacing or repairing the entire structure of a multi-component product. |
| Repurpose: R6 | Giving materials a new life by reusing redundant goods or parts. |
| Re-cycle: R7 | Recovering materials through processes such as melting and shredding. These materials can be reapplied in other product types. |
| Recover: R8 | Capturing energy that is embodied in waste. |
| Remine: R9 | Retrieval of materials after the landfilling stage. |

*Table 1: 10R typology framework (Reike, Vermeulen, & Witjes, 2018)*

The building and manufacturing industry is the frontrunner when it comes to the use of recycled materials. In 2016, the building and construction industry was responsible for the use of more than half of all recycled materials in the Netherlands. Nonetheless, just 38 percent of the materials used in this industry were recycled (CBS, 2019). The linear take-make-dispose model in which materials are sourced, used and then disposed of as waste, still dominates the building environment (Arup, Elen Macarthur foundation, 2018). Arup (2016) has identified eight facets of the building environment where circular strategies can have the biggest impact on efficiency and the reduction of costs and environmental impact. These facets of the building environment are elaborated on in table 2.

| Facet | Description |
|---|---|
| Ecosystem | Within the whole ecosystem, circularity has to be taken into account. The designing of buildings needs to comprehend the entire life cycle in order to ensure for circularity from the construction phase till the disassembly phase. |
| Design area | Within the design area, buildings need to be designed in such a way that it allows for future changes such as remodelling, expansion and disassembly. |
| Sourcing of materials | The sourcing of materials needs to be adaptable and modular. In order to do so parts of the buildings should be flexible, durable and reusable. |
| Construction | The construction should become more flexible, utilizing the advancements regarding off-side manufacturing and 3D-printing. |
| Operations | Operations should account for high efficiencies regarding the use of water and energy. The leasing of components and services should become more standard. |
| Renewal | Renewal of buildings should be strived for. Materials should be reused to minimize the use of virgin materials. |
| Disassembly | Possibilities to disassemble should be maximised in order to minimize demolition. This will give the opportunity to easily redesign buildings using the same components. |
| Repurpose | Materials will be repurposed. This implies that components should be reused in other building projects or even in other sectors. |

*Table 2: eight facets where circular strategies will have an impact (Arup, 2016)*

The realization to start working differently is growing. Raw materials are being depleted, the environment is polluted and the excessive use of fossil fuels has an impact on the climate. This requires a transition to a different way of working and living, without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems. The goal for the building sector is to become fully circular by 2050 (transitie-agenda circulaire economie 2018, 2018). A circular building environment is an environment where

*"buildings, areas and infrastructure are being developed, used and reused without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems. Building in a way that is economically responsible and that contributes to the well-being of humans and animals"* (Platform CB'23, 2020).

Within the building environment, five phases can be distinguished:

- From initiative to design
- From design to build
- From build to management
- Renovation, transformation or repurposing
- Demolition

These phases are most of the time strictly separated in traditional building. However, to be able to build circular, these phases need a lot of interaction. There is no start or end to these cycles because building projects needs to advance into other initiatives (platform CB'23, 2019). The entire supply chain needs to collaborate in order to build circular. Cao and Zhang (2011) define supply chain collaboration as

*"a partnership process where two or more autonomous firms work closely to plan and execute supply chain operations towards common goals and mutual benefits".*

The CB'23 platform (2019) developed a framework containing seven main subjects where unambiguous use of language and clarity is needed to facilitate the transition towards a circular building environment. Measurement of circularity and the sharing/transferring of information and data are two of the main subjects that require more research. Studying the relationship between supply chain collaboration and the implementation of value retention options can contribute to this demand of knowledge creation.

The building environment is characterised by long lifespans, many stakeholders, and hundreds of components and materials that interact dynamically in space and time. These characteristics of the building environment makes it more complicated to transition towards a circular environment. It is clear that there are barriers to overcome to enable the circular economy, and there is a small but growing body of literature devoted to this. The assumption is that the transition to a circular economy will be easier when more of these barriers can be overcome. Therefore certain triggers must be implemented, both to gain better conditions for CE generally and to deal with individual challenges (Hart, Adams, Giesekam, Tingley & Pomponi, 2019; Tura et al., 2019; Govindan & Hasanagic, 2018). This thesis tents to identify these barriers and drivers of CE in the building environment and to understand its

influence on the relationship between supply chain collaboration and the implementation of the value retention options.

Based on the above, the aim of this research can be formulated as follows:

*The purpose of this research is to contribute to the transition to a circular building environment by providing insights in how supply chain collaboration impacts the implementation of value retention options while taking barriers and triggers into account.*

In order to achieve this objective, the following research question must be answered:

*How does supply chain collaboration impact the implementation of value retention options in the building environment when influenced by barriers and triggers for CE?*

This thesis aims to contribute to the development of theory regarding CE by providing insights into the implementation of the 10 value retention options within a specific sector, the building and construction sector. In addition, this thesis is also of practical relevance. Studying the relation between supply chain collaboration and value retention options can deliver insights into how organisations in the building environment can work together in order to build more circular. Furthermore, identification of important barriers and triggers that influence the implementation of CE is helpful to improve circular business.

The structure of this thesis is as follows. Theory will be central in chapter two. In the first part of chapter 2, triggers and barriers for a more sustainable supply chain are discussed based on the research by Seuring and Muller (2008). Supply chain collaboration will be described by using Cao and Zhangs (2011) measurement model. Chapter 3 will delve deeper into the methodology of this research. The collected data will be analysed in chapter 4. The findings are discussed in chapter 5 and conclusions are made in chapter 6.

# Chapter 2: Literature review

Not much studies exist that investigate the different drivers and barriers that influence the implementation of the circular economy (Govindan & Hasanagic, 2018). Nonetheless, Tuna et al. (2019) developed a systematic categorization of triggers that support circular initiatives and barriers that hinder the transformation to a circular economy. They looked at many barriers and triggers for a circular economy and came up with seven distinct areas that can cover this variety of barriers and triggers. Namely: environmental, economic, social, political and institutional, technological and informational, supply chain, and organizational factors. The research by Tuna et al focused on the barriers and triggers for CE in a broader sense. Seuring and Muller (2008) identified the most common triggers and barriers in the supply chain. Identification of these barriers and triggers is needed in order to implement R-strategies in these different facets of the building environment. The next part will discuss these barriers and triggers, based on the literature on sustainable supply chain management (SSCM).

## 2.1 Sustainable supply chain management; barriers and triggers for CE

According to Seuring and Muller (2008) sustainable supply chain management (SSCM) is the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements. Seuring and Muller reviewed 191 papers on sustainable supply chain management and found a list of triggers and barriers for the implementation of a more sustainable supply chain.

They recognised external pressure and incentives set by different groups as the most important triggers. Two groups are most important, customers and governments. Customers are important because they need to accept the products and services created by the supply chain. The demand for more sustainable products and services will affect the supply chain. This also accounts for B2B. Complying to guidelines set by environmental and social standards becomes a more and more important issue for companies in choosing their suppliers (Corbett & Kirsch, 2001). According to Zimmann, O'Brien, Hargrave & Morrell (2016) consultation with clients at the start of a building project is required in order to promote the CE agenda.

Governments have the ability to control parts of the supply chain. Local municipalities, national or multi-national governments can all exert pressure for example trough legal demands

and regulations (Seuring & Muller, 2008). However, the building environment is still characterised by a lack of a consistent regulatory framework. Global consensus regarding policies supporting CE is missing and targets are not set nor defined appropriately. Besides this, governmental organisations have the ability to provide incentives for organisations in the building sector. Positive incentives can be provided when organisations implement CE activities, for example through tax incentives or funding. Negative incentives, such as fines, can be handed out for not complying to certain CE targets (Hart et al, 2019). Furthermore, competitive advantage and the loss of reputation were frequently named triggers in papers reviewed by Seuring and Muller. Loss of reputation is related to the customer demand trigger, mentioned earlier. Organisations might fear losing customers when environmental or social problems occur and thus gain a bad reputation. Competitive advantage can trigger organisations to implement certain CE activities if these CE activities foresee customer demand (Seuring & Muller, 2008).

Seuring and Muller also found three important barriers for the implementation of a more sustainable supply chain, namely: higher costs, coordination effort and complexity and insufficient or missing communication in the supply chain. For the building environment, higher costs relate to the increasing costs when implementing CE initiatives. Upfront investment costs are high and needed for example for R&D and the implementation of CE models such as reusing structures (Hopkinson, Chen, Zhou, Wong, & Lam, 2018). Committing to CE initiatives is especially hard because of the relatively low prices of virgin materials (Adams, Osmani, Thorpe, & Thornback, 2017).

Coordination effort-complexity and insufficient or missing communication are important barriers for a lot of sectors but can have a big impact especially in the building environment because of certain characteristics of this sector. Overall, the building environment is characterised as a highly complex sector. Long product life cycles and uncertainty around future ownership requires more coordination and communication over time (Hart et al., 2019). Multiple actors with different priorities and incentives interact and there is rarely continuity of ownership and control (Arup, 2016). There are still lots of technical challenges regarding material recovery in this sector such as separating bricks (Hopkinson et al., 2015) and the use of collaboration tools, information tools and CE metrics is lacking (Hart et al., 2019). Finally, the building sector itself is known as conservative, uncollaborative and adversarial (Arup, 2018).

The last two barriers discussed show that there is an increasing need for cooperation among partnering companies in sustainable supply chain management (Seuring & Muller, 2008). The next part will elaborate on supply chain collaboration based on the research by Cao and Zhang (2011).

## 2.2 Supply chain collaboration

Cao and Zhang (2011) define supply chain collaboration (SCC) as a partnership process where two or more autonomous firms work closely to plan and execute supply chain operations toward common goals and mutual benefits. In their definition, Cao and Zhang combine two groups of conceptualisations about SCC; process (Mentzer, De Witt, Keebler, Min, Nix, Smith, & Zacharia, 2001; Stank, Keller, & Daugherty, 2001; Manthou, Vlachopoulou, & Folinas, 2004; Sheu, Yen, & Chae, 2006) and relationships (Bowersox, Closs, & Stank, 2003; Golicic, Foggin, & Mentzer, 2003). Cao and Zhang distinguish seven interrelated components of SCC, namely, information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communication, and joint knowledge creation.

Information sharing is about the sharing of relevant, accurate, complete and confidential information between organisations in the supply chain (Cao & Zhang, 2011). The willingness to make data available, that can be useful to other organisations in the supply chain, is the most important aspect of this component (Global Logistics Research Team at Michigan State University 1995).

Goal congruence refers to the degree of goal agreement between organisations in the supply chain (Angeles & Nath, 2001). The goals should be aligned in such a manner that when goals of the supply chain are accomplished, the goals of single organisations in the chain are met as well (Lejeune & Yakova, 2005).

In order to optimize the advantages of the supply chain, organisations should involve each other in the decision-making process. Cao and Zhang (2011) refer to this as decision synchronization. The synchronization of decisions can lead to a more efficient and effective way of deploying resources. Lockamy and McCormack (2004) identify seven planning decision categories that are key for supply chain management: operations strategy planning, demand management, production planning and scheduling, procurement, promise delivery, balancing change, and distribution management.

Incentive alignment means that costs, risks and benefits are shared among the organisations in the supply chain. The gains of the collaboration should be in line with the investments and risk of collaborating (Cao & Zhang, 2011).

The alignment of capabilities and assets and the mutual investment of partners in the development of capabilities and assets is referred to as resource sharing. Examples of this are new innovations, facilities and equipment (Harland, Zheng, Johnsen, & Lamming, 2004).

According to Cao and Zhang (2011), collaborative communication refers to the transmission process of contact and messages between supply chain partners. Frequency, mode, direction and influence strategy are important aspects of successful collaborative communication.

The last component of SCC that Cao and Zhang (2011) identified is joint knowledge creation, which is the collective development of a better understanding of, and the response to, changes in the market by partners. Two forms of knowledge creation can be distinguished. Knowledge exploration refers to the process of acquiring new knowledge. Knowledge exploitation on the other hand, refers to the application of the newly acquired knowledge (Bhattand & Grover, 2005). The joint knowledge creation among partners can positively effect innovation and competitiveness of the supply chain.

## 2.3 10R typology and supply chain collaboration

The relation between supply chain collaboration and the implementation of value retention options is being studied. The study by Cao and Zhang (2011) is used to conceptualise supply chain collaboration. As mentioned above, Cao and Zhang distinguish seven components of SCC. SCC is high when these components are present to a large extent. The value retention options are operationalised based on the 10R typology by Reike et al. (2018). When these options are present to a large extent, operations will be more circular.

Supply chain collaboration could have a large impact in successfully implementing circular strategies. Still, just like higher costs, the need for more collaborative actions can be seen as a barrier for the implementation of the value retention options. In order to better understand the relation between SCC and the implementation of the value retention options, triggers and barriers for the implementation of circular initiatives are taken into account as well. These barriers and triggers are based on the research of Seuring and Muller (2008). The relation between the variables is depicted in figure 1.

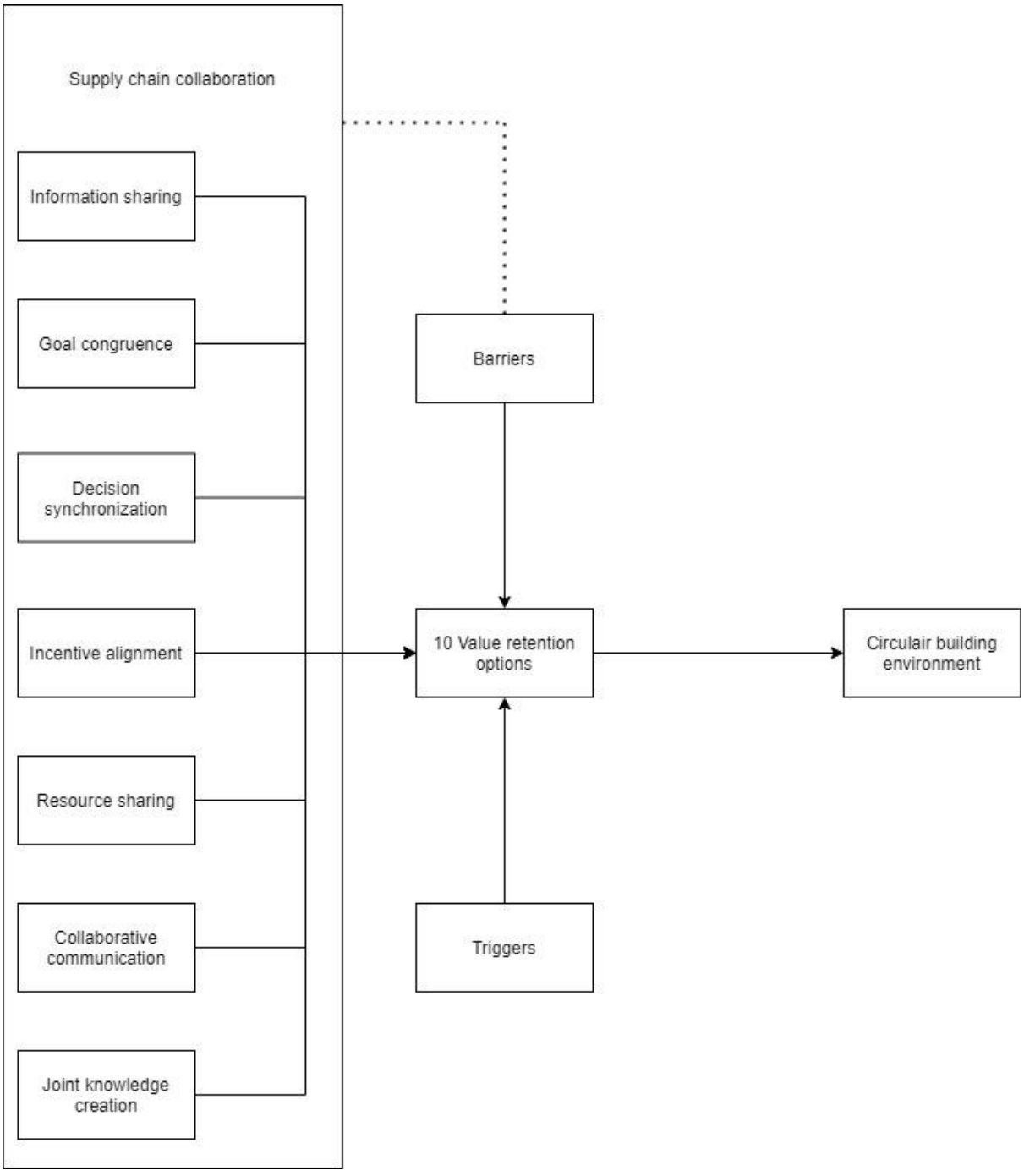


*Figure 1: conceptual framework*

# Chapter 3: Method

## 3.1 Research design

A qualitative study is conducted in order to answer the research question. Qualitative research is focused on the collection and interpretation of linguistic material in order to make statements about a particular phenomenon (Bleijenbergh, 2015). Qualitative research is best suited to gain a detailed understanding of a particular topic (Yin, 2014). The aim of this research is to contribute to the transition to a circular building environment by providing detailed insights in the relation between supply chain collaboration and the measurement and implementation of circular strategies when taken barriers and triggers into account, therefore this research is qualitative in nature.

A deductive research approach was chosen because the concepts central to this research are already extensively studied within literature. In deductive research, the central concepts are operationalised before the data is collected. Deductive research is thus theoretically driven (Bleijenbergh, 2015). The central concepts of 'supply chain collaboration' and 'circular strategies' are first operationalised before the data was collected. This was also the case for the identified triggers and barriers. The operationalisation scheme can be found in appendix A.

## 3.2 Case description

On the 28$^{th}$ of June 2019, the climate agreement was presented by the Dutch government. The climate agreement consists of more than 600 agreements to reduce the emission of greenhouse gasses (Klimaatakkoord, N.D.). The building environment is responsible for 35 percent of the overall CO2 emissions and thus one of the most polluting sectors in the Netherlands. Besides this, the building environment is responsible for 50 percent of the overall raw material consumption, 40 percent of the overall energy consumption and 30 percent of the overall water consumption (Rijksoverheid, 2016). The climate agreement stated that by 2050, 7 million houses and 1 million buildings should be free of natural gas. The first step is to make 1.5 million houses more sustainable by 2030. Municipalities are informed about when which residential area will be made more sustainable. The circular economy is seen as an important piece of the puzzle to sufficiently reduce CO2 emissions. By producing and reusing materials in a different way, fewer virgin materials will be needed, waste is lowered and CO2 emissions are reduced (Klimaatakkoord, N.D.).

The ‘transitieagenda circulaire bouweconomie 2018’ describes the strategy to achieve a circular building environment by 2050 and is leading for the Dutch government. Three terms are distinguished with different goals. The goal for 2018-2021 is to identify actions that are necessary to start the transition toward a circular building environment. The goal for 2021-2030 is to achieve 50 percent of the end goal. The goal of 2030-2050 is to become fully circular. At this point, the main focus is on exploring how the goal of a fully circular building environment can be achieved. An important short term intervention is that all requests from the government, national, provincial and municipal will be circular by 2023, unless this is not (fully) possible. Well defined actions regarding the reduction of CO2 emissions, legislation, subsidy possibilities, and a uniform measurement method of CE are still being developed (transitie-agenda circulaire economie 2018, 2018).

The region Arnhem-Nijmegen seeks to build 20.000 new houses by 2025 and up to 60.000 houses in the years to follow. The ‘woondeal regio Arnhem-Nijmegen’ contains agreements between the Dutch government, the province of Gelderland and 18 municipalities regarding the development of these houses (Regioan, N.D.). The region of Arnhem-Nijmegen was named the most circular region of the Netherlands in 2018. In the housing deal is therefore extra attention being paid to designing a circular living environment, nature-inclusive and climate-adaptive construction and the preservation of green space in the city. The ambitions regarding circularity correspond with the goals of the ´transitieagenda circulaire bouweconomie 2018´. They attempt to build at least circular for 25 percent by 2025, 50 percent by 2030 and fully circular by 2050. Besides this, the housing deal states that builders and developers are encouraged to make use of at least 10 percent of circular building material. Still, the region is, together with the province and Dutch government, working on the operationalisation of the circular concept and looking for incentives to stimulate CE (Woondeal regio Arnhem-Nijmegen, 2020).

The municipality of Beuningen is one of the 18 municipalities in the region Arnhem-Nijmegen that is involved in the housing deal. Currently, they are developing a new neighbourhood, called Ecowieck, in the city of Ewijk. The ambition is to be ecological friendly, meaning that the houses are low in energy consumption or can even produce energy themselves. Ecowieck is being developed in collective private commissioning (collectief particulier opdrachtgeverschap, CPO). At the moment two of these CPO’s are working on the development of the Ecowieck (gemeente Beuningen, n.d.). CPO means that residents develop the building projects themselves. CPO’s choose the professional parties working in the building project

(bouwen in eigen beheer, n.d.). In this study, interviews were held among different parties involved.

## 3.3 Data collection

This research started with three exploratory interviews. Two of these interviews were conducted among two members of the circular board of the region of Nijmegen and one was with an employee of the province of Gelderland. During these interviews, the demand was expressed to look at how the value retention options are implemented in a specific sector. The building environment was chosen because the honours academy thinktank building circular was already conducting a research on circularity in the development of the Ecowieck.

The data for this study is collected through weekly meetings with the honours academy thinktank, documents and open interviews. The documents are received from the province of Gelderland and the municipality of Beuningen. The open interviews are held among different parties involved in the building and development of Ecowieck Beuningen. There was no contractor yet involved in the development of the Ecowieck during the data collection for this thesis. In order to involve all the different type of actors in the building environment, a contractor that is part of the circular board of Nijmegen was interviewed instead.

In open interviews, respondents can determine the wording of the answers themselves. The advantage of open interviews is that a large amount of detailed information can be collected in a relatively short time. In addition, an open interview allows a respondent to provide a good picture of how that person experiences a social phenomenon themselves (Bleijenbergh, 2015). The open interviews are of a semi structured nature. In semi-structured interviews, the questions are written down in advance. The order of the questions is often predetermined, but can be changed depending on the respondent's answers. In this way, all subjects are covered and the respondents are asked the same questions which have a positive effect on the reliability of the study (Bleijenbergh, 2015). More reliable statements can be made about the relationship between SCC and circular strategies when all the actors that are working in the building project are asked the same questions. Besides this, the view of all the actors on the collaboration and circular strategies are obtained.

The interview questions related to circular strategies are based on the research of Reike et al. (2018). Reike et al. distinguished 10 value retention options. These value retention options serve as the dimensions. Questions will be asked about the actors perspective on these strategies and if and how these strategies are implemented and measured in their operations.

The interview questions related to supply chain collaboration are based on the measurement instrument developed by Cao and Zhang (2011). Cao and Zhang distinguish seven components of SCC which served as dimensions in this study. These seven components are: information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communication, and joint knowledge creation. Cao and Zhang developed a survey where respondents had to indicate to what extend they agree with the statements. This study will use the same dimensions, but the statements are transformed into interview questions. The identified triggers and barriers are based on the research of Seuring and Muller (2008). The operationalisation of the concepts can be found in Appendix A.

The interviews started with some general questions regarding the background of the respondents and the organisations they work for. The entire questionnaire can be found in Appendix B. Because the interviews are semi-structured, this questionnaire serves as a basis, but the order of the questions may differ slightly due to the answers given by the respondents.

## 3.4 Data analyses

The interviews and documents are analysed using a deductive approach. This means that prior to the analysis, a coding scheme was defined to guide the analysis of the data. This method of data collection is used because there is already a great deal of literature regarding the variables to be examined in this study (Bleijenbergh, 2015). The operationalisation scheme in Appendix A was leading for the analyses. The interviews were transcribed first. After this, the interviews were coded openly thus based on the indicators. The coded transcripts of the interviews can be found in Appendix C. After this, the transcribed interviews are coded axially. This means that the codes will be sorted under the right dimension. The axial coding scheme can be found in Appendix D. Codes that are appropriate for more than one dimension have a number in bold. A list with the documents used for the analysis can be found in Appendix E. Table 3 shows the codes that were used for the analysis.

| **Abbreviation** | **Meaning** |
|---|---|
| I | Indicator |
| D | Dimension |
| V | Variable |
| X | Number |
| Cpo 1 | Cpo Samen ecologisch bouwen |
| Cpo2 | Cpo Calimero |
| Gem | Municipally Beuningen |
| Ar | Architect Van Laarhoven |

| | |
|---|---|
| Aan1 | Klok Holding |
| Aan2 | Klok Holding |
| Pro | Province of Gelderland |

*Table 3: Abbreviation Scheme*

## 3.5 Limitations and research ethics

Six interviews were conducted because this study has a particular (short) time span. More interviews would have been recommendable to increase the external validity of this research. To increase the reliability of this research, semi structured interviews are conducted. Because the interviews are semi structured all the respondents had to answer the same questions which positively effects the reliability of the data (Bleijenbergh, 2015). Already studied and developed measurement models are used in this research to increase the construct validity (Yin, 2014). Still, these measurement models needed to be transformed to be appropriate in the building environment and in order to be suitable for interviews. This had an effect on the construct validity of this research.

After each interview, the transcript was sent back so the actor was able to check the transcript.

# Chapter 4: Analyses

## 4.1 Value retention options

The extent to which the ten value retention options are implemented in the operations of the different actors involved are presented in this paragraph. Reike et al. (2018) identified ten value retention options that an organisation can implement to enable circularity. Each of these value retention options will be elaborated upon in order to make statements about the degree of circularity in the building environment.

**R0 Refuse**

The retention option 'refuse' is a strategy that is considered a lot by the different actors. Cpo 2 made the following statement:

*"We still have a lot to discover. One is that people think it's normal to think about this. So, for example, we should not start using concrete slabs. So as little concrete as possible, as little steel as possible. These are things that people already came up with themselves without knowing the word circularity."*

This quote shows that at the start of a project, people consider if there are materials which are bad for the environment and which do not have to be used in the construction process. However, this is about parts and not about completely excluding environmentally unfriendly materials. This is elaborated upon in the next quote:

*"No, we don't have that at the moment. If you look at legislation, we build without gas, for example. But there are no materials that we are now investing in that we certainly do not want to use. But we do look at, how can we make sure that we know that some materials might… You have the concrete and the wood lobby, the two major building components. Wood is on the rise. Concrete is also a beautiful material. But building everything in concrete or everything in wood is not the solution. Eventually you get a kind of hybrid form. You will use the material that best fits the demand. So if we want to make a foundation and want to do something in the ground, concrete is still the best for that to date."*

So, according to this contractor, legislation can ensure that certain materials will not be used. This will be discussed in more depth later. When the use of specific materials is allowed, the material that best fits the demand will be used. When using harmful materials, the main focus is on how this can be 'reduced' which is the second value retention option.

**R1 Reduce**

Much attention is paid to how the use of harmful materials can be reduced in the building environment. For example, the architect explained that he is constantly searching for new ways to use natural materials but there are still parts in the building process in which you can't work without materials such as concrete.

*"I am therefore increasingly looking for natural materials, because I have seen and felt that you can achieve a more pleasant living and living climate as a result. And yes, concrete is the material which is almost eh, yes... as a designer you often have to make compromises. Of course. The foundation, you almost always have to make it in concrete, regardless of where you build, but often you can't do without materials that you might prefer not to use."*

The materials that are chosen are most of the time based on the impact it has on the environment. The materials that make the most impact according to the different actors are mostly biobased instead of renewed materials. Thus new materials that grow naturally and can afterwards be returned to nature, for example hemp. The optimum is when these materials are close at hand. The contractor made the following statement about the use of materials:

*"Thus as much as possible for biobased materials, otherwise recycled materials and, if absolutely necessary, new materials. Plus everything you make can be detachable."*

In addition to having to look carefully at which materials you do and do not use, it is important to ensure that the various materials and parts can be disassembled according to the contractor. The disassembly of parts and materials are important aspects of the following value retention options.

**R2 Resell/Re-use**

Much was said about demountable construction. However, it was always about how to build in such a way that new materials and parts are demountable in the future. There wasn't much said about re-using parts and materials in current construction. Especially releasability was taken into account in new projects in order to make more parts dismountable in the future. Besides this, prefabrication and the documenting of parts and materials are solutions according to the contractor to increase the re-use of parts and materials in the future:

*"Part of the solution is that we are going to prefabricate more because we can build under better conditions in the factory and more standard so that we know what is coming. Besides this we have to very well document what we used so that we can get the materials out properly in the future. Those are the solutions and then you can turn the buttons yourself. How detachable everything has to be. How many recycled materials do you want in the house?"*

The re-use of products and parts and the re-use of products and parts in another function was frequently used interweaved. Wood for example, was mentioned as a verry useful material to re-use but it was not always clear if it would keep its function when re-used (R2 Resell/re-use) or would receive another function (R6 Repurpose).

**R3 Repair, R4 Refurbish, R5 Remanufacture**

The value retention options repair, refurbish and remanufacture were not mentioned often either. Both Cpo's tried to use materials that need as little maintenance as possible. Cpo 1 made the following statement:

*"The group's often expressed wish is to have as little maintenance as possible during the life of the house. A wish of the group is therefore a wish for sustainability, but also an economic wish, to have it as sustainable as possible during the lifetime of the complete product."*

A long lifetime of products and materials was interlinked with sustainability.

**R6 Repurpose**

As discussed for the value retention option resell/re-use, buildings have to be constructed in such a way that parts and materials are demountable in order to be used again.

For the value retention option repurpose, these parts will be re-used in a different function. Contractor:

*"we need to look at how we can take buildings apart and reuse parts. If we do that, more and more good materials will come on the market that we can use again"*

Again, the documentation of materials used in a building was mentioned to increase the re-use of parts and materials later on in its current function or a new one.

**R7 Recycle**

As mentioned before, the actors mostly focused on the use of biobased materials when focussing on more sustainable materials. Besides this, materials used in new constructions are mostly re-used as demountable parts in the same or a new function. So recycling, recovering materials through processes such as melting and shredding to be reapplied in other product types wasn't an often used retention option.

**R8 Recover R9 Remine**

The value retention options 'recover' and 'remine' were not mentioned in the interviews or the analysed documents.

## 4.2 Sustainable supply chain triggers and barriers

The triggers and barriers for developing a more sustainable supply chain identified by Seuring and Muller (2008) are analysed in the next paragraph. The triggers: customer demand, governmental, competitive advantage and reputation loss are analysed first. After this, the barrier high cost will be analysed. Coordination efforts and communication issues are discussed in the paragraph concerning supply chain collaboration.

### 4.2.1 Sustainable supply chain triggers

**Customer demand**

Customer demand is mentioned as a very important trigger to implement circular initiatives. In the case of Ecowieck, the cpo's are formed because people have the same drive to live smaller and more environment friendly. These people work with an architect that values

this as well and are searching for a contractor that takes the environment into account when constructing new projects. The municipally of Beuningen said the following about the cpos´s:

*"I think there are people who are going to live there who prefer to build completely with tiny houses and circularly."*

However, customer demand can also affect the implementation of circular initiatives in a negative way. Cpo 1 mentioned that low maintenance was an important criteria for this group. In some situations, this means that the use of new materials is preferred over the use of renewed materials. This is in line with the contractor's statements:

*"As a contractor, why should you use recycled materials? It's worn it's crooked. Therein lies the problem that needs to be solved. The buyer prefers a house with new materials because it requires less maintenance."*

In the end, it comes down to looking at the wishes of the customer and together working out the best solutions according to the contractor:

*"So you will always consider what is the best material for this project in combination with the costs and the environmental impact. That's always the game we're on. That inconsultation with the end user."*

**Governmental**

Governmental requirements for building circular are increasing. The province of Gelderland stated in their performance program of 2021-2023 that new-built homes in Gelderland should for 25 percent be made out of circular materials. This is in line with the demand of the municipally of Beuningen that buildings should be built circular for at least 25 percent. Still, these demands are not made explicit.

*"I then said, together with my colleague, that 25% should be built in a circular way, but what that exactly entails? Is it 25% of the total homes or 25% of all materials? Everyone is still looking for that."*

This quote shows that it is not yet clear for the municipally of Beuningen how this 25 percent circularity should be achieved. There is also no general used definition of circularity. The constructor said the following about this:

*"No, the government has 130 definitions of circularity. The Arnhem Nijmegen residential deal states that we must be 25 percent circular. It's not defined yet, but it's coming. What is circular? That should become apparent."*

So it is not clear what is meant by circular and the demands are not defined yet. Besides this, the demands are not communicated appropriately to the parties involved. Cpo 1 for example was not aware of the circular demand and nothing was mentioned about the 25 percent demand in al the documents delivered by the municipally of Beuningen. According to the contractor, better defined and more demands set by governmental organisations are needed to increase the implementation of circular initiatives:

*"And the government… it would be nice if it indicated how much recycled materials you should use. If we can ensure that the government imposes requirements on us, then we can and we will."*

**Competitive advantage and Reputation loss**

Both, competitive advantage and reputation loss were not mentioned as triggers for implementing circular initiatives.

### 4.2.2 Sustainable supply chain barriers

**Higher costs**

*"If you take circularity more into consideration, you will have to sacrifice more in terms of costs and vice versa. Economically cheaper will be less circular."*

According to this quote from cpo 1, building more circular will lead to higher costs. This is mentioned by others as well because of the higher maintenance that is related to renewed materials. But the contractor mentioned another problem when building with renewed materials concerning costs. At this moment it is still cheaper to buy new materials and demolish old

buildings, than re-using and recycling parts from old buildings to use in new projects. New materials are still too cheap in relation to the labour costs of dismantling old buildings for parts and materials. This is made clear in the following quote from the contractor:

*"The main issue now is that materials, despite the fact that the prices are sky high, are relatively cheap. So it is not yet worthwhile to harvest materials from existing buildings. This is because the labor component becomes much higher and it is cheaper to just buy it."*

The contractor mentioned that they are in discussion with municipal's and housing associations to tackle this problem and to create a new revenue model.

**Coordination efforts and communication issues**

Coordination efforts and communication issues will be discussed in detail in the next paragraph about supply chain collaboration.

## 4.3 Supply chain collaboration

Supply chain collaboration is measured based on the operationalisation of Cao and Zhang (2011). They distinguish seven interrelated components of SCC, namely, information sharing, goal congruence, decision synchronization, incentive alignment, resources sharing, collaborative communication, and joint knowledge creation. These components will be analysed separately in the following paragraph.

**Information Sharing**

The exchange of information will be higher when the different parties involve each other in an early stage of the process. The architect made the following statement regarding early involvement of other actors:

*"The best thing would be that the person who is going to implement it is also involved at a fairly early stage. So what I always try is to work one on one with a contractor. Because then you can also include that pricing in the realization of a project from the start."*

The architect indicated that they try to be involved as early as possible so they can bring in their knowledge and add more value to the customer. In this way, they can contribute to subjects

such as cost efficiencies and sustainability. Nonetheless, early involvement seems to be a challenge. In the case of the Ecowieck, the cpo's had not made any contact yet with each other when the data was collected and there wasn't a contractor involved in the development stage of the houses. So relevant information is being exchanged but still a lot of important information is not correctly received or defined what makes information sharing relatively low.

**Goal congruence**

An important aspect of goal congruence is the agreement on goals. The different parties involved have the same goal, namely: the construction of the buildings. But the importance of circularity in this process can differ. This is especially the case when it means that costs will increase. The members of the cpo's do not always agree on specific materials used in their houses and have the freedom to implement different levels of circularity in their houses. According to the architect it is important to involve people that are like minded in the process:

*"I learned that when you really want to make a good and sustainable project, you have to work with like-minded people and they are sometimes difficult to find."*

As mentioned earlier, legislation set by the government is seen by actors as a way to positively influence the achievement of circular goals regarding the construction of new buildings. Still, working circularly, or at least in a more sustainable way was taken into account by all the actors and thus makes goal congruence relatively high.

**Decision synchronization**

The degree of decision synchronization between the different actors is high. First of all it was indicated that collaboratively working out solutions make it interesting to work together. According to the architect:

*"Well, that is also a bit inherent in my work, I find the most interesting thing to come to the most ideal solution in a kind of partnership with the client."*

The other actors shared the opinion to sit down with different actors early on to work out solutions together. An example where a solution was worked out together was when there were a lot of different designs for the houses in the Ecowieck and guidelines were made together.

For example about the placement of the houses. Also the municipally of Beuningen and the Province of Gelderland indicated that they try to involve as many parties as possible in the decision process and take the lead in bringing parties together. This was for example emphatically mentioned in the performance program of the province of Gelderland:

*"The circular economy can only get off the ground if there is intensive cooperation and communication. In chains, clusters, around locations and between parties that do development work. We lead the way in connecting and accelerating collaboration."*

**Incentive alignment**

Incentive alignment among actors is really low. Costs, benefits and risks are not shared, instead they are mostly separately defined for all the different actors. Cpo 2 described this as follows when asked about the sharing of risks with the municipality of Beuningen:

*"But the municipality does not have any agreements with the housing associations. They only say that you have to arrange this and if you don't you will be fined. So the cpo bears 100 percent of the risks. So that is very easy from the municipality. You get a lot and you just sort it out. All risks are therefore with us. For example, if someone does not arrange the finances for his lot."*

**Resource sharing**

No statements were made about the sharing of resources such as equipment and technical supports between different actors. Resource sharing among actors is thus low.

**Collaborative communication**

Collaborative communication is relatively low between the different actors. The cpo's had not made any contact yet with each other when the data was collected. Cpo 2 held the municipality responsible for not facilitating this already. Cpo 1 was not aware of any guidelines concerning circularity set by the municipality of Beuningen which showed that the contact with the municipality was also not on a regular basis. Open and two way communication was complicated by the corona crisis because communication was mostly online. This counts for the contact between the Cpo's and the municipality of Beuningen as well as with the architect:

*"But once you're in that design process, it's actually almost impossible to do that through Microsoft Teams."*

So communication between the different actors involved is relatively stiff. There are situations in which they involve each other and try to work out solutions but communication can still improve a lot.

**Joint knowledge creation**

The jointly creation of knowledge was mentioned especially when solutions had to be worked out and required new knowledge. When the different parties were together this was an important part:

*"The municipality wants the project leaders of both clubs to come together and a few representatives to share this picture and this story with each other. Then you can continue to say to each other like we're going to investigate that. We have also received a subsidy from the province. This includes an additional amount for research into ecological construction."*

As mentioned by Cpo 2, there are also subsidies from the Province of Gelderland available to improve the creation of new knowledge. The Province of Gelderland stated that they try to fulfill an informing, stimulating and coordinating role by bringing parties in chains, clusters and around top locations together and by making knowledge accessible. The jointly creation of new knowledge is relatively high but more contact and working together is necessary to increase this component.

## 4.4 Synthesis

In this paragraph, the results will be summarized first and used to answer the main question: *How does supply chain collaboration impact the implementation of value retention options in the building environment when influenced by barriers and triggers for CE?*

**Summary of results**

The value retention options refuse (R0) and reduce (R1) are the most commonly used value retention options. Some materials were not used in parts of the buildings because they have a negative effect on the environment. In other parts, it is still not appropriate yet to use other materials, for example the foundation of buildings. The amount of new materials used is reduced as much as possible. Especially the use of biobased materials is emerging. The impact a material makes on the environment is taken into account when choosing materials.

Re-use and resell is a strategy that is mostly used when thinking of the future. More and more parts are developed in such a way that houses can be demountable in the future. Al ready demountable parts are not often used in current construction projects. Prefabrication and the documentation of parts and materials will increase reselling and re-use of parts in the future. This accounts also for the value retention option repurpose.

Repair, refurbish and remanufacture are less common value retention options in the building environment. Especially the cpo's found it important to use materials that need as little maintenance as possible.

The use of biobased materials was most prevalent when focussing on sustainable materials. When old materials were used again it was mostly about re-using demountable parts. So the value retention option recycle was less used. Recover and remine were not mentioned at all.

Customer demand and governmental regulation are the most important triggers for the implementation of a more sustainable supply chain. Customer demand regarding sustainability is increasing but the wish for less maintenance, negatively effects the use of renewed materials. Governmental regulation is increasing and focussing more on circularity. Still, more and better defined requirements are needed. Competitive advantage and reputation loss does not seem to have a large effect on the implementation of circular initiatives in the building environment.

The higher costs that are perceived when building in a circular manner are an important barrier. The dismantling of buildings in order to re-use parts and materials is more expensive than the demolishing of buildings and buying new materials. Besides this, renewed materials are seen as requiring more maintenance which increases costs.

Information sharing among actors is relatively low. Actors can involve each other earlier in the process, especially in the case of Ecowieck. Important information is not always appropriately shared which influences the implementation of value retention options in a negative way.

Goal congruence is relatively high. Working circular, or at least in a more sustainable way is taken into account by all the actors. Increasing costs can influence these circular goals negatively while governmental regulations can contribute to obtain more circular goals.

The degree of decision synchronization between the different actors is high. Actors agree that working together can make an impact especially when new solutions have to be found.

Incentive alignment and resource sharing are both low. Costs, benefits and risks are not shared, instead they are mostly separately defined for all the different actors. Resources are not shared either among the different actors.

Collaborative communication is relatively low. There is no communication on a regular basis between the actors which resulted in missing of important information.

The jointly creation of new knowledge is relatively high. The province of Gelderland and municipality of Beuningen try to fulfill an important role in the facilitation of this but are not always achieving this due to a lack of communication.

**Main question**

*How does supply chain collaboration impact the implementation of value retention options in the building environment when influenced by barriers and triggers for CE?*

Circularity is taken into account mainly at the beginning of the building process which explains the presence to a high extent of the options refuse and reduce. The implementation of the value retention options concerning the re-use of materials when demolishing buildings can improve. The triggers customer demand and governmental regulation have a positive effect on the implementation of the value retention options when both interest groups stimulate the use of circular initiatives. Customer demand can have a positive effect when customers value a more environment friendly way of living but a negative effect when new materials are preferred over renewed materials because new is identified with less maintenance. Governmental requirements are increasing and thus positively influencing the implementation of value retention options. Still, common language and more and better defined requirements regarding circularity are needed. Higher costs related to circularity has a negative effect on the implementation of the value retention options. The re-using of parts and materials is expensive and new materials are relatively cheap. Supply chain collaboration can contribute to the implementation of the value retention options when all components are present to a high extent.

More collaborative goals concerning circularity should be defined and communication and information sharing can improve. Governmental organizations have an important role in the improvement of collaboration among actors in the building environment.

# Chapter 5: Discussion

As mentioned in the first chapter of this thesis, according to the CBS (2019), the building and manufacturing industry is the frontrunner when it comes to the use of recycled materials. In 2016, the building and construction industry was responsible for the use of more than half of all recycled materials in The Netherlands. The building industry takes into account which materials they use at the beginning of the process but fail to take circularity into account at the end of the lift time of buildings. Reike et al. (2018) identified ten options an organisation can implement to enable circularity. The prevention options (R0 and R1) are present to a large extent but the options concerning reutilization (R2, R3, R4, R5, R6, R7, R8 and R9) can still improve drastically. Prefabrication, standardisation and documentation of parts and materials used are important actions to tackle this problem.

According to Seuring and Muller (2008), customer demand is seen as an important trigger for the implementation of more circular strategies which is reflected in the analyses of this thesis when the residents value sustainability. On the other hand, the demand for less maintenance decreases the demand for circularity. Governmental regulation is another important trigger identified by Seuring and Muller (2008). The province of Gelderland and the municipality of Beuningen are setting preconditions but they are not defined well and hard to monitor. It is not clear how the demand of 25 percent of circularity should be imposed on new building projects and it is hardly monitored. The use of a common language by governmental institutions regarding circularity is also missing. So improvements should be made in governmental regulations in order to trigger initiatives regarding circularity. Competitive advantage and reputations are two other triggers mentioned by Seuring and Muller (2008) but do not seem to have an effect on the actors interviewed in this study.

Increasing costs is an important barrier for the implementation of circular initiatives according to Seuring and Muller (2008). The interviewed parties also acknowledged this barrier. Especially the reutilisation of parts and materials is still too expensive in comparison to the use of new materials. This is in line with the findings of Adams et al. (2017). At this moment, there is no incentive yet for contractors to re- use most of the materials which there is for example for the recycling of plastic bottles.

In order to have a positive impact on the implementation of circular initiatives, components of supply chain collaboration should be present to a high extent according to Cao and Zhang (2011). SCC becomes a barrier when this is not the case. In order to build circular it

is important that the different phases in the building process interact with each other (platform CB'23, 2019). It was expected that the case of Ecowieck, a building project that was promoted as a circular and sustainable project, consist of a higher degree of SCC than most projects. For some components this was the case while other components were lower than expected. Resources, incentives and information could be shared on a more regular basis. Goals regarding circularity and sustainability were set but could have been more explicit. Communication was mostly online and building processes should have been less separated. The involvement of a contractor earlier in the process would have been recommendable. Decision synchronisation was high due to the fact that solutions were worked out collaboratively and new knowledge was created in this way.

# Chapter 6: Conclusions

This thesis tried to provide an answer to the question: *How does supply chain collaboration impact the implementation of value retention options in the building environment when influenced by barriers and triggers for CE?* In order to answer this question, a qualitative study was conducted among different actors involved in the building and development of the Ecowieck in the city of Ewijk. The conceptualisation of the value retention options was based on the 10R typology framework of Reike et al. (2018). Supply chain collaboration was operationalised by means of the research of Chao and Zhang (2011) and the list of barriers and triggers identified by Seuring and Muller (2008) was used as barriers and triggers for this thesis. The data for this study was collected through weekly meetings, document analyses and interviews among different parties involved in the building process.

From the results it was found that the prevention options (R0 and R1) are present to a large extent but the options concerning reutilization (R2, R3, R4, R5, R6, R7, R8 and R9) are lower than would be expected. Customer demand and governmental regulation are the most important triggers for the implementation of CE. Competitive advantage and reputation loss did not seem to have an effect on the implementation of CE. Higher costs are an important barrier because of the relatively low price of virgin materials and increasing costs for implementing circular initiatives. Information sharing, incentive alignment, resource sharing and collaborative communication are low. Goal congruence, decision synchronization, joint knowledge creation are present to a higher extent.

This thesis has shown that supply chain collaboration positively impacts the implementation of the value retention options when all components are present to a high extent. As shown in the results, for some components this was the case, while other components can still improve. Communication and sharing of information among actors could improve. Collaboratively set goals concerning CE should be made more often and should be better defined. This is especially important for the value retention options concerning reutilisation because circularity is taken into account mostly at the beginning of the building process but less at the end of the life of buildings. Agreements concerning prefabrication, standardisation and documentation of parts and materials are necessary to improve the re-use of parts and materials. Higher costs regarding CE is an important barrier. Incentives regarding the re-use of most of the materials should be found collaboratively in order to overcome this barrier. Customer demand and governmental regulation are the most important triggers for CE. When both groups

stimulate CE, new initiatives will emerge. Governmental organisations should set stricter and better defined goals regarding CE and should take an active role in the improvement of collaboration among actors in the building environment.

## 6.1 Limitations

This thesis has several limitations. First of all, because there was no contractor involved yet in the building and development of the Ecowieck, an unrelated contractor was interviewed instead. This made it hard to make statements that are entirely accurate for the building and development of the Ecowieck. Some parts of the interview questionnaires were not appropriate yet because the development and building process was still in a quite early stage. This made it more difficult to access all the collaborations regarding the Ecowieck. Besides this, statements that were externalised to the entire building environment lose their power because there are only a limited number of actors interviewed for the writing of this thesis because of the limited time span of it. More interviews would thus have been recommendable to increase the external validity. As mentioned in chapter three, the measurement models had to be transformed from statements into questions in order to be appropriate for interviews. Items where transformed in order to be more appropriate for the building environment. This had an effect on the construct validity of this research.

## 6.2 Recommendations

Based on the discussion and conclusions described above, the following practical and theoretical recommendations can be made.

Prefabrication, standardisation and documentation of parts and materials used in buildings should increase in order to improve the implementation of value retention options regarding reutilization (R2, R3, R4, R5, R6, R7, R8 and R9). Common language by governmental institutions regarding circularity needs to be adopted. Requirements regarding circularity set by governmental institutions should be more explicit and the adherence to these requirements should be monitored more actively. The requirements need to be more strictly defined and should also involve the reusability of parts and materials. Incentives for contractors to dismantle old buildings should be set. For example through subsidies. Actors should involve each other early on in the process. For example, contractors can be involved in the design process in order to collectively work out the best solutions regarding circular initiatives. Governmental institutions should play an important role in informing, stimulating and

coordinating actors in the building environment. The ambitions that are laid down must be implemented step by step. This should be done collaboratively and not too fast but challenging enough.

More case based research is needed to better understand the challenges the building environment is facing. Besides this, this thesis tried to get a better picture of circularity in the building environment through interviewing at least one of all the important actors in the supply chain. For example, interviewing more contractors will improve this research. Research into circularity regarding other industries could result in interesting findings for the building environment as well. An in depth research into other subjects, for example the customer demand and governmental triggers, that was shortly elaborated up on in this research is also suggested.

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# Appendix A: Operationalisation scheme

| Variables | Dimensions | Indicators | Items |
|---|---|---|---|
| Resource value retention options | | | |
| | Refuse | Purchasing circular, avoiding, declining, preventing, rejecting | How is the circular strategy of refuse taken into account? |
| | Reduce | Dematerialising, efficiencies', buy less, extending life span | How is the circular strategy of reduce taken into account? |
| | Resell/Re-use | Second hand buying hardly adapted, second hand selling hardly adapted | How is the circular strategy of resell/re-use taken into account? |
| | Repair | Repairing of parts, revitalization, maintenance, life time extension | How is the circular strategy of repair taken into account? |
| | Refurbish | Upgrading, Refurbishing, advancing, modernising | How is the circular strategy of refurbish taken into account? |
| | Remanufacture | Dismantling of entire structure, reconditioning | How is the circular strategy of remanufacture taken into account? |
| | Repurpose | Up/downcycling, reusing in new function | How is the circular strategy of repurpose taken into account? |
| | Re-cycle | Rewinning of pure materials, processing, repurposing of waste | How is the circular strategy of re-cycle taken into account? |
| | Recover | Generating, incinerating, biofuel | How is the circular strategy of recover taken into account? |
| | Remine | Landfill mining, retrieving | How is the circular strategy of remine taken into account? |
| | | | |
| Sustainable supply chain | | | |
| | Triggers | | |
| | | Customer demand | |
| | | Governmental | |
| | | Competitive advantage | |
| | | Reputation loss | |
| | Barriers | | |
| | | Higher costs | |
| | | Coordination efforts | |
| | | Communication issues | |
| Supply chain collaboration | | | |
| | Information sharing | | |
| | | 1. exchange of relevant information | |

| | | | |
|---|---|---|---|
| | | 2. exchange of timely information | |
| | | 3. Exchange of accurate information | |
| | | 4. exchange of complete information | |
| | | 5. Exchange of confidential information | To what extent do you share information with partners? What kind of information (relevant, timely, complete and confidential)? (1, 2, 3, 4, 5) |
| | Goal congruence | | |
| | | 6. Agreement on goals | Which goals do you share with the other partners? (6) |
| | | 7. Agreement on the importance of collaboration | How important is the collaboration with other partners for you? (7) |
| | | 8. Agreement on beneficial improvements | |
| | | 9. Agreement on own goal achievement through collaboration | To what extent do you achieve your own goals when working together with partners? (8, 9) |
| | | 10. Layout of collaboration implementation plans | |
| | Decision synchronization | | |
| | | 11. Jointly planning on promotional events | |
| | | 12. Jointly developing demand forecasts | |
| | | 13. Jointly managing inventory | |
| | | 14. Jointly planning on product assortment | Which partners do you include in decision processes? (11, 12, 13, 14) |
| | | 15. Jointly working out solutions | How do you jointly work out solutions? (15) |
| | Incentive alignment | | |
| | | 16. Co-develop systems to evaluate each other performance | How do you evaluate each other performance? (16) |
| | | 17. Sharing of costs | What kind of costs do you share with partners? (17) |
| | | 18. Sharing of benefits | What kind of benefits do you share with partners? (18) |
| | | 19. Sharing of risks | What kind of risks do you share with partners? (19) |
| | Resource sharing | | |
| | | 20. The use of cross-organisational teams | How do you make use of cross-organisational teams? (20) |

| | | | |
|---|---|---|---|
| | | 21. Dedication of personal to manage collaboration processes | How do you dedicate personal to manage the collaboration? (21) |
| | | 22. Sharing of technical supports | What kind of technical support do you share? (22) |
| | | 23. Sharing of equipment | What kind of equipment do you share with partners? (23) |
| | | 24. Pooling of financial and non-financial resources | What kind of financial and non-financial resources are pooled together? (24) |
| | Collaborative communication | | |
| | | 25. Contact on a regular basis | What is the contact with partners like? (25) |
| | | 26. Open and two-way communication | |
| | | 27. Informal communication | Is there any form of informal communication? What does it looks like? (27) |
| | | 28. Different communication channels | Which communication channels do you make use of in order to communicate with partners? (27, 28) |
| | | 29. Influencing decisions through discussions | |
| | Joint knowledge creation | | |
| | | 30. Jointly searching and acquiring of new and relevant knowledge | How do you search and acquire knowledge with other partners? (30) |
| | | 31. Jointly applying relevant knowledge | |
| | | 32. Jointly identifying customer needs | |
| | | 33. Jointly discovering new or emerging markets | |
| | | 34. Jointly learning the intentions and capabilities of our competitors | How do you share knowledge with other partners? (31, 32, 33, 34) |

# Appendix B: Questionnaire

**General questions**

1. What is your name?
2. What is the name of youre organisation?
3. What is your function?

**Resource value retention options**

4. How is the circular strategy of refuse taken into account?
5. How is the circular strategy of reduce taken into account?
6. How is the circular strategy of resell/re-use taken into account?
7. How is the circular strategy of repair taken into account?
8. How is the circular strategy of refurbish taken into account?
9. How is the circular strategy of remanufacture taken into account?
10. How is the circular strategy of repurpose taken into account?
11. How is the circular strategy of re-cycle taken into account?
12. How is the circular strategy of recover taken into account?
13. How is the circular strategy of remine taken into account?

**Information sharing**

14. To what extent do you share information with partners? What kind of information (relevant, timely, complete and confidential)?

**Goal congruence**

15. Which goals do you share with the other partners?
16. How important is the collaboration with other partners for you?
17. To what extent do you achieve your own goals when working together with partners?

**Decision synchronization**

18. Which partners do you include in decision processes?
19. How do you jointly work out solutions?

**Incentive alignment**

20. How do you evaluate each other performance?
21. What kind of costs do you share with partners?
22. What kind of benefits do you share with partners?
23. What kind of risks do you share with partners?

**Resource sharing**

24. How do you make use of cross-organisational teams?

25. How do you dedicate personal to manage the collaboration?
26. What kind of technical support do you share?
27. What kind of equipment do you share with partners?
28. What kind of financial and non-financial resources are pooled together?

**Collaborative communication**

29. What is the contact with partners like?
30. Is there any form of informal communication? What does it looks like?
31. Which communication channels do you make use of in order to communicate with partners?

**Joint knowledge creation**

32. How do you search and acquire knowledge with other partners?
33. How do you share knowledge with other partners?