Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Economics

Contextual factors influencing the development of a Circular business model in aquaponics
- a case study of Peckas Tomater

Sofia Björkén
Elin Bystedt

Master's thesis • 30 credits

Environmental Economics and Management - Master's Programme 120,0 hp
Degree project/SLU, Department of Economics, 1217 • ISSN 1401-4084
Uppsala, Sweden 2019

Contextual factors influencing the development of a Circular business model in aquaponics - a case study of Peckas Tomater

Sofia Björkén
Elin Bystedt

Supervisor: Per-Anders Langendahl, Swedish University of Agricultural Sciences, Department of Economics

Examiner: Richard Ferguson, Swedish University of Agricultural Sciences, Department of Economics

Credits: 30 credits
Level: A2E
Course title: Master thesis in business administration
Course code: EX0904
Programme/Education: Environmental Economics and Management-Master's Programme 120,0 hp
Course coordinating department: Department of Economics

Place of publication: Uppsala
Year of publication: 2019
Cover picture: Peckas Naturodlingar AB
Name of Series: Degree project/SLU, Department of Economics
Part number: 1217
ISSN: 1401-4084
Online publication: http://stud.epsilon.slu.se

Key words: aquaponic, bio-economy, business model, circular business model, circular bio-economy, circular economy, controlled environmental farming.

Swedish University of Agricultural Sciences
Faculty of Natural Resources and Agricultural Sciences
Department of Economics

Acknowledgements

First and foremost, the authors would like to thank the company Peckas Tomater for their participation in this study, and especially our contact person, Carina Åberg. We would also like to thank the interviewees for taking the time to answer our questions, without your participation, this study would not be possible. Our classmates who have taken the time to proofread this thesis and given us feedback also deserve a big thank you. Furthermore, we would like to thank our supervisor Per-Anders Langendahl for guiding us through this. Lastly, we would like to thank our family for all the love and support during this thesis.

Uppsala, June 2019

Sofia Björkén & Elin Bystedt

Abstract

Research within the area of aquaponics is mostly focusing on technical perspectives such as aquaculture, hydroponics, and engineering. There are also few existing commercial aquaponics businesses globally and little knowledge about how aquaponic business model develop in practice. This study's aim was to examine contextual factors that enable and inhibit developments of aquaponic business model. The purpose was to create in-depth insights on how aquaponic business model are developed in practice and what factors that affect the development towards a circular bio-economy. The unit of analysis was the Swedish company Peckas Tomater. A qualitative methodology was chosen and it had an inductive approach. A case study was conducted with five semi-structured interviews.

This study's major conclusions were that the most significant internal factors that enabled the development of Peckas Tomater's business model towards circular bio-economy were key persons, Pecka Nygårds knowledge, and internal culture. The most significant external enabling factor was the mature market. Difficulty to find key persons and energy consumption was the two most significant internal constraining factors while legislations were the most significant external constraining factor.

It could be stated that Peckas Tomater potentially can be seen as a business that contributes to a circular economy and circular bio-economy since they use the latest technology regarding aquaponics, only uses renewable energy, have excluded plastic, and is seen to create positive societal impacts. Aquaponics have therefore the potential of making food production more sustainable due to the closed circular system that enables reuse of materials. However, it could be argued that aquaponics cannot be the only solution.

Sammanfattning

Den forskning gällande akvaponi som publicerats har främst utgått utifrån ett tekniskt perspektiv, som till exempel vattenkulturen, hydroponi och det tekniska systemet. Det finns dessutom få befintliga kommersiella akvaponiska företag globalt och väldigt lite kunskap gällande hur akvaponiska affärsmodeller utvecklas i praktiken. Denna studie syftar till att undersöka kontextuella faktorer som möjliggör och hämmar utvecklingen av akvaponiska affärsmodeller. Syftet är att skapa en fördjupad förståelse för hur akvaponiska affärsmodeller utvecklas i praktiken och vilka faktorer som påverkar utvecklingen mot en cirkulär bio-ekonomi. Det svenska företaget Peckas Tomater var studiens utgångspunkt varvid en kvalitativ metod valdes med ett induktivt tillvägagångssätt. En fallstudie genomfördes med fem halvstrukturerade intervjuer.

De främsta slutsatserna från studien var att de viktigaste interna faktorerna som möjliggjorde utvecklingen av Peckas Tomaters affärsmodell mot en cirkulär bio-ekonomi var nyckelpersoner, Pecka Nygårds kunskap och den interna kulturen. Den viktigaste externa möjliggörande faktorn var den mogna marknaden. Svårigheten att hitta nyckelpersoner och energiförbrukningen var de två viktigaste interna faktorerna som begränsade utvecklingen medan lagstiftningen var den viktigaste externa begränsningsfaktorn.

Peckas Tomater kan potentiellt anses vara ett företag som bidrar till en cirkulär ekonomi och cirkulär bio-ekonomi eftersom de använder den senaste tekniken inom akvaponi, endast använder förnybar energi, har uteslutit plast och anses skapa positiva samhällsekonomiska effekter. Akvaponiska odlingar har därför potentialen att göra livsmedelsproduktionen mer hållbar på grund av det stängda cirkulära systemet som möjliggör återanvändning av material. Det kan dock hävdas att akvaponiska odlingar inte kan vara den enda lösningen.

Table of Contents

List of figures

List of tables

Abbreviations

BE: Bio-Economy
BM: Business Model
CBE: Circular Bio-Economy
CBM: Circular Business Model
CE: Circular Economy
CEA: Controlled Environmental Farming
SBM: Sustainable Business Model
SME: Small and Medium-sized Enterprise

1 Introduction

This chapter presents the background for the chosen topic and it will highlight the problems that have emerged within this area. It also describes the study's relevance to the research field, its aim, and research questions. This chapter also includes the study's delimitations and outline.

1.1 Background

The human overuse and abuse of natural resources have pushed the global ecosystems to a verge (Rockström *et al*., 2009). In research, there is a general agreement that it is the environmental, social and economic challenges that drive the need for improved solutions for food systems (Köning *et al.,* 2018). These challenges are socially constructed and are shaped by a particular time and space context. On the production side, the increase in food demand cannot be sustained by using more natural resources and on the consumption side, changes need to be made to improve food security in developing countries (Köning *et al.,* 2018; Van der Goot *et al.,* 2016). To achieve sustainability within food production there is a need for innovations that exceed the traditional paradigms and that account for the complexity regarding sustainability. One strategy is to change the way the food is being processed and another is to change the way the food is being produced, by changing the technology while also trying to change consumer behavior (Van der Goot *et al.,* 2016).

Ellen MacArthur Foundation (2019) presents Circular economy (CE) for food as a potential model to achieve sustainability since it has the opportunity to bring economic, health, and environmental benefits. Circular food systems can be described as regenerative, resilient, non-wasteful, and healthy (ibid.). In these systems, Ellen MacArthur Foundation (2019) argues that there is a benefit of locating the farmers closer to the consumer through urban farming. Fertilizer and pesticides should be minimized and digital solutions have the opportunity to meet supply and demand that creates a less wasteful, on-demand system. Another concept that also reconciles economic, environmental and social challenges is Bio-economy (BE). CE and BE are two different concepts that have developed in parallel, however, according to Hetemäki *et al.* (2017), these need to be connected to reinforce each other. Hetemäki (2017) introduces the concept Circular bio-economy (CBE), which, according to Antikainen *et al.* (2017a), has the opportunity to present new functions for bio-based materials, such as longer lifecycle, improved endurance, and less toxicity, which CE cannot provide alone. CBE are often referred to as a dream scenario but that lacks a contextual attachment. However, due to the environmental, social and economic challenges being socially constructed it is important when developing a CBE to consider that specific context.

A way to conceptualize CBE is through a Business Model (BM) that is created for the specific context to where the environmental, social and economic challenges are socially constructed. A BM can be described in several ways, however, this study will define a BM according to Richardson's (2008) definition where it is based on three different components, *the value proposition, value creation and delivery, and value capture.* A BM is often seen as a driver of competitiveness since it defines how the business is positioned on the market compared to competitors (Chesbrough, 2007; Chesbrough 2010). The design of a BM is considered as a strategic priority for managers and their companies since it demonstrates how a business intends to make money (Osterwalder *et al.,* 2010). When businesses try to develop a circular thinking into their BM, a circular business model (CBM) can be created (Lewandowski, 2016). CBM can be seen as a subcategory to BM (Antikainen & Valkokari, 2016), which considers a wider group of stakeholder interest, such as the society and the environment

(Bocken *et al.*, 2014). According to Reichel *et al. (*2016), repair, reuse, refurbishment, remanufacture, sharing, take-back, and recycling are all common activities which involve value creation in a CBM. This opposes from the linear model where value creation mainly involves virgin materials.

Controlled Environmental Farming (CEA) can be seen as the modification of the natural environment to optimize plant growth and quality (Jensen, 2002). These modifications can be made both above ground and in the root environments to increase the crop yield, lengthen the growing season and allow plant growth during periods that are usually not used. Most hydroponic systems are, according to Love *et al*. (2014), performed in controlled environmental facilities, such as a greenhouse and can be traced back to the work by Dr. William Gericke at the University of California in the year 1929. The science behind hydroponic is to grow plants in a nutrient solution without soil, eliminating the soil-borne diseases and weeds (Sheikh, 2006).

Aquaponics is an example of an integration between agriculture and aquaculture (Kloas *et al.*, 2015) and applies the methods developed by the hydroponics industry (Love *et al.*, 2014). It is also considered to be a possible way to improve food systems and make them more circular and sustainable (Van der Goot *et al.*, 2016; Love *et al.*, 2014). According to Love *et al.* (2014) it is also common for aquaponic production to use greenhouses and controlled environmental agriculture methods to increase crop yields. To produce fish and annual plants combined is not new, it has been practiced since ancient times. However, modern-day aquaponics, where aquaculture and soil-less vegetable production (hydroponics), are combined is still quite new and popular worldwide (Junge *et al.*, 2017). Blidariu and Grozea (2011) state that one of the benefits with aquaponics is that dissolved fish water can provide nutrition to plants which, according to Rakocy *et al*. (2006), can reduce emissions to the environment, counteract the eutrophication problem and make the food production more circular. However, many producers struggle with making a profit due to the high capital investment, high level of knowledge, consistency and reliability of input, and the willingness from the market to pay a higher price for the products due to the high production cost. Aquaponics could potentially contribute to sustainability through technology since it changes the way food is being produced. However, in order to establish these systems, BMs that are adapted for aquaponics and the closed circular process need to be developed.

1.2 Problem

Research within the area of aquaponics is mostly focusing on technical perspectives such as aquaculture, hydroponics, water quality, microbiology, and engineering (Van Woensel *et al.*, 2015). Van der Goot *et al.* (2016) and Love *et al.*, (2014) state that the technology of aquaponics has the potential to improve food systems and make them more sustainable. According to Richardson (2008) and Chesbrough (2010), BMs can be seen as vehicles for technology appropriation and can also be used as an analytical lens to understand the objective of firms.

There are today few existing commercial aquaponics businesses globally and very little knowledge about how aquaponics BMs develop in practice. The lack of knowledge regarding existing aquaponic BMs also suggests that there are few businesses that have succeeded in making aquaponics a profitable business. This may also be due to the high capital investments, high level of knowledge, and the consistency and reliability of input that is required in an aquaponic business (Rakocy *et al*., 2006, Somerville *et al*., 2014; FAO, 2016). According to Köning *et al.* (2018), there is a lack in the overall empirical understanding of the

concept aquaponics as a technological innovation system and its empirical perspective on functional activities. One way to study how aquaponics develops in practice is to not look at businesses as organizational entities that use this system, but to look at BMs in which this technology is appropriated and used. By building on this analytical approach it will allow a micro level perspective to understand how aquaponics BMs are developed in its context.

It can, therefore, be concluded that there is a gap in knowledge regarding how BMs for aquaponics are developed in practice and in its context. Due to this gap, this study contributes to the empirical research field regarding BMs for aquaponics by examining what contextual factors affect the development of a BM towards CBE. To understand contextual factors that shape business development, this study's analytical perspective is based on the work of Gouldson (2008). Contextual factors are separated in terms of internal and external. Internal factors are for example governance structure, corporate culture, and capacity for innovation and the external factors are for example government, market, and civil society.

1.3 Aim and research questions

This study aims to examine contextual factors that enable and inhibit developments of aquaponic business models. The purpose is to create in-depth insights on how aquaponic business model are developed in practice and what factors that affect the development towards a circular bio-economy.

Research questions:

- What contextual factors enable the development of aquaponic business models towards a circular bio-economy?
- What contextual factors inhibit the development of aquaponic business models towards a circular bio-economy?

1.4 Unit of analysis

The unit of analysis in this study is the Swedish company Peckas Tomater. They were chosen because they possesses the largest commercial aquaponics in Europe with salmon trout and tomatoes, cultivated in a closed system (Peckas, 2019). Peckas Tomater claims that their aquaponic contributes to an environmentally sustainable society since they use the latest technology where the fish nourish the tomato plants and the tomato plants cleanse the water, which prevents emissions from both the fish and the tomato cultivation (Peckas Naturodlingar AB, 2017). Their business concept is to provide locally produced and high-quality vegetables and fishes to the growing market (Peckas Naturodlingar AB, 2017). The objective is to lead the development in large-scale aquaponics and in this way become the market leader in providing food from aquaponics. Due to this, Peckas Tomater is used as a practical example that potentially could highlight crucial insights regarding the development of an aquaponic BM towards CBE.

1.5 Delimitations

This study only looks at aquaponics from a business perspective and does not focus on it as a technological innovation. A case study will be conducted on the aquaponic business Peckas Tomater in order to create in-depth insights about aquaponic BMs and how they move towards CBE. BMs do not evolve in a vacuum, therefore Peckas Tomater's local context will be examined. As mentioned before, there is very few commercial aquaponics that has succeeded on the market and due to this, only a single case study will be included.

1.6 The outline of the study

To help orient the reader, the outline of the study is illustrated in Figure 1. In the introductory chapter (chapter 1), the background to the chosen topic is first presented and then the study's problem is highlighted. This chapter also includes the aim of the study, the research questions and the delimitations that was made. The next chapter (chapter 2), presents the methodology that will be used in the collection of both theoretical and empirical data. The following chapter, (chapter 3), presents the theoretical framework, which later was used in the discussion chapter. The next chapter in this study (chapter 4) presents the empirical data that was collected from the case company Peckas Tomater and is followed by the discussion and analysis (chapter 5). There, the empirical data is linked to the conceptual framework in order to answer the questions of the thesis. The final chapter (chapter 6) answers the aim and presents the conclusions drawn from this case study.

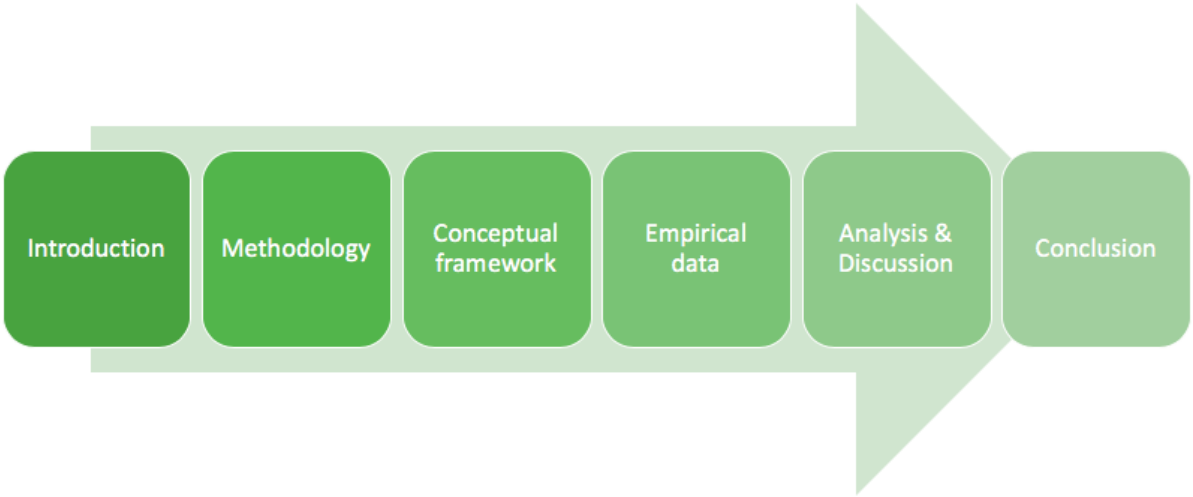

Figure 1. The outline of the study. *(Own processing).*

2 Methodology

This chapter presents the method and research approach that has been used in this study to be able to collect empirical and theoretical data. It also describes ethical and quality assurance issues related to this study, delimitations and chosen method to analyze the collected data.

2.1 Research approach

As mentioned before, this study aims to examine contextual factors that enable and inhibit developments of aquaponic BMs towards CBE. A qualitative method will, therefore, be used where the emphasis of data collection is on words rather than quantification (Bryman & Bell, 2015). A qualitative methodology is, according to Golafshani (2003) and Bryman and Bell (2015), characterized by its contextual focus when studying a phenomenon. The aim is to develop an understanding of the social context and how people interpret it. The approach is also focusing on social characteristics, which are a result of an interaction between people. Golafshani (2003) argues that both qualitative and quantitative methodologies have to be tested to show their credibility. In qualitative studies, it is the researcher who is the instrument that can affect the credibility.

This study will have an inductive approach where the theory is going to be generated through the collected data. The results are going to be generated through real-life situations, which will be developed naturally rather than by statistical measurements. The research will have an interpretivist epistemology, which is social science oriented since it divides society and nature because they differ (Bryman & Bell, 2015). It will focus on humans and their institutions were the social reality is different for all people. The ontological position will be constructionist, which aims to see social phenomena that are created continually by social actors who interact with each other (ibid.). Researchers using this ontological position are presenting a specific version of the social reality rather than one that can be seen as definitive. Therefore, constructionism claims that there are many subjective realities out there.

2.2 Literature review

A narrative literature review was done in the initial process to gain an impression of the selected topic and also to help develop the conceptual framework used in this study. According to Bryman and Bell (2015), a literature review could help the researcher by giving ideas to the content, by showing previous research, and by giving the researcher the opportunity to learn from other's mistakes. Bryman and Bell (2015) state that a literature review either can be systematic or narrative, however, they argue that a narrative review is more suitable for a qualitative research method due to the greater flexibility of the review. Yin (2013) states that a narrative literature review is less strict compared to a systematic and, therefore, it gives the researcher an opportunity to discover new and in-depth understandings of the topic. Furthermore, an important factor to consider is that a narrative literature review tends to easily become unfocused and more comprehensive than a systematic review.

To enable to find relevant articles, books, and reports within the area databases such as Primo, Google Scholar, Web of Science, and Retriever Business was used. Keywords such as "Business model", “Circular business model”, “Aquaponics”, “Circular Economy”, “Bio-economy”, “Circular bio-economy” and “Controlled environmental farming” were used to specify the search and to reduce the number of items. Relevant articles were then sorted after if it was peer-reviewed, its relevance to the study and if it was well-cited to ensure its quality and increase the trustworthiness of the study.

2.3 Sampling strategy

According to Patton (1990), the sampling approach is one of the most obvious differences between quantitative and qualitative methods. Qualitative research typically focuses on in-depth, small samples, which is selected purposefully. Quantitative research is on the other hand typically depended on larger samples, selected randomly. Patton (1990) claims that it is not only the techniques for sampling that are different but also the logic of each approach since the purpose of each strategy is different. In short terms, the purpose of quantitative research is to conduct a generalization from the sample to a larger population (ibid.). Qualitative research, on the contrary, tries to select information-rich cases for study in depth with the purpose to highlight issues and importance to the purpose of the research (ibid.).

Coyne (1997) claims that in qualitative research, sampling strategy is a complex issue since it is described in many different ways in the literature. Some definitions are even overlapping which creates confusion, particularly when discussing purposeful and theoretical sampling (ibid.). Theoretical sampling is often associated with grounded theory, developed by Glaser and Strauss in 1967. Grounded theory can be understood as ”*...the discovery of theory from data systematically obtained from social research”*(Glaser & Strauss, 1967, p.2). Theoretical sampling can, therefore, be seen as a method of analyzing qualitative data with the purpose to produce a theory.

In this study, purposeful sampling will be used. Purposeful sampling can be categorized to a wide range of different techniques, where several, authors have all made diverse divisions. This study will use the technique, coined by Patton (1990), called extreme (or deviant) case sampling. This technique was chosen because it is used for cases that are special or unusual in some way, for example, it highlights cases with notable outcomes, failures or successes. This study will focus on Peckas Tomater, which in this perspective can be seen as a successful business since they have been able to develop a circular thinking in their aquaponic business model. Therefore, Peckas Tomater will be used as a practical example that potentially could highlight crucial insights regarding the development of aquaponic business models. Patton (1990) argues that these extreme (or deviant cases) are useful in the sense that they provide significant insight into a specific phenomenon, which can help future research and practice within the specific area. Therefore, this technique suits this research since the goal is to provide notable insights about the development of aquaponic business models which will be useful for both the academia and businesses.

2.3.1 Case study

Cresswell (2013) presents five different approaches to qualitative inquiry; *narrative research, phenomenology, grounded theory, ethnography, and case study.* In this study, a case study will be conducted where the unit of analysis is Peckas Tomater. A case study is, according to Bryman and Bell (2015), detailed and has the opportunity to describe the specific nature and complexity of a phenomenon. It allows the researcher to investigate a specific area through one or several cases within a bounded system (ibid.). This bounded system or multiple bounded systems, are investigated over time through detailed and in-depth data collection involving multiple sources of information, for example through observations and interviews. Cresswell (2013) argues that a case study can be a single case study or multiple case studies. This thesis will conduct a single case study since it will only investigate Peckas Tomater. This is due to the chosen aim, research questions, and the unit of analysis. The aim is not to compare different businesses but to highlight crucial insights of Peckas Tomater that can be educational for other businesses and to the research area of aquaponic BMs. Another reason

for not doing a multiple case study is that there is very few commercial aquaponics that has succeeded on the market and is therefore not relevant for this study.

2.3.2 Semi-structured interviews

According to Bryman and Bell (2015), the two major types of interviews are called structured (standardized) and semi-structured interviews. The main difference between those two is that structured interviews emphasize specific questions and often offer the interviewee a fixed range of answers.

In this study, semi-structured interviews were conducted with Elena Petukhovskaya (CEO), Hugo Wikström (Co-founder), Carina Åberg (Marketing director), Andrea Gambardella (Technology consultant), and Pecka Nygård (founder) from the chosen company, Peckas Tomater (see table 1). In order to gather important insights about their context and their social interactions, these interviews were conducted at their facilities in Härnösand. This also made it possible to create an understanding of how the business function as a whole. These persons were chosen because they represent different parts of the company as a way for the authors to receive a wider perspective. Semi-structured interviews, unlike structured interviews, are flexible and focus on the respondents' own perceptions and interpretations in order to get comprehensive and detailed answers (Bryman & Bell, 2015). These interviews have been used in this study as they allow the interviewers to determine in advance the topics that the interviews should concern and, in part, direct the respondent to respond within these areas (ibid.). An important aspect for the interviewer is to avoid leading questions, as it is the respondents' own perspective the interviewer want to reach (ibid.). It is also important to acknowledge that the answers could be biased which may have affected the results.

Table 1. Interview scheme. *(own processing).*

Respondent	Position	Method	Duration	Date	Ethical considerations
Elena Petukhovskaya	CEO	Semi-structured interview	30 min	2019-04-04	Recorded, transcribed & respondent validation
Hugo Wikström	Co-founder	Semi-structured interview	45 min	2019-04-04	Recorded, transcribed & respondent validation
Carina Åberg	Marketing Director	Semi-structured interview	50 min	2019-04-04	Recorded, transcribed & respondent validation
Andrea Gambardella	Technology Consultant	Semi-structured interview	50 min	2019-04-04	Recorded, transcribed & respondent validation
Pecka Nygård	Founder	Semi-structured interview	30 min	2019-04-04	Recorded, transcribed & respondent validation

Wilson (2014) states that a semi-structured interview should be chosen when the researcher has some information about a topic but wants to gather greater knowledge by raising new issues. The semi-structured interview is also suited when dealing with complex issues since you are allowed to ask spontaneous questions to explore, deepen understanding, and clarify answers to questions (ibid.). Before the interviews were conducted, an interview guide was prepared (see Appendix 1). This guide can be seen as a tool for the researcher since it gives them an overview of what information they need from the respondents in order to answer the chosen research questions. Wilson (2014) presents five things that this guide should include,

these are *an introduction to the purpose and topic of the interview, list of topics and questions to ask about each topic, suggested probes and prompts, and closing comments.*

2.4 Data analysis

A qualitative content analysis will in this study be conducted after the empirical data is collected and transcribed. It was chosen since it allows the researcher to find patterns and themes regarding the topic (Zhang & Wildemuth, 2009). Titscher *et al.* (2000, p.55) claims that content analysis is ...*"the longest established method of text analysis among the set of empirical methods of social investigation".* However, it does not exist one homogenous understanding of the method. The book written by Berelson *"Content analysis in communication research",* was published in 1952 and was at that time the first book which included methods and goals of quantitative content analysis (Kohlbacher, 2006). As a critical reaction to this book, Kracauer published an article called *"The challenge of quantitative content analysis"*(Kracauer, 1952). Kracauer concluded that the quantitative approach neglected the quality of texts and that the importance was to reconstruct contexts (ibid.). He also argued that counting or measuring could not demonstrate patterns or wholes. This critical reaction was the starting point of the development of qualitative approaches to content analysis.

Babbie (2011, p.304) defines qualitative content analysis as ..*"the study of recorded human communications".* It can also be seen as a coding operation where the process is to transform raw data into a standardized form (Babbie, 2011). According to Zhang and Wildemuth (2009), a content analysis allows for the inclusion of various kinds of data. Zhang and Wildemuth (2009) present eight general steps that should be included in the content analysis, these are *preparation of data, defining the unit of analysis, developing categories and coding schemes, testing of categories and schemes, coding the data, assessing coding consistency, drawing conclusions from coded data and, reporting.* Kohlbacher (2006) argues that a content analysis would be an appropriate analysis and interpretation method when conducting a case study. Remenyi *et al.* (2002, p. 5-6) states that it as a technique that can be used in order *…"to transform what is essentially qualitative evidence into some sort of quantitative evidence"*

Therefore, content analysis will be conducted in this research since it is concluded to be an appropriate method when doing a case study and it will allow the researchers to draw conclusions from the coded data. In detail, the content analysis will emphasize what internal and external factors that have enabled or inhibit the development of an aquaponic BM towards CBE.

2.5 Ethical and quality assurances issues

In the conventional positivist research paradigm, criteria such as validity, reliability, and objectivity is used to evaluate the quality of the research (Zhang & Wildemuth, 2009). This study has an interpretive epistemology and therefore it is more suited to be evaluated based on its trustworthiness and authenticity. These alternative criteria should be used instead of reliability and validity because they are not built on the presumption that there is a single absolute account of social reality (Bryman & Bell, 2015). Instead, Bryman and Bell (2015) argue that there are more or several views of reality. Trustworthiness is based on four different criteria; *credibility, transferability, dependability, and confirmability.*

2.5.1 Credibility

Credibility can be referred to as the *"… adequate representation of the constructions of the social world under study"* (Zhang & Wildemuth, 2009). The criterion wants to ensure that the research is done according to "good practice" and that the findings are submitted to members of the social world to confirm that they are correctly understood (Bryman & Bell, 2015). There are several activities that can be used as tools to improve the credibility of the research, for example, prolonged engagement in the fields, persistent observation, triangulation, negative case analysis, and respondent validation.

According to Bryman and Bell (2015), triangulation can be referred to as an approach that uses multiple observers, theoretical perspectives, sources of data and methodologies. Researchers may use multiple methods such as a literature review and multiple case studies to facilitate a deeper understanding of a social phenomenon. The purpose of a respondent validation is to receive confirmation from the respondent that the description provided is correct. A respondent validation and triangulation are, therefore, going to be made after a compilation of the empirical data.

2.5.2 Transferability

Transferability is the second criteria of trustworthiness and wants to encourage researchers to produce rich accounts of a culture so that others can use them as references (Bryman & Bell, 2015). To achieve this, detailed and frequent descriptions of the social reality that is being studied is required. This sub-criterion can be difficult to achieve in qualitative studies since it is an intensive examination of people with common characteristics (Bryman & Bell, 2015). This has been taken into account in the selection of semi-structured interviews, where the goal was to reach detailed and comprehensive answers.

2.5.3 Dependability

The third criteria is dependability and entails that the researcher should adopt an auditing approach to ensure that proper procedures have been followed (Bryman & Bell, 2015). This means that there should be a complete description of all phases in the research process available. For example, problem formulation, selection of interview persons, notes, and interview guide. These choices must then be examined by an external party who is to assess the quality and how the elections have been applied. However, in qualitative studies, this procedure is not common, as the task is time-consuming because of the large amount of data. According to Golafshani (2003), dependability as a sub-criterion that is irrelevant in qualitative studies. This is because these studies have the purpose of generating an understanding and acting as an interpretation of reality and not explaining reality which is the purpose in quantitative studies (ibid.).

This study will be reviewed by several external parties such as an opposition group, a supervisor and employees from the chosen company. This paper is therefore examined by external parties with different perspectives and insight, which strengthens its dependability.

2.5.4 Confirmability
The last criteria for trustworthiness are confirmability and deals with the researcher's objectivity (Bryman & Bell, 2015). Even though complete objectivity is impossible, it can be shown that the researcher acted in good faith without being consciously influenced by personal values. If this is not achieved, it can affect the performance and the results generated by a study. These arguments have been taken into account when there are difficulties regarding the objectivity of both the interviewer and the people who have been interviewed. For example, the interviewees can have their own personal agendas, which could affect their responses during the interview.

2.5.5 Authencitity
Authenticity is a criterion that raises a wider set of issues and are criteria appropriate for judging the quality of inquiry (Bryman & Bell, 2015). By presenting different viewpoints from the people that were interviewed and controlling if the answers are truthful and genuine are two ways to fulfill this criterion. In this study, this was done through respondent validation and triangulation to erase the possibility for misunderstandings and untruthful answers.

2.5.6 Ethical considerations
According to Bryman and Bell (2015), it is important to take ethical considerations when doing a qualitative study because of the closeness between the researchers and the respondents. To avoid that important information is misunderstood or missed, the interviews will be recorded. The information will also be transcribed after the interviews and sent back to the respondents to allow them the opportunity to approve the information that will be used in the study. The researcher will also explain to the respondent that information from the interviews will be used in this study. To be able to ensure the integrity of the respondents and as a way to protect their personal data according to GDPR (General Data Protection Regulation), a letter of consent was signed by all respondents before the interviews were conducted.

2.6 Critical reflections
According to Bryman and Bell (2015), a qualitative study often gets to receive criticism for being subjective in its assessment where the researchers own opinions affects the outcome. Many researchers argue that the researcher's own characteristics such as sex, age and personality will affect the study, which will lead to difficulties in replication. Eisenhardt (1989) also argues that there is a risk that researchers draw preconceived conclusions about the results of a study and about the generalization of the results when doing a case study.

A common misunderstanding of case study research is that they cannot be generalized (Flyvbjerg, 2006). According to Flyvbjerg (2006), it is possible to generalize the results from a qualitative study in the sense that once a phenomenon has been proven to exist, it should also be considered significant in a broader context. However, it does not have to mean that the phenomenon applies to all members of a larger population (ibid.). Yin (2013, p. 10) also discusses these problems in his book where he explains it in the sense that case studies ..”*does not represent a sample, and the investigator´s goal is to expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization)”.* This study will still use this method since it emphasizes the respondent´s own perceptions and interpretations and because it allows the researcher to go into detail and see the contextual importance of aquaponic BMs.

Wilson (2014) presents several weaknesses related to semi-structured interviews, where "interviewer effect" is one of the most common. Attributes such as background, sex, age, and other demographics can influence how much information the respondents are willing to share with the interviewer. Leading questions is another common problem where the interviewer guide the respondents into a specific answer (ibid.). A way to overcome these problems is to conduct an interview guide, which was mentioned above. This is a way for the interviewers to prepare beforehand and therefore minimize the risk of fall for these weaknesses.

3 Literature review and Conceptual framework

This chapter presents the literature review and conceptual framework that will be used in this study. The purpose of the literature review is to introduce the concept of controlled environmental farming and aquaponics. The theories that the conceptual framework will be built on is divided into two different sections. The first section is about Circular bio-economy (CBE), and the second is about Circular business model (CBM). The purpose of this chapter is to develop a conceptual framework that will be connected to the empirical findings, and in the end, will help to answer the study's research questions.

3.1 Literature review

According to Jensen (2002), Controlled Environmental Farming (CEA) can be seen as the modification of the natural environment to optimize plant growth and quality. These modifications can be made both in the aerospace and in the root environments to increase the crop yield, lengthen the growing season and allow plant growth during periods that are usually not used. Control can be applied to air and root temperatures, lighting, water, humidity, carbon dioxide, and plant nutrients. Most hydroponic systems are according to Love *et al*. (2014) performed in controlled environmental facilities, such as a greenhouse and can be traced back to the work by Dr. William Gericke at the University of California in the year 1929. The science behind hydroponic is to grow plants in a nutrient solution without soil, eliminating the soil-borne diseases and weeds (Sheikh, 2006).

Aquaponics applies the methods developed by the hydroponics industry (Love *et al.,* 2014) and is considered to be a possible way to improve food systems and make them more sustainable (Van der Goot *et al.,* 2016). According to Love *et al.* (2014) is it also common for aquaponic production to use greenhouses and controlled environmental agriculture methods to increase crop yields. To produce fish and annual plants combined is not new, it has been practiced since ancient times. However, modern-day aquaponics, where aquaculture and soil-less vegetable production (hydroponics) are combined is still quite new and popular worldwide (Junge *et al.,* 2017). As mentioned before, the most aquaponic application has a theoretical perspective and there are very few studies that go beyond the technical aspect. This result in difficulties for practitioners and policymakers due to the lack of practical guidelines (Van Woensel *et al.,* 2015).

Aquaponics is an example of an integration of agriculture and aquaculture (Kloas *et al.,* 2015). According to Somerville *et al.* (2014), it is the integration between recirculating aquaculture and hydroponics in one production system. Recirculating aquaculture is when, after a cleaning and filtering process, the water is reused for the fishes and hydroponics is when the cultivation of the plant is carried out in nutrient-rich water and is a soil-less system. To combine these two systems creates a polyculture of fish (in tanks) and plants that are grown in the same circle of water (Graber & Junge, 2009). According to Blidariu and Grozea (2011), the primary goal with aquaponics is to enable reuse of the nutrients found in the fish water to cultivate plants. This is one of the benefits with aquaponics, that the dissolved fish water can provide nutrition to the plants which according to Rakocy *et al*. (2006) can reduce emissions to the environment and counteract the eutrophication problem.

Aquaponics is often encouraged in soil-poor areas where water is hard to come by, like in urban areas, arid climates, and low-lying islands (FAO, 2016). According to Goda *et al.* (2015), the size of the aquaponics can vary between small-scale production to commercial production. However, commercial production at a large scale is not always suitable in the location, resulting in failure for many start-ups (FAO, 2016). Many producers also struggle

with making a profit due to the high capital investment, high level of knowledge, consistency and reliability of input, and the willingness from the market to pay a higher price for the products due to the high production cost (Rakocy *et al*., 2006, Somerville *et al*., 2014; FAO, 2016). Therefore, new business models are needed in order to develop these systems.

3.2 Circular bio-economy (CBE)

The first section is built on two different concepts, Circular-economy (CE) and Bio-economy (BE). The purpose of this section is to introduce two concepts that have developed in parallel, but lately in the literature started to be introduced as a combination, called Circular bio-economy (CBE). The aim is to conduct an introduction to theories which will be important to understand before the next section will be presented.

3.2.1 Circular Economy (CE)

Circular economy (CE) is a concept that has gained increasing attention of academia, businesses, and decisions makers since it is offering an attractive solution for environmentally sustainable growth (Antikainen *et al.*, 2017a). CE contradicts the original linear "make-buy-use-dispose" model where it aims to find a solution for how to maximize the value of products and materials and at the same time reduce the usage of natural resources and create positive societal and environmental impacts (Antikainen *et al.*, 2017a; Prieto-Sandoval *et al.*, 2018). Despite the increasing attention the concept has gained today, the knowledge and discussions about CE are not new (Kraaijenhagen *et a*l., 2016). According to Ellen MacArthur Foundation (2015), the concept cannot be traced back to one single author or date, however, it has gained momentum since the late 1970s, influenced by a small number of academics, thought-leaders, and businesses. According to Jun & Xiang (2011) is a CE build upon five features. First, consumption and production have to move from using energy that is causing pollution of the environment to using renewable green energies. Second, consumption of raw materials should be minimized and materials that can be recycled should instead be prioritized. Third, avoid packaging with the purpose of dumping goods and instead use packaging materials that can be recycled. Forth, industrial waste have to be reduced and recycled. Fifth, foster recycling resources and reduce life waste landfill and incineration to a minimum.

A design concept that has become important when describing CE is "cradle to cradle", coined by McDonough and Braungart (2002). The concept is built on the assumption that all materials that are included in industrial and commercial processes are seen as nutrients. These can, in turn, be divided into two main categories, biological and technical cycles. EPEA (2019) describes the biological and technical cycles as follows

> *"In the biological cycle materials are returned to the biosphere in the form of compost or other nutrients, from which new materials can be created. In the technical cycle materials that are not used up during use in the product can be reprocessed to allow them to be used in a new product" – EPEA (2019)*

The concept Cradle to cradle highlights the safe and productive processes of nature´s "biological metabolism" as a model for creating a "technical metabolism" flow of industrial materials (McDonough & Braungart, 2002). Therefore, products should be developed for continued recovery and utilization as biological and technological nutrients within these metabolisms. The concept differentiates from conventional recycling and eco-efficiency since it highlights eco-effectiveness and shows more than just the humans' negative impact on the environment (EPEA, 2019). CE is, according to Ellen MacArthur Foundation (2015), based

on three different principles; *preserve and enhance natural capital, optimize resource yields, and foster system effectiveness by revealing and designing out negative externalities*. These principles can be transformed into six different business actions; *REgenerate, Share, Optimise, Loop, Virtualise, and Exchange*, referred to as the ReSolve framework (see table 2). The ReSolve framework can be seen as a tool for businesses for generating circular strategies and growth initiatives. Ellen MacArthur Foundation (2015) argue that a great number of global leaders have built their success on innovations related to just one of these presented actions.

Table 2. The ReSolve framework *(Own processing).*

ReGenerate	• Shift to renewable energy and materials • Reclaim, retain and restore health of ecosystems • Return recovered biological resources to the biosphere
Share	• Share assets • Reuse/second-hand
Optimize	• Increase performance/efficiency of products • Remove waste in production and supply chain • Leverage big data, automation, remote sensing and steering
Loop	• Remanufacture products or components • Recycle materials • Digest anaerobically • Extract biochemicals from organic waste
Virtualize	• Books, music, travel, online shopping, autonomous vehicles etc.
Exchange	• Replace old with advanced non-renewable materials • Apply new technologies • Choose new product/service

The ReSolve framework analyses CE in terms of three human needs, stated as circular mobility, food, and built environment. This analysis is made because it could contribute with an understanding of how these systems could look different from today and if they could be cost competitive (Ellen MacArthur Foundation, 2015). The analysis defines, for each system, a potential future state which will be based on technology. In this study, circular food systems are of interest. Circular food systems can be described as regenerative, resilient, non-wasteful, and healthy. Therefore, farms would be located close to the consumer through urban farming. Fertilizer and pesticides would be minimized through organic agriculture where people would receive high quality and non-toxic food. Digital solutions have, in the circular food system, the opportunity to meet supply and demand that creates a less wasteful, on-demand system.

According to Ellen MacArthur Foundation (2019) has the current food systems supported a fast-growing population which has provided economic development and urbanization. However, these productivity benefits have come at a cost and the model does not longer fit future term needs. CE for food is presented as a beneficial model with great economic, health, and environmental benefits, which include the whole food value chain and society. Ellen MacArthur Foundation (2019) states that there is a lack of knowledge regarding the negative impacts of current food production methods. In the report, Ellen MacArthur Foundation

(2019) concludes that for every dollar spend on food, the society pays double in health, environmental, and economic costs. Half of these costs, a total of USD 5.7 trillion each year, are connected to how food is produced. The report highlights the opportunities for implementing CE for food as getting more value out of the food as a way for urban food actors to influencing which food is produced and how.

Critical reflection of CE

The shift from a linear to a CE for businesses causes a wide range of practical challenges since it often requires a radical change (Bocken *et al.,* 2016). Rizos *et al.,* (2015) present several barriers for implementing CE in Small and medium size enterprises (SMEs). SMEs can, according to the European Commission (2010), be defined as businesses that have 10 to 250 employees (Verheugen, 2006). Rizos *et al.,* (2015) categorizes the barrier as the environmental culture, financial barriers, lack of governmental support and effective legislation, lack of knowledge, administrative burden, technical skills, and support from the supply and demand network.

The environmental culture can be described as the attitude towards sustainable businesses where the manager plays a crucial role since they have the power over the strategic decisions of the business (Rizos *et al.,* 2015). However, Bradford and Fraser (2008) also highlight the attitude from the sector that the business operates which also can affect the implementation. Financial barriers are often described as one of the major barriers to the adoption of sustainable practices (Rizos *et al.,* 2015). Direct financial costs such as upfront costs and the expected payback period are especially crucial for SMEs since they are often more sensitive compared to large enterprises (Oakdene Hollins, 2011). Indirect ”hidden” costs are also presented as barriers such as human resources since it is often a crucial obstacle for the implementation due to SMEs lack of time and human capital (ibid.). Rizos *et al.,* (2015) also argue that access to finance and sources of funding could be essential for SMEs. Lack of governmental and effective legislation is described as for example provision of funding opportunities, training, effective taxation policy, and import duty (ibid.). Hillary (2004) argues that SMEs are more influenced by regulations and local authorities than larger businesses. Lack of knowledge regarding the benefits of CE is another barrier that has been identified in SMEs. For example, possible financial gains from improving efficiency is a commonly neglected benefit. A shift to a CE often incurs administrative burdens, such as time and resources, which arise from the environmental legislation (OECD, 2010). External consultants are often used because SMEs often lack the specific knowledge regarding legislation which entails extra costs for the businesses (ibid). Lack of internal technical skills similar to the before mentioned barrier where SMEs do not have the capacity to identify, assess, and implement more advanced technical alternatives which have the opportunity to reduce the environmental impact and at the same time create cost savings (Rizos *et al.,* 2015). Lack of suppliers and customers environmental awareness is the last mention barrier presented by Rizos *et al.,* (2015). It can be argued that consumers purchasing decisions are partly influenced by environmental aspects, even if these are not so often prioritized. Although CE has endured a lot of criticism regarding the implementation, it will still be used in this study due to it being relevant and suitable for this topic.

3.2.2 Bio-economy (BE) and Circular bio-ecnomy (CBE)

Another concept, like CE, that has gained a lot of attention in the last decades since it reconciles economic, environmental, and social goals is bio-economy (BE) (D'Amato, 2017). Reime *et al.* (2016) argue that the concept is not well established in Scandinavia and can, therefore, be categorized as new and growing. Hetemäki *et al*. (2017, p.12) define BE as..." *as the knowledge-based production and utilization of biological resources, innovative biological processes, and principles to sustainably provide goods and services across all economic sectors".* The principle is rooted in the idea that industrial input, such as material, chemicals, and energy, should be received from renewable biological resources (D'Amato, 2017). For that reason, the forestry industry and agriculture, can both play a vital role in producing bio-based substitutes for non-renewables (ibid.)

As a political vision, BE is often specified as sustainable and circular bio-economy (CBE) (Viaggi, 2016). CE and BE are two different concepts that have developed in parallel, however, according to Hetemäki *et al.* (2017), these need to be connected to reinforce each other. One way of doing this is to move to a CBE, since the use of renewable non-fossil raw materials and products increases in a sustainable, resource efficient and circular way (ibid.). Hetemäki *et al*. (2017), continue their argumentation by stating that connecting these two concepts makes them stronger and clarifies how countries can reach societal goals. Another aspect is that CBE has the opportunity to present new functions for bio-based materials, such as longer lifecycle, improved endurance, and less toxicity, which CE cannot provide alone (Antikainen *et al.*, 2017b). Reime *et al.* (2016) present another view of the concepts were they argue that bio-economy sometimes is circular in its nature. The authors argue that it depends on the treatment of by-products, that has to be valorized and treated optimally. For example, BE cannot be seen as circular when biomasses are used as waste incineration or landfill. Sheridan (2016) states that authors that are regarding BE to be circular in its nature are instead highlighting the fact that it incorporates renewable resources.

3.3 Circular business model (CBM)

The second section is built on two different concepts, Business model (BM) and Circular Business model (CBM). The purpose of this section is to introduce two concepts which in the literature can be defined in several ways. The aim is to present which definitions will be used in this study and to give the reader an understanding of the concepts.

3.3.1 Business model (BM)

A BM can be defined as a concept that …"*describes the rationale of how an organization creates, delivers, and captures value" (*Osterwalder *et al.*, 2010 p. 14). Osterwalder *et al.* (2010) argue that a BM can best be described through nine basic building blocks that demonstrate how a business intends to make money. These building blocks are *Customer segment, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure.* These building blocks are also included in the four main areas of a business as *customers, offer, infrastructure, and financial viability (*Osterwalder *et al.*, 2010).

Richardson (2008) made another description of a BM, where he based the model on only three components. These three components were categorized as *the value proposition, the value creation and delivery system, and the value capture system* (see figure 2). Value proposition concerns the product or service which offers to generate an economic return (Boons and Lüdeke-Freund, 2013). Value creation can be seen as the heart of a BM where businesses often create value by entering new business opportunities, new markets, and new

revenue streams (Beltramello *et al*., 2013; Teece, 2010). Value capture concerns how a business earns revenues from the provision of good, services or information to users and customers (Teece, 2010).

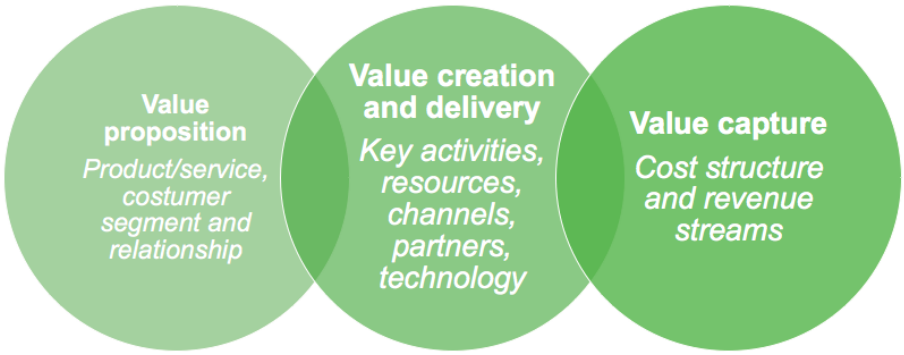

Figure 2. Conceptual business model framework. *(Bocken et al., 2014, Own processing).*

A BM can, therefore, be seen as a driver of competitiveness since it defines how the business is positioned in the market compared to competitors (Chesbrough, 2007; Chesbrough 2010). The design of a BM is considered as a strategic priority for managers and their companies. A BM can be described in several ways, however, this study will define a BM by the three components, *the value proposition, value creation and delivery, and value capture.*

3.3.2 Circular business model (CBM)

Antikainen and Valkokari (2016) claim that circular business models (CBM) and sustainable business models (SBM) can be viewed as a subcategory of BMs. Although the definition of the subcategory is the same, authors within the research field use different terms of the concept. To avoid confusion, the term CBM will be used in this study. According to Upward and Jones (2016), in conventional profit-normative companies, a successful business is often measured by economic performance. In the sense of sustainability, this view is too narrow which raises the need for a more holistic view of value that also combines social and environmental goals (Bocken *et al.,* 2013). The traditional view of economic systems has suffered a lot of criticism because of its focus on efficient resource allocation, ignoring societal well-being and the carrying capacity of biological ecosystems (Daly & Farley, 2004). However, Joyce and Paquin (2016) argue that measuring emissions is not enough when investigating the environmental impact. Ecosystem impact, biological diversity, human health, and water use should also be measured.

When businesses try to apply principles such as CE and BE into their BM, they use a CBM as they shift from a linear BM to a more circular one (Lewandowski, 2016). According to Bocken *et al.* (2014), a CBM integrates a triple bottom line approach since it considers a wide group of stakeholder interest, including the society and environment. Stubbs and Cocklin (2008) even argue that society and environment are the key stakeholders for such businesses. CBM can, therefore, be defined as a tool that:

> *"...helps describing, analyzing, managing and communicating (i) a company's sustainable value proposition to its customers and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social and economic capital beyond its organizational boundaries."*
> - Schaltegger *et al*., 2016, p. 268.

Common activities which involve value creation in a CBM are often presented as repair, reuse, refurbishment, remanufacture, sharing, take-back, and recycling (Reichel *et al.*, 2016). This opposes from the linear model where value creation mainly involves virgin materials. Bocken *et al.* (2014) present CBMs as a subcategory that differs from the linear value creation since it creates value from waste or is providing functions rather than products. Therefore, CBMs can be defined as models where *"...the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings"* (Linder & Williander, 2017, p.183).

Critical reflections of CBM

Both Reim *et al*. (2015) and Tukker (2015) are claiming that even though the literature indicates that CBMs appears to have benefits, the transition has been slow. Schaltegger *et al.* (2012) are also presenting one of the key challenges for CBMs as designing a BM, which captures economic value for itself through delivering social and environmental benefits. It is therefore not clear how social and environmental benefits can be compared to profit and competitive advantage for the business (ibid.). Chesbrought (2010) claims that existing BM for CE have limited transferability and there is a lack of a framework that suits different kinds of companies in creating a CBM. According to Chesbrought (2010) and Lewandowski (2016), there are very few studies focusing on how a CBM actually should look like and what components the BM should consist of. Difficulties regarding the evaluation of environmental impacts are another disadvantage that is often discussed in the literature, where it is difficult to identify differences compared with the traditional linear BM. According to Bocken *et al.* (2016), it can be identified through life-cycle analyses and material flow analyses, however, these calculations would not be effective since it is time-consuming and resource-intensive. Kirchherr *et al.* (2017) state that the central driving force for CBM is the customers, however, this view is often excluded which hamper the development of CBM. Although CBM has endured a lot of criticism regarding how to measure the benefits and the transition, it will still be used in this study due to it being relevant and suitable for this topic.

3.4 Conceptual framework

The conceptual framework in this study consist of the theories that have been presented earlier in this chapter (see Figure 3). The purpose with this section is to illustrate how the theories will be used and are connected to each other in order to answer the study's aim and research questions. The study's aim is to examine contextual factors that enable and inhibit developments of aquaponic BMs. The purpose is to create in-depth insights on how aquaponic BMs are developed in practice and what factors that affect the development towards a CBE. What contextual factors enable and inhibit the development of aquaponic business models towards a CBE are the study's research questions.

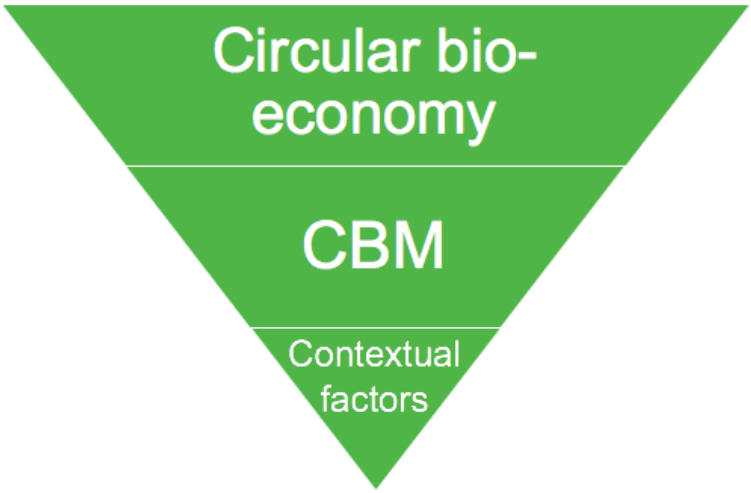

Figure 3. Conceptual framework. *(Own processing).*

Figure 3 also illustrates the different abstract levels of the chosen theories. As mentioned before, CBE is a combination between the concepts CE and BE since the use of renewable non-fossil raw materials and products increases in a sustainable, resource efficient and circular way (Hetemäki *et al.*, 2017). It also has the opportunity to present new functions for bio-based materials, such as longer lifecycle, improved endurance, and less toxicity, which CE cannot provide alone (Antikainen *et al.*, 2017b). In this study, CBE is an appropriate theory to use since it could help to examine if an aquaponic BM can contribute to a CBE. However, CBE is often referred to as a dream scenario but that lacks a contextual attachment. Therefore, CBM can in this study help to contextualize the concept since it is created for a specific context. A BM consists of three different components, *the value proposition, the value creation and delivery system, and the value capture system* (Richardson, 2008). It can also be seen as a driver for competitiveness. CBM can be referred to as a subcategory to BM since it includes a wider group of stakeholder interest and combines economic goals with environmental and social (Antikainen & Valkokari, 2016).

Contextual factors are in this study conceptualized as internal and external. Internal factors are for example governance structure, corporate culture, and capacity for innovation and the external factors are for example government, market, and civil society (Gouldson, 2008). These factors will be used in order to examine how aquaponic BMs evolve in practice and what factors that enable and inhibit their development.

4 Empirical data

This chapter presents the collected empirical data. It begins with background information about the chosen case company Peckas Tomater and follows with information about their BM that has been collected during the semi-structured interviews. This chapter also includes additional secondary data that has been collected from the company's webpage.

4.1 Peckas Tomater

Peckas Tomater is founded on the unique knowledge and experience from one of the founders Pecka Nygård (Peckas Naturodlingar AB, 2017). Nygård has more than 20 years of experience with recycling cultivation and has a background within fishing and education in gardening. For many years Nygård grew fishes in the ocean but due to the damage done on the environment, they were later moved to fish tanks on land. It began as a small hobby for Nygård as he tried different kinds of fishes and grew everything from melons to spices. In the year 2015, Pecka Nygård together with the entrepreneurs Hugo Wikström, Daniel Brännström, and Johan Stenberg founded Peckas Naturodlingar AB. The CEO of Peckas Naturodlingar AB is today Elena Petukhovskaya. To avoid confusion, the business name Peckas Tomater will in this study be used. The company has also developed an advisory board which includes three people, Pecka Nygård, Jan Smith, and Björn Frostell. Jan Smith works professionally with growing vegetables in Finland and Björn Frostell works as a professor in industrial ecology, at the Royal Institute of Technology in Stockholm.

Peckas Tomater's core business is to provide high-quality products without any toxins, emissions or unnecessary transports. Therefore it can be stated that their business concept is to provide locally produced and high-quality vegetables and fishes to the growing market (Peckas Naturodlingar AB, 2017). Peckas Tomater has production all year around and distribute its products through retailers and directly to restaurants and caterers. They argue that it is due to the high quality, that they are locally grown, and that there are few intermediaries in the distribution that creates the possibility for a good margin on the products. Peckas Tomater also claims that their aquaponic contributes to an environmentally sustainable society since they use the latest technology where the fish nourish the plants and the plants cleanse the water, which prevents emissions from both the fish and the tomato cultivation. Another aspect is the closeness to the market, which implies that the environmental impact due to transports decreases. When packaging the tomatoes, Peckas Tomater uses plastic-free packaging consisting of 100 % carton. This result in them saving over five tons of plastic every year. That they only use renewable energy produced from wind power can also be considered as a way to contribute to an environmentally sustainable society. Furthermore, it could be argued that their locally located facilities contribute to the local economy by creating jobs for the residents.

It is stated that the objective of the business is to lead the development in large-scale aquaponics and in this way become the market leader in providing food from aquaponics (Peckas Naturodlingar AB, 2017). The overall goal is to expand the business and establish additional production units in local markets throughout Sweden, and in the long term in Europe. Peckas Tomater's first facility was being built at the end of April in the year 2017 and is located in Härnösand, in the north of Sweden. The facility has the capacity to have an annual production of 200 tons of tomatoes and 20 tons of fishes. The next project is to build a larger facility located close to one of the biggest cities in Sweden, such as Stockholm, Gothenburg or Malmo. This project is being invested and built through new subsidiaries. In the year 2021, the goal is to grow vegetables on 100 000 m2 and have an annual production of 6 500 tonnes of tomatoes and 650 tones of fishes. Another plan that Peckas Tomater has is to

develop the aquaponics for other vegetables such as cucumbers, peppers, eggplants, melons, and herbs.

In the year 2018, Peckas Solutions AB was created as a subsidiary to Peckas Naturodlingar AB (Peckas Naturodlingar AB, 2017). They work towards creating a system that can be licensed together with service and support agreements. The goal is to create new sources of revenue for Peckas Naturodlingar AB and help the company to faster provide the world with more sustainable and environmentally friendly cultivation of fish and vegetables. This is due to the lack of existing systems on the market today that could optimize the profitability and production of recycling cultivation.

4.2 Enabling factors

This section presents internal and external factors that have enabled the development of Peckas Tomater's BM. The presented information were collected from the semi-structured interviews that was conducted with the employees at Peckas Tomater.

4.2.1 Internal factors

Knowledge and key persons are seen as two of the most important internal enabling factors for Peckas Tomater (pers.com., Åberg, 2019; pers.com., Wikström, 2019; pers.com., Gambardella, 2019; pers.com., Petukhovskaya, 2019). They argue that without Pecka Nygårds unique knowledge and experience about aquaponics, the company would not be where it is today. Åberg and Petukhovskaya (pers.com., 2019) also highlight that the company has avoided many obstacles due to his already developed system. They only needed to scale it up and therefore they did not need to put extra time and money into developing a new system. However, it is not only Nygård that is seen as a key person. Wikström (pers. com, 21019) argues that all the employees possess a unique competence and experience about their own field that is crucial for the company. For example, the greenhouse workers have years of experience from farming, the CEO has important experience from the food industry and the marketing director has experience in marketing. Together, they all contribute to the same goal, to spread knowledge about aquaponics and to grow as a business (pers.com., Wikström, 2019). Therefore, company culture is also an internal enabling factor according to Wikström (pers.com, 2019).

Another internal enabling factor for Peckas Tomater is their products. Wikström (pers.com., 2019) states that a company based on aquaponics cannot rely on the fact that they have a good concept, their products also need to have a high standard. He argues that the concept itself can catch the consumers interest and get them to buy the product the first time, but it is the quality and the good taste of the products that get them to continue buying. According to Gambardella (pers.com., 2019), technology can also be seen as an internal enabling factor. In aquaponics the technology is crucial, and it is very important to find the right balance between the plants and the fishes. Due to the lack of industry knowledge, the company had to rely on the developed system created by Nygård and Gambardella (pers.com, 2019) describes their technology as old but completely new to the industry of aquaponics. The technology also enables the company to use less water, to reuse resources within a closed system and to not be dependent on the external environment. Wikström (pers.com., 2019) also states that the high investments needed at the beginning of an aquaponic business is not significant for Peckas Tomater, due to them being able to receive a cash flow from the investment within a couple of months.

4.2.2 External factors

A mature market is according to Åberg (pers.com., 2019) one of the most important external enabling factors for Peckas Tomater. She states that consumers today are more well informed and wants to consume locally produced and ecological products and that they are not as price sensitive. Therefore, there is a demand from the market for more sustainable food and Åberg argue that it is due to this demand that they have been able to grow and expand their business. Petukhovskaya (pers.com., 2019) also agrees with Åberg and states that they started their business at the right time and place considering their business model to produce more sustainable food. She argues that this is due to climate change and that the demand from the market for more sustainable produced food has been a crucial external enabling factor for Peckas Tomater.

Due to the cold winters in Sweden, it is not possible for traditional farming to grow tomatoes all year round (Peckas Naturodlingar AB, 2017). This results in a shortage of vegetables during the winters that force retailers in Sweden to import from other countries. Because of this, the market in Sweden is very sensitive to crop failure or other events that could affect imported vegetables. The political interest for local food production and self-sufficiency has increased in recent years and in the year 2017, the Swedish government presented a proposition regarding the future food production (ibid.). It involves that the government wants to invest approximately one million to develop innovative and competitive production and to stimulate organic production and consumption. According to Åberg (pers.com., 2019), Peckas Tomater can grow tomatoes all year around in their greenhouses. This enables them to supply the market with locally produced tomatoes even in the winters when other Swedish farmers cannot. Therefore the government and location can be argued to be an external enabling factor.

The retailers are also an external factor to be considered (pers.com., Wiktröm, 2019). Wikström states that it is the retailers that enable Peckas Tomater to reach their customers and it is, therefore, important that they are satisfied with the company. Wikström also argues that the retailers could use Peckas Tomater, which is considered to be a premium product, to improve their image by showing the consumers that they want to fulfill their demands for more ecological and locally produced products (pers.com., Wikström, 2019).

Another important external enabling factor is the local society. Wikström and Petukhovskaya (pers.com., 2019) state that they have many first time investors from the local society and that they have been very supportive. Wikström (per.com., 2019) argues that this is because of an emotional attachment. That the locals want to support the company because they are proud of them and of what they are trying to achieve for the environment and the local society in Härnösand. Åberg (pers.com., 2019) also thinks that the local society is supportive because they want to be a part of the company.

Wikström (pers.com., 2019) states that another external enabling factor is that they are a public company. He argues that they have a different view on the finances compared to a family-owned business for example. A family owned business may have other objectives than a publicly owned, due to them being owned by stakeholders that require them to make a profit. Another argument to why this could be an enabling factor is that they can have emissions to raise more money to finance their expansion (pers.com., Wikström, 2019). Knowledge is not just a very important internal enabling factor for Peckas Tomater but also an external (pers.com., Wikström, 2019). In Närpes, which is located in the Finnish Ostrobothnia, tomatoes have been grown for over 100 years at our latitudes. The knowledge and experiences from this are therefore unique and are included in their advisory board (ibid.).

4.3 Constraining factors

This section presents internal and external factors that have inhibited the development of Peckas Tomater's BM. The presented information was collected from the semi-structured interviews that were conducted with the employees at Peckas Tomater.

4.3.1 Internal factors

According to Åberg (pers, com., 2019), one of the internal constraining factors is related to recruitment. She explains that Peckas Tomater has struggled to find people with the right competence and experience, especially regarding farming since aquaponics is not a well-known area. Another crucial constraining factor is that the business is sensitive for unpredictable situations. Åberg describes that the warm weather that Sweden had the last summer, in the year 2018, caused pests in one of the greenhouses, which they have struggled with since then. The outcome of these pests was that they had to remove all of the tomato plants that they had in this greenhouse earlier than expected. In return, this unpredicted situation caused a loss in sales since they could not deliver as many tomatoes that they had expected and it also caused increased costs. Related to pests, Petukhovskaya (pers, com., 2019) argues that an internal constraining factor is that Peckas Tomater does not use chemicals and therefore they are especially sensitive for these kinds of infestations compared to other farmers that do use chemicals.

Both Wikström and Gambardella (pers, com., 2019) present energy consumption as one of the most crucial internal constraining factor. This is due to the high costs and that the system is not that flexible. Gambardella explains that they have to have lighting in the greenhouses even though it is sunny outside and they cannot have lighting during the nights, which had made it possible to spread the energy consumption throughout the day. The reason for that is that the bumblebees that they have in the greenhouses are awake and are pollinating the tomato plants during the daytime. A solution for that is to pollinate the plants by hand, however, that is both time-, and resource consuming.

Wikström (pers, com., 2019) argues that the lack of a well-developed industry is not considered as an internal constraining factor for Peckas Tomater. This is due to Nygård's knowledge and well-developed system that they are using. However, an internal constraining factor that has been identified is how Peckas Tomater can use Nygård's knowledge and scale it up in larger proportions since it has only been used on a hobby level. It is also crucial for Peckas Tomater to develop effective planning-, and management processes when planning on building a larger facility (Peckas Naturodlingar AB, 2017). This is because it may cause negative consequences for the business and its profitability if they fail to develop these processes.

According to Gambardella (pers, com., 2019), it can also be a struggling factor that Peckas Tomater has to solve their problems by themselves and often "learn by doing", which can be both time-, and resource consuming. The technology that is used in the greenhouses which control the temperature and humidity are as well made for traditional farming (Gambardella, pers, com., 2019). This can be seen as an internal constraining factor since it does not account for the water system that is used in the greenhouses which affect the humidity. Another internal constraining factor identified by Gambardella is the salmon trouts. They are very dominant in their behavior and a crucial factor is not to overfeed them since they eat even though they are not hungry which can be life-threatening for them.

4.3.2 External factors

Åberg (pers, com., 2019) claims that one external constraining factor for Peckas Tomater has been the packaging of the tomatoes. In the beginning, they used paper containers with a plastic lid to protect the products, however, that did not last long since the lid was very difficult to put on. Therefore, they started to use containers that only consisted of paper instead. Those containers were not perfect either in the beginning since they looked smaller than the ones they used before and the tomatoes fell out of the containers which the retailers complained about. Åberg (pers, com., 2019) argues that it was a hard decision to step away from using plastic but since they wanted the products to be as sustainable as possible, excluding plastic was a natural choice for them.

Another external constraining factor identified by Åberg (pers, com., 2019) concerns ecological labeling. Neather the tomatoes or the salmon trout can today be considered as ecological products since the fish is being grown under the ceiling and the tomatoes are grown in gravel and not in soil. Ecological products are well known and often entails an extra value for the consumer, which makes these products less price sensitive. This opposes from products produced in aquaponics since consumers are not aware of the benefits that these kinds of food systems contribute with. Åberg explicate this argument by saying that is is hard to change human consumption patterns, and it had been easier for them if their products could be defined as ecological.

It could also be argued that Peckas Tomater acts on a competitive based market, which can be seen as an external constraining factor (Peckas Naturodlingar AB, 2017). It will always be a risk that increased competition from other market participants with significantly greater financial resources, may lead to reduced growth opportunities or that Peckas Tomater's operations in other ways will be adversely affected. Another external constraining factor is that Peckas Tomater is active on a market that is expected to show continued growth and good earnings opportunities (Peckas Naturodlingar AB, 2017). However, it is a risk that the market will develop in an unfavorable direction for Peckas Tomater due to changed macroeconomic factors, rising energy prices, technical development, new regulations or other unaffordable external factors. Such events entail risks of a negative impact on Peckas Tomater's profitability and financial position.

Both Petukhovskaya and Wikström (pers, com., 2019) highlight the legislation regarding aquaponics as an external constraining factor for Peckas Tomater. This is because aquaponic is a rather new concept on the market and is not treated individually from other kinds of food systems. An example is the legislation regarding fish farming where nitrogen and phosphorus emissions are calculated. However, this is not useful for Peckas Tomater since they have a closed loop and therefore do not have any of these emissions. Petukhovskaya (pers, com., 2019) explains it as Peckas Tomater is put in a "grey area" were the legislation does not concern aquaponics. Since aquaponics is a new concept it is also difficult to receive grants, which could be vital for the business's survival.

4.4 Empirical summary

To simplify for the readers, a summary of all contextual factors identified from the semi-structured interviews have been conducted (see table 3).

Table 3. Conceptual factors influencing Peckas Tomater. *(Own processing).*

	Internal	External
Enabling factors	Key persons	Mature market
	Pecka Nygård's knowledge	Local society
	Internal culture	Well informed consumers
	Unique concept	Acceptance from retailers
	Good product	Public company
	Cash flow	Government
	Technology	
Constraining factors	Difficult to find key persons	Packaging
	Sensitive harvest	Ecological labeling
	Enegry concumption	Competitive based market
	High investments	Uncertainty regarding the future
	Technology	Change consumption patterns
	Salmon trout	Legislation

The table consist of two colums that seperates the internal and external factors. It also seperates the internal and external factors depending on weather they have enabled or constrained the development of Peckas Tomater´s aquaponic BM.

5 Analysis and Discussion

This chapter presents an analysis of the empirical data presented in the previous chapter and the conceptual framework that has been developed in this study. The analysis has been divided into two different sections, Circular bio-economy (CBE) and Circular business model (CBM). The chapter aims to analyze contextual factors that enable and inhibit developments of aquaponic business models towards CBE.

5.1 Circular bio-economy (CBE)

This first section will analyse the concept Circular bio-economy (CBE) together with the empirical data. However, since CBE is built on the two concepts Circular economy (CE) and Bio-economy, this section will start with an analysis of those two.

5.1.1 Circular economy (CE)

CE aims to find a solution for how to maximize the value of products and materials and at the same time reduce the usage of natural resources and create positive societal and environmental impacts (Antikainen *et al.*, 2019). Jun & Xiang (2011) describe CE through five features. First, consumption and production have to move from using energy that is causing pollution of the environment to use renewable green energies. Second, consumption of raw materials should be minimized and materials that can be recycled should instead be prioritized. Third, packaging with the purpose of dumping goods should be substituted to packaging materials that can be recycled. Forth, industrial waste has to be reduced and recycled. Fifth, foster recycling resources and reduce life waste landfill and incineration to a minimum. Today, Peckas Tomater possesses the largest commercial aquaponics in Europe with salmon trout and tomatoes, cultivated in a closed system (Peckas, 2019). Peckas Tomater could potentially be seen as a business that contributes to a CE since they use the latest technology where the fish nourish the plants and the plants cleanse the water, which prevents emissions from both the fish and the tomato cultivation (Peckas Naturodlingar AB, 2017). Another factor is that they only use renewable energy produced from wind power which prevents pollution of the environment. They also use materials when packaging the tomatoes that can be recycled since they have excluded plastic. It could also be argued that they create positive societal impacts since their locally located facilities contribute to the local economy by creating jobs for the residents.

Another concept that has become important when describing CE is “cradle to cradle”, coined by McDonough and Braungart (2002). This concept can be divided into two main categories, biological and technical cycles. The main difference is that in biological cycles, new materials can be created from compost or other nutrients and in the technical cycles, materials that are not used up during use have the potential to be reprocessed and used in new products (EPEA, 2019). In the case of Peckas Tomater, they reuse the nutrients found in the fish water to fertilize the tomato plants which can be seen as a technical cycle. This is due to the fish water being reprocessed and reused for the tomatoes which, in this particular case, can be seen as a new product. The fish water is then purified by the tomato plants and has once again been reprocessed.

A tool that has been presented for businesses for generating circular strategies and growth initiatives is The ReSolve framework (Ellen MacArthur Foundation, 2015). The tool is based on six different business actions as *REgenerate, Share, Optimise, Loop, Virtualise, and Exchange* (see table 2). The purpose of the framework is to analyze CE in terms of three human needs, stated as circular mobility, food, and built environment. Ellen MacArthur

Foundation (2015) describe circular food systems as regenerative, resilient, non-wasteful, and healthy. Farms would, therefore, be located close to the consumer, fertilizer and, pesticides would be minimized and digital solutions have the potential to meet supply and demand that creates a less wasteful, on-demand system. The first business action, REgenerate, can be seen in Peckas Tomater since they have moved from using not renewable to renewable materials when packaging their tomatoes and that they only use renewable energy produced from wind power in their greenhouses. The second, Share, can be seen in Peckas Tomater as they reuse the nutrients in the fish water to cultivate the tomato plants. The third, Optimise can also be related to the reuse of nutrients because it is a way for them to increase their efficiency and minimize their waste in production. Another factor is that the greenhouses are dependent on artificial intelligence that leverage big amounts of data related to, for example, the humidity and temperature, as a way to optimize the production. The fourth, Loop, is perhaps the most evident due to them recycling the materials such as the nutrients in the fish water as a way to extract biochemicals from organic waste and their choice to use plastic-free packaging. The last business activity that can be seen in Peckas Tomater is Exchange, as they use aquaponics which is an old technology but new in the sense of producing food in a sustainable way. The description of a circular food system made by the Ellen MacArthur Foundation (2015) fits the business concept of Peckas Tomater. Their goal is to decrease the Swedish import of food and therefore it can be argued that they are located close to the consumer. Another factor is that because they use nutrients from the fish water, they exclude fertilizer and pesticides and finally, aquaponics can be seen as a digital solution to create a less wasteful and on-demand system.

Barriers for CE

Bocken *et al.* (2016) state that a shift to CE for businesses causes a wide range of practical challenges since it often requires a radical change. Barriers for implementing CE can be categorized as the environmental culture, financial barriers, lack of governmental support and effective legislation, lack of knowledge, administrative burden, technical skills, and support from the supply and demand network (Rizos *et al.,* 2015). Environmental culture can be described both as the internal attitude toward sustainable businesses (ibid.) and the external attitude from the sector that the business operates (Bradford & Fraser, 2008). As mentioned before, the manager plays a crucial role in the internal attitude due to their power over strategic decisions. It could be argued that Peckas Tomater never encountered this barrier since their business was founded on the idea of creating sustainable food production. If Peckas Tomater originally had conventional farming without a sustainable perspective, perhaps this might have been different. Then they would have had to implement CE into their business which increases the risk of meeting resistance from the employees which makes the role of the manager more crucial. The second barrier is financial and can both be direct and indirect costs. Upfront costs and expected payback period are direct costs which have been crucial for Peckas Tomater. This is due to the high investments required at the beginning such as the technology and facilities needed for aquaponics. Peckas Tomater overcame this barrier by becoming a public company and by having emissions in order to raise more money. SME's are often more sensitive to the expected payback period which also is the case of Peckas Tomater. They are more sensitive for unpredictable situations that can affect their harvest resulting in a loss in sales which then will affect their expected payback period. Indirect "hidden costs" can, for example, be human resources. For Peckas Tomater these indirect costs are not only a barrier for creating a CE but also for them as an aquaponic business since that business concept requires a lot of unique knowledge and experience from the employees.

Regarding the CE critic about governmental support and effective legislation, Peckas Tomater is affected in a negative way since aquaponic is not treated individually from other kinds of

food systems. The legislation is not flexible enough and cannot deal with food systems that do not fit the conventional description. This result in aquaponics being placed in between legislation which makes it harder for Peckas Tomater to receive fundings and effective taxation policy. Another barrier that in Peckas Tomater's case is related to the lack of specific legislation for aquaponic food systems is the administrative burden. Due to them being placed in a "grey area" they also have difficulties in receiving an environmental certification such as ecological labeling. Because of this, they do not have an administration burden regarding environmental legislation. Lack of knowledge and technical skills are also barriers for implementing a CE which can be related to the before mentioned barrier regarding indirect costs. Peckas Tomater has struggled with finding employees with the right competence and experience since aquaponic is not a well-known area. Another barrier is how Peckas Tomater can take advantage of Nygård's knowledge and well-developed system to scale it up in larger proportions since it only has been used on a hobby level. The last mentioned barrier for implementing CE is the lack of suppliers and customers environmental awareness. This concerns Peckas Tomater in the sense that their products cannot be considered as ecological products. Ecological products are well known and often entails an extra value for the consumer, which makes these products less price sensitive. This opposes from products produced in aquaponics since consumers are not aware of the benefits that these kinds of food systems contribute with. However, because consumers are more aware today and take environmental aspects into account, Peckas Tomater can still market their product as locally produced and free from toxins and emissions and therefore this barrier is not as significant as it could be.

5.1.2 Bio-economy (BE) and Circular bio-economy (CBE)

Another concept that has gained a lot of attention in the last decades since it reconciles economic, environmental, and social goals is BE (D'Amato, 2017). The overall goal with the concept is that industrial input, such as material, chemicals, and energy, should be received from renewable biological resources (D'Amato, 2017). According to Hetemäki *et al.* (2017) CE and BE are two different concepts that have developed in parallel but that need to be connected to reinforce each other. A solution for that is to move towards a CBE, since the use of renewable non-fossil raw materials and products increases in a sustainable, resource efficient and circular way (ibid.). Antikainen *et al.* (2017b) state that CBE has the opportunity to present new functions for bio-based materials, such as longer lifecycle, improved endurance, and less toxicity, which CE cannot provide alone. At Peckas Tomater they water the tomato plants by using the fish water. In this way, Peckas Tomater can reuse the water from the fish tanks because the tomato plants purify it by absorbing the nutrients, creating a longer life cycle and a closed circular system. Another advantage is that they do not need to use any fertilizers because the nutrients found in the water act as a natural fertilizer. This results in the tomatoes being free from toxins and emissions. The energy is also, as mentioned before, only produced from wind power which is considered to be a renewable resource. Furthermore, Peckas Tomater changed their packaging from consisting of plastic to 100 % carton so that they could move away from using fossil raw materials. To pollinate the tomato plant they use bumblebees. It is possible to pollinate the plants by hand, however it is both time-, and resource consuming. By using bumblebees it is possible to create a more natural biological cycle in the greenhouses.

As mentioned before, CBE are often referred to as a dream scenario but that lacks a contextual attachment. This is evident in the discussion regarding Peckas Tomater as it only catches the characteristics of a CBE and if Peckas Tomater fits the descriptions. It could, therefore, be argued that this concept can be seen as too mechanical as it do not consider how

it develop in a specific context. However, this concept are important to include in the study since the purpose is to examine the development of aquaponics BMs towards CBE which is difficult to achieve without a clear meaning of the concept. A way to conceptualize CBE is through a BM that are created for the specific context to where environmental, social and economic challenges are socially constructed.

5.2 Circular business model (CBM)

A BM can be described in several ways, were Osterwalder *et al.* (2010 p. 14) define it as a concept that … ”*describes the rationale of how an organization creates, delivers, and captures value”.* Richardson (2008) argues that a BM can be explained through three components, categorized as *the value proposition, the value creation and delivery system, and the value capture system* (see figure 2). A BM can, therefore, be seen as a driver of competitiveness since it defines how the business is positioned in the market compared to competitors (Chesbrough, 2007; Chesbrough 2010). As mentioned before, Peckas Tomater's goal is to provide high-quality products without any toxins, emissions or unnecessary transports all year around. This description can be seen as their value propositions since it is their way to generate an economic return.

Value creation can be seen as the heart of a BM where businesses create value by entering new business opportunities, new markets, and new revenue streams (Beltramello et al., 2013; Teece, 2010). In the case of Peckas Tomater, they create value by having an aquaponic to cultivate the tomatoes. Aquaponics can, therefore, be seen as their value creation since it allows them to identify new business opportunities and to enter new markets. It also allows them to receive new revenue streams since they can sell both the tomatoes and the fishes that they produce in their aquaponic. As mentioned before, they are also trying to create a system that is developed specifically for aquaponics which can, when it is complete, create new revenue streams since they can sell this system to other actors on the market. In the food industry today there are few actors that produce vegetables trough aquaponics. It could, therefore, be argued that Peckas Tomater is unique in the industry which can also create value for their customers. Another part of their value creation is that they are close to their customers. This allows Peckas Tomater to avoid unnecessary transports which result in reduced emissions. A closer distance also permits Peckas Tomater to delay the harvest compared to actors that export vegetables to Sweden because they need to account for the transport time. By having this delay the tomatoes can mature before they get harvest which gives them more flavor. The value capture concerns how a business earns revenues from the provision of good, services or information to users and customers (Teece, 2010). It is stated that Peckas Tomater tries to sell their tomatoes as a premium product which allows them to have a higher price on their products compared to competitors. It is therefore crucial for Peckas Tomater to inform their customers about the value that they would receive by buying Peckas Tomater's products.

A CBM can, according to Antikainen and Valkokari (2016), be viewed as a subcategory of BMs. In conventional profit-normative companies, a successful business is often measured by economic performance (Upward and Jones, 2016) but in the sense of sustainability, this view is too narrow (Bocken *et al.,* 2013). This raises the need for a more holistic view of value that also combines social and environmental goals, which a CMB does (ibid.). Reichel *et al.* (2016) present common activities which involve value creation in a CBM as *repair, reuse, refurbishment, sharing, take-back, and recycling*. The activities that can be identified in Peckas Tomater are reuse, take-back, and recycling. This is because they are reusing the water from the fish tanks to water the tomatoes instead of using fresh water. The take-back activity

appears when the purified water from the tomatoes is returned to the fish tanks again without adding any fresh water. The last activity identified at Peckas Tomater is recycling which concerns their packaging. As mentioned before, their packaging is today made of 100 % carton and is therefore recyclable.

Barriers for CBM

A key challenge with CBM is to design a BM which captures economic value for itself through delivering social and environmental benefits (Schaltegger *et al*., 2012). It is therefore not clear how social and environmental benefits can be compared to profit and competitive advantage for the business (ibid.). Evaluation of environmental impacts is another disadvantage that is often discussed in the literature, where it is difficult to identify differences compared with the traditional linear BM. Bocken *et al.* (2016) argue that it can be identified through life-cycle analyses and material flow analyses, however, these calculations would not be effective since it is time-consuming and resource-intensive. At Peckas Tomater it could be argued that they capture economic value through delivering social and environmental benefits. This is due to their aquaponic, which produces an output (tomatoes and fishes) without toxins or emissions that they can sell while also creating jobs for the local people. While other businesses have difficulties with comparing social and environmental benefits to profit and competitiveness, it could be argued that this is not the case for Peckas Tomater. This is due to the fact that their value proposition relies just as much on the social and environmental benefits as the economic. This could be because they founded their business on these benefits and did not need to implement the social and environmental perspectives into an already existing BM. To evaluate environmental impacts is difficult due to the analyses being time-consuming and resource-intensive (Bocken *et al.*, 2016). This is also the case for Peckas Tomater and because they are small they may not have enough time and resources to analyze this properly.

5.2.1 Internal factors

As mentioned before, this study's analytical apparatus is to understand contextual factors that shape business development will be built on the work of Gouldson (2008). He states that internal factors are for example governance structure, corporate culture, and capacity for innovation. Internal factors that have been crucial in enabling Peckas Tomater to develop an aquaponic BM are key persons, Pecka Nygårds's knowledge, and the internal culture. It could be argued that key persons are a crucial factor due to aquaponics being a new concept within business development and that it lacks a mature and well-developed industry. Therefore, it has been important for Peckas Tomater to find persons with the unique knowledge and experience of an area within aquaponics and then to enable them to put that knowledge and experience together. However, due to Peckas Tomater being dependent on key persons with specific knowledge, this also becomes a constraining factor. If they want to continue to expand or if someone quits, they need to find other employees that also have this knowledge which can be difficult, both because of their location (a small town in the north of Sweden) and also because of the lack of industry. Pecka Nygård and his knowledge is also a very important internal enabling factor for the business. As mentioned before, many commercial aquaponics fail due to the location, the high capital investments and lack of knowledge for example. It could, therefore, be argued that without Nygård, Peckas Tomater would not exist or at least not be as successful as it is today. This is due to the fact that Nygård already had developed a system that he knew worked and therefore they only needed to scale up the production and use his high level of knowledge. The internal culture also plays a crucial role in the development. Peckas Tomater has succeeded in creating a "we" culture where all employees move toward the same goals and share the same beliefs and values about

sustainability and growth. Therefore, it could be argued that they do not meet the same resistance from employees regarding implementing a BM towards CBE. However, this could be because the business was founded on these beliefs and values and in the fact that they could have only employed persons that already possessed them.

Other internal factors that can be seen as enabling is the unique concept, that they have a good product, receive cash flow and that they already possess the technology. Aquaponic as a business concept is still quite new and there are not many similar businesses, at least not in Sweden. Therefore, Peckas Tomater can gain a lot of attention from the consumers by just developing an aquaponic BM. However, a business cannot only rely on a unique concept, but they also need to have a good product which Peckas Tomater state that they have. Aquaponics requires high capital investment and is argued to be one of the reasons that many commercial aquaponics fail. At Peckas Tomater this is not seen as a significant problem as they argue that they can receive cash flow from the investment within a couple of months. This may be due to the fact that they already have the required knowledge and resources so that when the tomato plants are in place, they know that it will not be long before they can sell the tomatoes and get a profit. The last internal enabling factor is argued to be technology. In an aquaponic business, technology is crucial, and it is important that the business finds the right balance between the plants and the fish. In this case, it could be argued that Peckas Tomater has had an advantage. The technology behind aquaponics is old but it is new to the industry. Due to the fact that Peckas Tomater could rely on a technology that they knew worked, they did not need to invest as much time and money into "try and error", earning them a head start. However, technology can also be seen as a constraining factor for Peckas Tomater due to the fact that their technology regarding the control of water and humidity in the greenhouses was originally made for traditional farming. This creates problems for them which they are trying to overcome by developing a new system made specifically for aquaponic businesses. This may slow down the development of their BM since the process it is both time-, and resource consuming but in the end, Peckas Tomater wants to sell their solution to other aquaponic businesses which will earn them an economic return.

The most significant internal constraining factor is its energy consumption. This is due to the high energy costs and that the system is not flexible enough. The greenhouses require a lot of energy and due to their use of bumblebees that need natural sunlight to pollinate, Peckas Tomater cannot spread the energy consumption throughout the day to decrease the costs. Therefore, the costs associated with their energy consumption can be seen as a factor that constrains Peckas Tomater in their development. Other constraining factors are the sensitive harvest and the salmon trout. Peckas Tomater cannot use any pesticides and therefore the harvest is more sensitive against infestations. This is seen as a constraining factor because a lost harvest means a loss in sales and that they may need to replace all the plants which increase the costs and hinders their development. The salmon trout can be identified as a constraining factor for Peckas Tomater since they are very dominant in their behavior which makes them unmanageable. Therefore, it has been very time-, and resource consuming to gather knowledge on how to manage them in the right way.

5.2.2 External factors

Built on the work of Gouldson (2008), he defines external factors as for example government, market, and civil society. One of the most important external enabling factors for Peckas Tomater is the mature market. The demand for more sustainable food has made it possible for Peckas tomater to grow and expand their business. This demand may be due to the consumers being more well-informed and that there is a higher awareness about climate change today.

The retailers may also have an effect on the demand. By offering their consumers more sustainable products it could improve the retailers' image by showing that they want to fulfill the consumers demand for more ecological and locally produced products. It could be argued that the demand from the market is the most important factor for a business when trying to develop a BM. This is because, without a demand from the market, the business cannot survive. In the case of Peckas Tomater, the retailers can also be seen to have an important role when creating this demand. Without retailers' support, it would be difficult for them to sell their products and reach their consumers.

The local society is also an important external enabling factor for Peckas Tomater in the development of their BM. Many local people have invested in the business and are also buying the products, which shows that they are very supportive. This may be due to an emotional attachment that the locals have and the fact that they want to support a local business that values the environment and the local society in Härnösand. If the business was not located in a small town, this could have been different due to the fact that the emotional attachment may have been lost. Other external enabling factors are government and that Peckas Tomater is a public company. Their view on finances may have been different if they were a family owned business since the objectives often differ. A public owned company has to meet the requirements of their stakeholders and also make a profit. However, the advantage of being a public company is that they can raise money through emissions, which has been one of the key factors that have enabled Peckas Tomater to expand and grow. It could be argued that this factor is only crucial because they needed to expand their business rapidly and having emissions to raise money is a way of achieving that.

In recent years the political interest from the Swedish government regarding local food production and self-sufficiency has increased. This is due to Sweden being very dependent on imported vegetables from other countries during the winter season. The Swedish government has therefore presented a proposition regarding the future food production and wants to invest approximately one million SEK to develop innovative and competitive production and to stimulate organic production and consumption. Therefore, support from the government can be presented as an external enabling factor for Peckas Tomater since they can supply the market with locally produced tomatoes even in the winters when other Swedish farmers cannot. As mentioned before, knowledge is an important internal enabling factor but it can also be an external. Peckas Tomater has an advisory board where they have gathered knowledge and experience from other external sources. The board has been an important source for knowledge and has helped Peckas Tomater in their development of an aquaponic BM.

The packaging of the tomatoes can be considered to be an external constraining factor for Peckas Tomater. This is because they want to have a packaging that is sustainable, durable and that meets the demand from the retailers. It has been both time-, and resource consuming for Peckas Tomater to achieve all of these requirements and therefore it can be seen as a constraining factor. Other constraining factors are legislation, ecological labeling and consumption patterns. Aquaponic is not treated individually from other kinds of food systems and the legislation is not flexible enough to deal with food systems that do not fit the conventional description. This makes it difficult for Peckas Tomater to receive fundings and to get an effective taxation policy due to aquaponics being placed in between legislation. Due to them being placed in a "grey area", they also have difficulties in receiving an environmental certification such as ecological labeling. Ecological products are well-known by the consumers and therefore they often entail an extra value for them. This opposes from

products produced in aquaponics since consumers are not aware of the benefits that these kinds of food systems contribute with. To change consumption patterns is hard, however by using a well known label it could be easier for Peckas Tomater to communicate their objectives to their customers.

The last external constraining factors are a competitive based market and uncertainty regarding the future of the industry. It will always be a risk that increased competition from other market participants with significantly greater financial resources, may lead to reduced growth opportunities or that Peckas Tomater's operations in other ways will be adversely affected. Another uncertainty is that they are active in a market that is expected to show continued growth and good earnings opportunities. However, it is a risk that the market will develop in an unfavorable direction for Peckas Tomater due to changed macroeconomic factors, rising energy prices, technical development, new regulations or other unaffordable external factors. Such events entail risks of a negative impact on Peckas Tomater's profitability and financial position. This is a constraining factor in the development because it is not just an uncertainty for the business itself but also for their stakeholders. If there are a lot of uncertainties regarding the future, which in this case there are, trying to predict the future and account for all the possible outcomes into the BM are very time-, and resource consuming. However, by trying to stay at the front of the technical development and also creating other revenue streams, Peckas Tomater can continue to be a leading actor on the market and minimize the uncertainty.

5.3 Critical reflection

When discussing what sustainable food production is and how it can be achieved, it is important to have a critical perspective. Aquaponics have the potential to be make food production more sustainable due to the closed circular system that enables a reuse of materials. However, it could be argued that aquaponics cannot be the only solution. High investments and costs associated with aquaponics require vegetables and fishes that generate an economic return that exceeds these costs. This means that not all vegetables and fishes are suited for this kind of food production. By using greenhouses, aquaponics have the advantage of controlling the environment. In this way, aquaponics can give the vegetables the best conditions to maximize the output. However, this controlled system requires a high use of energy which increases the costs that could be avoided with traditional farming. Due to the higher production costs, the products often get a higher price. For the companies that produces these products, it means that they can market their products as premium products. However, this higher price could as well have a negative aspect since it excludes consumers that cannot afford these products.

In this study, key informants at the aquaponic business Peckas Tomater were interviewed. They were chosen because they represent different parts of the company as a way to receive a wider perspective. However, it is important to acknowledge that the answers could be biased which may have affected the results. Another aspect to consider is that the results in this study are specific for Peckas Tomater. This is because a BM is created in a specific context and therefore all factors identified in this study does not have to be the same for every aquaponic business. If a case study was conducted in another country that is not relying on imported vegetables in the same amount as Sweden and if the acceptance for sustainable food production was not as high, the results may also differ.

6 Conclusion

In this chapter, the conclusions from the study will be presented. The aim of this study was to examine contextual factors that enable and inhibit developments of aquaponic business models. The purpose was to create in-depth insights on how aquaponic BM are developed in practice and what factors that affect the development towards CBE. In order to receive these in-depth insights on how an aquaponic BM is developed, a case study of the company Peckas Tomater was conducted.

The most significant internal factors that have enabled the development of Peckas Tomater's BM towards CBE have been identified as key persons, Pecka Nygårds knowledge, and the internal culture. Key persons have been crucial for them since it is few existing commercial aquaponics globally and that there is a lack of a mature and well-developed industry. Pecka Nygård's knowledge has been identified as significant due to the developed system that Nygård introduced for Peckas Tomater that they only needed to scale up to fit their production volumes. The internal culture is the last mentioned enabling factor that has been crucial for Peckas Tomater's development. Since they have succeeded in creating a "we" culture, where all of the employees share the same goals and values concerning sustainability and growth. Other internal enabling factors that have been identified, but that is not as significant for Peckas Tomater, are their unique concept, good product, cash flow, and technology. The most significant external enabling factor for Peckas Tomater is the mature market. Without a demand for more sustainable food, it would not be possible for the business to survive, grow or expand. This goes hand in hand with the consumers that are more well-informed and that possesses a higher awareness about climate change today. It can be concluded that retailers can also affect the demand by offering their consumers more sustainable food as a way for them to improve their image and fulfill the demand from the market. The support from the local society is another important external enabling factor for Peckas Tomater. It can be stated that this support can be related to an emotional attachment which may have been lost if the business was not located in a small town. The last identified external enabling factors are the government and that Peckas Tomater is a public company.

Difficulty to find key persons and energy consumption was identified to be the two most significant internal constraining factors for the development of Peckas Tomater's BM towards CBE. Those factors were also identified to be the two that Peckas Tomater relies on the most. Without people with the right knowledge and experience and without energy for the greenhouses, the business would not survive. Other internal constraining factors were the sensitive harvest, high investments, the salmon trout, and the technology. The external constraining factors identified in this study were packaging, ecological labeling, competitive based market, uncertainty regarding future market development, change consumption behavior, and legislation. The most significant factor is legislation due to aquaponics being put in a "grey area" which makes it difficult for Peckas Tomater to receive fundings and to use certifications.

This study explains a BM through three components: *the value proposition, the value creation and delivery system, and the value capture system*. Peckas Tomater wants to generate an economic return by providing high-quality products without any toxins, emissions or unnecessary transports all year around and is, therefore, their value proposition. It was concluded in this study that Peckas Tomater creates value by cultivating the tomatoes through an aquaponic and also by being located close to their customers. Peckas Tomater captures value by selling their tomatoes as a premium product which allows them to have a higher price compared to their competitors. It was also concluded that Peckas Tomater's BM can be

seen as a CBM. This is due to the reuse, take-back and recycling activities that exist in Peckas Tomater's BM. Another conclusion is that Peckas Tomater has been able to avoid key challenges regarding the implementation of a CBM since they designed their BM to involve social and environmental benefits from the beginning. This study also concludes that Peckas Tomater's BM potentially could contribute to a CBE. This is because their industrial input, such as material, chemicals, and energy, is received from renewable biological resources. Their use of renewable non-fossil raw materials and products also increases in a sustainable, resource efficient and circular way. A key challenge regarding CBM that has been identified at Peckas Tomater is how to evaluate their environmental impacts due to these analyses being time-consuming and resource-intensive.

It can also be stated that Peckas Tomater could potentially be seen as a business that contributes to a CE since they use the latest technology regarding aquaponics, only uses renewable energy produced from wind power, have excluded plastic in their packaging, and is seen to create positive societal impacts. "Cradle to cradle" has become an important concept when describing CE and can also be related to Peckas Tomater. They reuse the nutrients found in the fish water to fertilize the tomato plants which can be seen as a technical cycle. This is due to the fish water being reprocessed and reused for the tomatoes which, in this particular case, can be seen as a new product. The initiative ReSolve framework, coined by Ellen MacArthur Foundation (2015) have also been used as a way to analyze Peckas Tomaters business in terms of CE. The business actions identified at Peckas Tomater were REgenerate, Share, Optimise, Loop, and Exchange were Loop was the most evident identified activity. This is because they recycle materials such as the nutrients in the fish water as a way to extract biochemicals from organic waste and their choice to use plastic-free packaging. Barriers that has affected Peckas Tomater's development towards a CE are financial barriers, lack of governmental support and effective legislation, lack of knowledge, and technical skills.

Further, this study contributes with an in-depth insight on how an aquaponic BM is developed in practise and what contextual factors that enabled and inhibit the development towards a CBE.

Future research

This study focused on what contextual factors that enable and inhibit the development of an aquaponic BM towards CBE. For future research, this study, therefore, proposes that more case studies should be conducted to further develop this research field. There is a need for more knowledge regarding how CBMs are developed in their local context and how they can contribute to creating a CBE. This is due to the lack of empirical data and, therefore, it would be beneficial to compare differences and similarities between cases. By comparing different cases and find factors that are significant in all these cases, it could enable researchers to draw conclusions that can be useful in a bigger context.

Bibliography

Literature and publications

Antikainen, M., Aminoff, A., Kettunen, O., Sundqvist-Andberg, H. & Paloheimo, H. (2017a). Circular Economy Business Model Innovation Process – Case Study. In: Campana, G., Howlett, R.J., Setchi, R., & Cimatti, B. (eds) *Sustainable Design and Manufacturing 2017*. Cham: Springer International Publishing, pp. 546–555.

Antikainen, R., Dalhammar, C., Hildén, M., Judl, J., Jääskeläinen, T., Kautto, P., Koskela, S., Kuisma, M., Lazarevic, D., Mäenpää, I., Ovaska, J.-P., Peck, P., Rodhe, H., Temmes, A. & Thidell, Å. (2017b). Renewal of forest based manufacturing towards a sustainable circular bioeconomy. p. 128.

Antikainen, M. & Valkokari, K. (2016). A Framework for Sustainable Circular Business Model Innovation. *Technology Innovation Management Review*, vol. 6 (7), p. 8.

Babbie, E.R. (2011). *The basics of social research*. 5th ed. Australia ; Belmont, CA: Wadsworth / Cengage Learning.

Beltramello, A., Haie-Fayle, L. & Pilat, D. (2013). *Why New Business Models Matter for Green Growth*. (2013/01).

Blidariu, F. & Grozea, A. (2011). Increasing the Economical Efficiency and Sustainability of Indoor Fish Farming by Means of Aquaponics - Review. *Scientific Papers*, p. 8.

Bocken, N., Short, S., Rana, P. & Evans, S. (2013). A value mapping tool for sustainable business modelling.(Lenssen, Mollie Painter, Aileen Ion, G., ed) *Corporate Governance: The international journal of business in society*, vol. 13 (5), pp. 482–497.

Bocken, N.M.P., de Pauw, I., Bakker, C. & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, vol. 33 (5), pp. 308–320.

Bocken, N.M.P., Short, S.W., Rana, P. & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, vol. 65, pp. 42–56.

Boons, F. & Lüdeke-Freund, F. (2013). Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. *Journal of Cleaner Production*, vol. 45, pp. 9–19.

Bradford, J. & Fraser, E.D.G. (2008). Local authorities, climate change and small and medium enterprises: identifying effective policy instruments to reduce energy use and carbon emissions. *Corporate Social Responsibility and Environmental Management*, vol. 15 (3), pp. 156–172.

Bryman, A. & Bell, E. (2015). *Business Research Methods*. Oxford University Press.

Chesbrough, H. (2007). Business model innovation: it's not just about technology anymore. *Strategy & Leadership*, vol. 35 (6), pp. 12–17.

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning*, vol. 43 (2–3), pp. 354–363.

Coyne, I. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing*, vol. 26 (3), pp. 623–630.

Cresswell, J.W. (2013). Five qualitative approaches to inquiry, Chpt. 4 in Qualitative inquiry and research design: Choosing among five approaches. SAGE Publications.

Daly, H.E. & Farley, J.C. (2004). *Ecological economics: principles and applications*. Washington: Island Press.

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B.D. & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production*, vol. 168, pp. 716–734.

Eisenhardt, K.M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, vol. 14 (4), pp. 532–550.

Ellen MacArthur Foundation (2015). Growth within: a Circular Economy Vision for a Competitive Europe. *McKinsey Center for Business and Environment, SUN*, pp. 1–98.

Ellen MacArthur Foundation, (2019). *Cities and circular economy for food*.

FAO, (2016). The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Rome.200 pp.

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, vol. 12 (2), pp. 219–245.

Glaser, B.G. & Strauss, A.L. (1967). *The discovery of grounded theory: strategies for qualitative research*. 4. paperback printing. New Brunswick: Aldine.

Goda, A. M. A., Essa, M. A., Hassaan, M. S., & Sharawy, Z. (2015). Bio economic features for aquaponic systems in Egypt. *Turkish Journal of Fisheries and Aquatic Sciences*, 15(3), 525-532.

Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research.The Qualitative Report, 8(4), 597-606.

Gouldson, A. (2008). Understanding business decision making on the environment. *Energy Policy*, vol. 36 (12), pp. 4618–4620.

Graber, A. & Junge, R. (2009). Aquaponic Systems: Nutrient recycling from fish wastewater by vegetable production. *Desalination*, vol. 246 (1), pp. 147–156.

Hetemäki, L., Hanewinkel, M., Muys, B. & Aho, E. (2017). *Leading the way to a european circular bioeconomy strategy*. Joensuu: European Forest Institute. (From Science to Policy; 5).

Hillary, R. (2004). Environmental management systems and the smaller enterprise. *Journal of Cleaner Production*, vol. 12 (6), pp. 561–569.

Jensen, M.H. (2002). CONTROLLED ENVIRONMENT AGRICULTURE IN DESERTS, TROPICS AND TEMPERATE REGIONS - A WORLD REVIEW. *Acta Horticulturae*, (578), pp. 19–25.

Joyce, A., & Paquin, R. L. (2016). The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production*, 135, 1474-1486.

Jun, H. & Xiang, H. (2011). Development of Circular Economy Is A Fundamental Way to Achieve Agriculture Sustainable Development in China. *Energy Procedia*, vol. 5, pp. 1530–1534.

Junge, R., König, B., Villarroel, M., Komives, T. & Jijakli, M. (2017). Strategic Points in Aquaponics. *Water*, vol. 9 (3), p. 182.

Kirchherr, J., Reike, D. & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, vol. 127, pp. 221–232.

Kloas, W., Groß, R., Baganz, D., Graupner, J., Monsees, H., Schmidt, U., Staaks, G., Suhl, J.,Tschirner, M., Wittstock, B., Wuertz, S., Zikova, A. & Rennert, B. (2015). A new concept for aquaponic systems to improve sustainability, increase productivity, and reduce environmental impacts. *Aquaculture Environment Interactions*, vol. 7 (2), pp. 179–192.

Kohlbacher, F. (2006). The Use of Qualitative Content Analysis in Case Study Research. *FQS* , vol 7 (1), pp. 30.

König, B., Janker, J., Reinhardt, T., Villarroel, M. & Junge, R. (2018). Analysis of aquaponics as an emerging technological innovation system. *Journal of Cleaner Production*, vol. 180, pp. 232–243.
Kracauer, S. (1952). The Challenge of Qualitative Content Analysis. *Public Opinion Quarterly*, vol. 16 (4, Special Issue on International Communications Research), p. 631.
Kraaijenhagen, C., Can Oppen, C. & Bocken, N.M.B. (2016). *Circular business. Collaborate & Circulate.* Amersfoort, The Netherlands: Circular Collaboration.
Lewandowski, M. (2016). Designing the Business Models for Circular Economy—Towards the Conceptual Framework. *Sustainability*, vol. 8 (1), p. 43.
Linder, M. & Williander, M. (2017). Circular Business Model Innovation: Inherent Uncertainties. *Business Strategy and the Environment*, vol. 26 (2), pp. 182–196.
Love, D.C., Fry, J.P., Genello, L., Hill, E.S., Frederick, J.A., Li, X. & Semmens, K. (2014). An International Survey of Aquaponics Practitioners.(Wang, H., ed) *PLoS ONE*, vol. 9 (7), p. e102662.
McDonough, W. & Braungart, M. (2002). *Cradle to Cradle: remaking the way we make things*. New York: North Point Press.
Oakdene Hollins (2011). *The Further Benefits of Business Resource Efficiency*. London: Department for Environment, Food and Rural Affairs.
OECD (2010). *Regulatory Policy and the Road to Sustainable Growth*. Paris.
Osterwalder, A., Pigneur, Y. & Clark, T. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*. Hoboken, NJ: Wiley.
Patton, M.Q. (1990). Qualitative evaluation and research methods. Beverly Hills, CA: Sage, pp. 169–186.
Peckas Naturodlingar AB (2017). Investeringsmemorandum Erbjudande till aktieteckning i Peckas Naturodlingar AB (Publ). pp. 1-28.
Prieto-Sandoval, V., Jaca, C. & Ormazabal, M. (2018). Towards a consensus on the circular economy. *Journal of Cleaner Production*, vol. 179, pp. 605–615.
Rakocy, J.E., Masser, M.P. & Losordo, (2006) T.M.Recirculating Aquaculture Tank Production Systems: Aquaponics—Integrating Fish and Plant Culture. p. 17.
Reichel, A., De Schoenmakere, M. & Gillabel, J. (2016). *Circular Economy in Europé eDeveloping the Knowledge Base*. European Environmental Agency. (02).
Reim, W., Parida, V. & Örtqvist, D. (2015). Product–Service Systems (PSS) business models and tactics – a systematic literature review. *Journal of Cleaner Production*, vol. 97, pp. 61–75.
Reime, M., Røste, R., Almasi, A. & Coenen, L.Report: (2016) The circular bioeconomy in Scandinavia. *SusValueWaste,* pp. 35.
Remenyi, D., Money, A., Price, D. & Bannister, F. (2002). The creation of knowledge through case study research. *Irish Journal of Management*, vol. 23 (2), pp. 1–17.
Richardson, J. (2008). The business model: an integrative framework for strategy execution. *Strategic Change*, vol. 17 (5–6), pp. 133–144.
Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M. & Ioannou, A. (2015). The Circular Economy: Barriers and Opportunities for SMEs. pp. 25.
Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S.I., Lambin, E., Lenton, T., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R., Fabry, V., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J. (2009). Planetary Boundaries: Exploring the Safe Operating Space for Humanity. *Ecology and Society*, vol. 14 (2). DOI: https://doi.org/10.5751/ES-03180-140232.

Schaltegger, S., Freund, F.L. & Hansen, E.G. (2012). Business cases for sustainability: the role of business model innovation for corporate sustainability. *International Journal of Innovation and Sustainable Development*, vol. 6 (2), p. 95.
Schaltegger, S., Lüdeke-Freund, F. & Hansen, E.G. (2016). Business Models for Sustainability. *Organization & Environment*, Vol. 29 (3) 264–289
Sheikh, B.A. (2006). HYDROPONICS: KEY TO SUSTAIN AGRICULTURE IN WATER STRESSED AND URBAN ENVIRONMENT. *Pak. J. Agric., Agril. Eng., Vet. Sci*, (22), pp. 53–57.
Sheridan, K. (2016). Making the Bioeconomy Circular: The Biobased Industries' Next Goal? *Industrial Biotechnology*, vol. 12 (6), pp. 339–340.
Somerville, C., Cohen, M., Pantanella, E., Stankus, A. & Lovatelli, (2014) A.Small-scale aquaponic food production. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS p. 1.
Stubbs, W. & Cocklin, C. (2008). Conceptualizing a "Sustainability Business Model." *Organization & Environment*, vol. 21 (2), pp. 103–127.
Teece, D.J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning*, vol. 43 (2–3), pp. 172–194.
Titscher, S., Meyer, M., Wodak, R. & Vetter, E. (2000). *Methods of text and discourse analysis*. London: SAGE Publications.
Tukker, A. (2015). Product services for a resource-efficient and circular economy – a review. *Journal of Cleaner Production*, vol. 97, pp. 76–91.
Upward, A. & Jones, P. (2016). An Ontology for Strongly Sustainable Business Models: Defining an Enterprise Framework Compatible With Natural and Social Science. *Organization & Environment*, vol. 29 (1), pp. 97–123.
Van der Goot, A.J., Pelgrom, P.J.M., Berghout, J.A.M., Geerts, M.E.J., Jankowiak, L., Hardt, N.A., Keijer, J.,Schutyser, M.A.I., Nikiforidis, C.V. & Boom, R.M. (2016). Concepts for further sustainable production of foods. *Journal of Food Engineering*, vol. 168, pp. 42 51.
Van Woensel, L., Archer, G., Panades-Estruch, L., Vrscaj, D., European Parliament & Directorate-General for Parliamentary Research Services. (2015). *Ten technologies which could change our lives: potential impacts and policy implications : in depth analysis.* Brussels: European Commission.
Verheugen, G. (2006). Den nya definitionen av SMF-företag. *Publikationer om näringsliv och industri*. pp. 1-52. Europeiska unionen.
Viaggi, D. (2016). Towards an economics of the bioeconomy: four years later. *Bio-based and Applied Economics*, Vol 5 (2) , pp. 101-112.
Wilson, C. (2014). Semi-Structured Interviews. *Interview Techniques for UX Practitioners*. Elsevier, pp. 23–41.
Yin, R.K. (2013). *Case Study Research: Design and Methods*. SAGE Publications.
Zhang, Y. & Wildemuth, B.M. (2009). Qualitative Analysis of Content. p. 12.

Internet

EPEA (2019) *The Cradle to Cradle® design concept*. Available from: https://epea-hamburg.com/cradle-to-cradle/. [2019-02-11].

Peckas tomater (2019) *Peckas Tomater - Direkt från växthuset till din butik*. Available from: http://www.peckas.se/. [2019-02-05].

Personal messages

Gambardella Andrea, *Technology Consultant,* Peckas Tomater. Personal meeting, 2019-04-04
Nygård Pecka, *Founder,* Peckas Tomater, Personal meeting. 2019-04-04
Petukhovskaya Elena, *CEO,* Peckas Tomater, Personal meeting. 2019-04-04
Wikström, Hugo, *Co-founder,* Peckas Tomater, Personal meeting. 2019-04-04
Åberg Carina, *Marketing Director,* Peckas Tomater, Personal meeting. 2019-04-04

Appendix 1

Interview guide

This study aims to examine contextual factors that enable and inhibit developments of aquaponic business models. The purpose is to create in-depth insights on how aquaponic business model are developed in practice and what factors that affect the development towards a circular bio-economy.

Research questions:

- What contextual factors enable the development of aquaponic business models towards a circular bio-economy?
- What contextual factors inhibit the development of aquaponic business models towards a circular bio-economy?

Topics

Internal factors

1. What were the fundamental factors that affected Pecka and made him change the way he cultivated the fish? That is, when he stopped using the oceans and started using fish tanks instead.
2. Were there factors that were critical for the change to happen
3. Were there some factors that can be identified and hindered the change?
    a. How did you overcome these?
4. Were the some factors that can be identified and that enabled the change?
    a. How did you take advantage of these?
5. How did Pecka come up with the idea of using aquaponics and to start growing tomatoes?
    a. Inspiration from someone else?
6. In what way does Pecka Tomater create value for the customers?

External factors

1. Were there some external factors that can be identified that hindered the change?
    a. How did you overcome these?
2. Were there some external factors that can be identified that enabled the change?
    a. How big of a role have the municipal played?
    b. Are there other institutions that have played a crucial role?
    c. How big of a role have the market played in enabling your success?
    d. Have the environmental trend played a big role?
    e. Or that consumers are today more willing to pay for “better” food?
3. How big of a role have the technology played in enabling your success?

Aquaponics

1. What makes Peckas Tomater unique?
2. What is your business model?
3. Why Aquaponics?
4. Why Härnösand?
5. In what way are you affected by the industry being so underdeveloped?
6. Are there any laws or legislations that are specific for aquaponics?

Barriers for a circular economy

- Environmental culture
  - Sector and firm acceptance
- Financial barriers
  - High investments?
  - Help from an external part
- Lack of governmental support and effective legislation
  - Laws
  - Grants
  - Tax reductions
- Lack of knowledge
  - Underdeveloped industry
  - No prior example on a profitable company
- Administrative burden
  - Time and resources
- Technical skills
  - Pecka Nygård?
- Support from the supply and demand network
  - Demand from the market?
  - Do you think you had succeeded if you started your business 10 years ago?