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Sustainable Business Models for Commercializing Renewable and Circular Plastics – A Multiple Case Study Research

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A paradigm shift from linear economy to a circular and bioeconomy based plastic industry is projected to play a key role in meeting global climate targets. The transition towards bio-based and circular plastics calls for increasing contributions from private companies to fundamentally reconfigure the existing value chain. Sustainability literature has recognized the ability to agilely move into novel business models as an essential source of sustainable competitive advantage. However, the existing research pays little attention to the actual mechanisms through which companies create viable business models for introducing sustainable innovations to market and drive sustainability to industries in scale. This study seeks to increase our understanding of how sustainable business models function in companies to successfully commercialize the sustainable innovations.

This study adopts a qualitative research approach to analyze the creation and deployment of sustainable business models for renewable innovations. The research employs a multiple case study design with two raw material suppliers, one oil refining and one petrochemical company, to understand how the novel sustainable business models support the commercialization of the renewable and circular plastic innovations and translate into economic success and competitive advantage.

The findings of the study are three-fold: First, a wide range of barriers for commercializing the renewable and circular plastic innovations are identified. Second, the results present four *business model functions* that support the successful market introduction of the innovations – by improving transparency and traceability, fostering collaboration for research and development, enhancing exploration of novel business opportunities, and securing long-term profitability. Third, the findings provide a mapping of how the business model functions translate sustainable innovations into successful business cases when they are actively managed to (i) induce open collaboration with stakeholders to accelerate change, and (ii) leverage complementary assets through business model ambidexterity.

The study contributes to existing knowledge of the key mechanisms through which companies successfully create business cases for sustainability. In addition, the findings add to the growing body of literature on sustainable innovation by elaborating how companies can benefit from encouraging openness while leveraging complementary assets to create hard-to-imitate sustainable business models.

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Paradigman muutoksella nykyisestä lineaarisesta taloudesta kierto- ja biotalouspohjaiseen petrokemikaalien tuotantoon oletetaan olevan merkittävä rooli globaalien ympäristötavoitteiden saavuttamisessa. Siirtymä vaatii yksityisiltä toimijoilta merkittävää työpanosta uudelleenjärjestämään nykyisen arvoketjun. Kestävään innovointiin ja liiketoimintaan keskittynyt kirjallisuus on ehdottanut, että yrityksen kyky innovoida liiketoimintamalleja ketterästi tuo yrityksille merkittävää kilpailuetua. Kuitenkin vain vähäinen määrä tutkimusta on käsitellyt todellisia mekanismeja, joiden avulla yritykset onnistuvat kehittämään kestäviä liiketoimintamalleja ja onnistuneesti kaupallistamaan innovaatioita.

Työssä käytetään laadullista tutkimustapaa analysoimaan kestävien liiketoimintamallien kehittämistä ja käyttöönottamista uusiutuville ja kiertäville muovi-innovaatioille. Työ toteutetaan monitapaustutkimuksena, joka keskittyy kahteen alan raaka-aine toimittajaan; öljy-yhtiöön ja petrokemikaaliyritykseen. Tutkimuksen tavoitteena on ymmärtää, kuinka yrityksessä käyttöönotetut kestävät liiketoimintamallit tukevat muovi-innovaatioiden kaupallistamista ja luovat yrityksille kilpailullisia etuja petrokemikaalimarkkinoilla.

Työn tulokset ovat kolmijakoiset: Ensinnäkin työ tunnistaa laajan joukon erilaisia esteitä uusiutuvien ja kiertävien muovi-innovaatioiden kaupallistamisessa. Toiseksi tulokset esittävät neljä *liiketoimintamallifunktiota,* jotka tukevat innovaatioiden kaupallistamista parantamalla arvoketjun läpinäkyvyyttä ja jäljitettävyyttä, edistämällä yhteistyötä eri alan osakkaiden kanssa, tehostamalla uusien liiketoimintamahdollisuuksien tutkimista, ja suojaamalla pitkän aikavälin tuottavuutta. Kolmanneksi tulokset kuvaavat, kuinka liiketoimintamalli-funktiot luovat uusiutuville innovaatioille kestävää liiketoimintaa (i) tehostamalla avointa yhteistyötä eri alan toimijoiden kanssa siirtymän kiihdyttämiseksi ja (ii) hyödyntämällä täydentäviä resursseja liiketoimintamallin kaksikätisyyden kautta.

Tutkimus kasvattaa nykyistä ymmärrystä avainmekanismeista, joiden kautta yritykset kykenevät luomaan kestävää liiketoimintaa. Tulokset laajentavat kestävän innovoinnin ja liiketoiminnan kirjallisuutta täsmentäen sitä, kuinka yritykset hyötyvät avoimuudesta ja yhteistyön edistämisestä samalla kun ne hyödyntävät täydentäviä resursseja luodakseen vaikeasti imitoitavaa liiketoimintaa.

Avainsanat: biopohjainen muovi, kiertotalous, kestävä liiketoimintamalli, kestävä innovaatio

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Table of Contents

ACKNOWLEDGEMENTS III

TABLE OF CONTENTS IV

LIST OF FIGURES VI
LIST OF TABLES VII
LIST OF TERM DEFINITIONS VIII

1. INTRODUCTION 1

1.1. BACKGROUND AND MOTIVATION 1
1.2. RESEARCH QUESTIONS AND OBJECTIVES 3
1.3. RESEARCH METHOD AND KEY FINDINGS 6
1.4. THE STRUCTURE OF THE THESIS 7

2. LITERATURE REVIEW 8

2.1. SUSTAINABLE BUSINESS MODEL AND INNOVATION 8
2.1.1. THE CONCEPT OF SUSTAINABLE INNOVATION 9
2.1.2. BUSINESS MODEL AS A CONCEPT 10
2.1.3. SUSTAINABLE BUSINESS MODEL ARCHETYPES 15
2.1.4. BUSINESS MODEL AS A DEVICE 17
2.2. CREATING SUSTAINABLE BUSINESS MODELS 19
2.2.1. CONDITIONS FOR SUSTAINABLE DEVELOPMENT 19
2.2.2. PARALLEL BUSINESS MODEL IMPLEMENTATION TO DRIVE SUSTAINABILITY 24
2.2.3. CHALLENGES FOR CREATING SUSTAINABLE BUSINESS MODELS 26
2.2.4. SUSTAINABLE BUSINESS CASE DRIVERS 29
2.3. THEORETICAL SYNTHESIS 31

3. METHODOLOGY 33

3.1. RESEARCH APPROACH AND CASE SELECTION 33
3.2. RESEARCH PROCESS 34
3.2.1. DATA COLLECTION 35
3.2.2. DATA ANALYSIS 36
3.3. RESEARCH ASSESSMENT 38

4. FINDINGS 40

4.1. CASE DESCRIPTIONS 40
4.1.1. CASE A 40
4.1.2. CASE B 43
4.2. CHALLENGES IN COMMERCIALIZING RENEWABLE AND CIRCULAR PLASTIC SOLUTIONS 45
4.2.1. CO-CREATION OF ENVIRONMENTAL, SOCIAL AND ECONOMIC VALUE 46
4.2.2. ENGAGEMENT WITH STAKEHOLDERS 48
4.2.3. INITIALLY NICHE TECHNOLOGIES AND DESIGNS 49
4.2.4. LACK OF METHODS TO MEASURE SUSTAINABILITY 50

4.3. BUSINESS MODELS TO COMMERCIALIZE RENEWABLE AND CIRCULAR PLASTIC SOLUTIONS 52
4.3.1. IMPROVING TRANSPARENCY AND TRACEABILITY 53
4.3.2. FOSTERING COLLABORATION FOR R&D 55
4.3.3. ENHANCING EXPLORATION 57
4.3.4. SECURING LONG-TERM PROFITABILITY 59
4.4. BUILDING COMPETITIVE ADVANTAGES WITH NOVEL BUSINESS MODELS 62
4.4.1. COLLECTIVE AND OPEN ENGAGEMENT WITH STAKEHOLDERS TO ALLOW CIRCULARITY OF RENEWABLE SOLUTIONS 63
4.4.2. BUSINESS MODEL AMBIDEXTERITY TO UNFOLD VIABLE INNOVATION 66
4.5. SUMMARY OF THE FINDINGS 69

5. DISCUSSION 71

5.1. ANSWERING THE RESEARCH QUESTIONS 71
5.2. CONTRIBUTIONS TO EXISTING LITERATURE 78
5.2.1. EXTENDING THE BUSINESS MODEL FOR SUSTAINABLE INNOVATIONS FRAMEWORK 79
5.2.2. OPEN INNOVATION TO CREATE SUSTAINABLE VALUE TO A BROADER RANGE OF STAKEHOLDERS 81
5.2.3. BUSINESS MODEL AMBIDEXTERITY TO CREATE HARD-TO-IMITATE CAPABILITIES AND DRIVE SUSTAINABILITY IN SCALE 82

6. CONCLUSIONS 86

6.1. PRACTICAL IMPLICATIONS 86
6.2. LIMITATIONS 87
6.3. FUTURE RESEARCH 88
REFERENCES 90
APPENDIX 1 96
APPENDIX 2 97

List of Figures

Figure 1: Research question framework..... 5

Figure 2: Visualization of the business model canvas by Osterwalder and Pigneur (2010). 13

Figure 3: The initial framework for business model for sustainability innovation by Lüdeke-Freund (2019).....30

Figure 4: The theoretical framework.....32

Figure 5: Case study approach: the replication process adapted from Yin (2003). 35

Figure 6: The identified business activities and the business model functions to support commercialization of renewable and circular plastics solutions.....52

Figure 7: The event chain from deploying business model focused on engaging with various stakeholders to the competitive advantages 65

Figure 8: The event chain from deploying business model ambidexterity to the competitive advantages 68

Figure 9: The extended business model for sustainable innovation framework including the key research results.....80

List of Tables

Table 1: Interpretations of business models by different authors. 12

Table 2: Sustainable business model archetypes by Bocken, et al. (2014). 16

Table 3: Challenges for creating sustainable business models. 27

Table 4: List of the interviews, the informant roles and the sources of archival data.....36

Table 5: Description of each business segment and the novel development units, and the current states of each unit of the Case company A. 42

Table 6: Description of the main offerings divided into three business segments and the novel development unit, and the current state of each segment of the Case company B. 44

Table 7: Challenges for creating sustainable business models for commercializing renewable and circular plastic solutions. 46

List of term definitions

Plastics	A wide range of synthetic or semi-synthetic materials that are exploited for various consumer and industrial applications (Andrady & Neal, 2009).
Bio-based plastics, renewable plastics	Plastics, in which a fossil-fuel feedstock has been fully or partly been replaced with renewable feedstock, such as renewable waste and residues, sugar, cellulosic fibers, wheat, or starch. The primary objective for bio-based materials is to reduce GHG emissions relative to their fossil-fuel-derived alternatives. (EASAC, 2020)
Biodegradable plastics	Either fossil-fuel or bio-derived plastics that can break down to environmentally benign residues through biological processes under various conditions encountered in the natural environment. (EASAC, 2020)
Recyclable plastics, **circular plastics**	Plastic that can be sorted and aggregated into defined streams for commercial recycling processes and becomes a raw material that is exploited in the production of new products (APR & PRE, 2018).
Recyclate	Raw material sent to and processed in a waste recycling plant for producing recycled plastics (APR & PRE, 2018).

1. Introduction

The following chapters introduce the background and motivation for the research topic of sustainable business models for commercializing renewable and circular plastics. The chapters also outline the research objectives and questions of the study and provide the research context, and the structure of the thesis.

1.1. Background and motivation

Plastics have become an essential material in almost all sectors of the economy, and many industries, such as the packaging industry, strongly rely on the large-scale production of plastics (Geyer, Jambeck, & Law, 2017). The industry has matured over 100 years and obtained the most sophisticated and cost-effective processes for manufacturing plastic polymers, such as polyethylene (PE) and polypropylene (PP), for various applications (Andrady & Neal, 2009). Today, over 350 million tonnes of plastics are globally produced every year (PlasticsEurope, 2020). In recent years, the environmental issues created by the linear economy based industry value chain, have become increasingly well documented (EASAC, 2020). Unfortunately, an overwhelming amount of at least 8 million tonnes of plastic waste is estimated to leak into the ocean every year (Ellen MacArthur Foundation, 2016). As plastics leak to the environment, many of the material benefits, such as strength and durability, become major disadvantages. The increasing discussion and consumer awareness of the plastic emissions and waste challenges has motivated petrochemical industry actors to explore more sustainable options for conventional polymer production. Regulations to support bioeconomy and circular economy based industry value chains have started to emerge, and the interest towards producing renewable and circular plastics has been increasing.

To first clarify some ambiguous terminology, bio-based or renewable plastics in this thesis refer to plastics in which a fossil-fuel feedstock is partly or entirely replaced with

renewable feedstock, such as organic waste or residues, sugar, vegetable oil, cellulosic fibers, wheat, or starch (for further specifications, see List of term definitions).

Whereas the estimated growth rate for production of fossil-derived plastics in Europe is expected to continue to decrease (PlasticsEurope, 2020), the bio-based plastic production is projected to witness a significant growth at a compound annual growth rate of approximately 3% between 2019 and 2024 (European Bioplastics, 2019). Even so, the production is yet fractional (<1%) in comparison to conventional plastics production, and companies aiming to be a part of this transition are required to make significant efforts to transform and reconfigure the established businesses and value networks (European Bioplastics, 2019).

Furthermore, the entire plastic value chain requires fundamental and systemic reforms to reverse damaging the environment and biodiversity. Society needs to adopt new behaviors and rules to move towards a circular economy, reusing and recycling the plastic goods and packaging, and most importantly, not letting any plastics leak into the environment (EASAC, 2020). The market for renewable and circular plastics has remained nascent, and the technologies for producing renewable polymers and recycling are still relatively expensive. The literature up to date has neither articulated the central benefits for different actors related to this transformation, nor has it developed worthy sustainable business models for companies in the market to pursue (EASAC, 2020; Iles & Martin, 2013; Lüdeke-Freund, Massa, Bocken, Brent, & Musango, 2016).

Academics have recognized a business model – a set of activities and systems to create, deliver, and capture value (Zott, Amit, & Massa, 2011) – as an appropriate approach to analyze how sustainable changes are delivered into industrial systems (Adams, Jeanrenaud, Bessant, Denyer, & Overy, 2016; Boons & Lüdeke-Freund, 2013; Schaltegger, Lüdeke-Freund, & Hansen, 2012; Stubbs & Cocklin, 2008). The business model provides a link between long-term strategy and short-term operations of a company and adequately combines the theoretical and practical discussion (Osterwalder & Pigneur, 2012; Seddon, Lewis, Freeman, & Shanks, 2004; Teece, 2010). The literature yet lacks discussion of sustainability elements in value creation and capture, and little research exists on the actual mechanisms fostering successful creation of business models in different contexts (Boons & Lüdeke-Freund, 2013; Bucherer, Eisert, & Gassmann, 2012; Chesbrough, 2007a; Margolis & Walsh, 2003; Massa, Tucci, & Afuah, 2017).

1.2. Research questions and objectives

The primary objective of this thesis is to analyze how sustainable business models support market introduction of renewable and circular plastic innovations. The study seeks to understand what prevents companies to deploy renewable and circular plastic innovations and how business models can mediate these challenges and create successful business cases for the sustainable innovations.

Over the last decade, attention among academics has increasingly started to focus on business model approach to tackle the issues related to sustainability transition in various industries (Bocken, Weissbrod, & Tennant, 2016; Boons & Lüdeke-Freund, 2013; Chesbrough, 2010; Schaltegger et al., 2012; Sosna, Trevinyo-Rodríguez, & Velamuri, 2010). Even though the prior literature lacks definitional clarity for business model concept, scholars commonly agree that in today's dynamic business environments, companies are required to continuously innovate the models by exploring novel ways to create and capture value (Teece, 2007; Zott et al., 2011). The extant sustainability literature further recognizes business model innovations to enable successful commercialization of sustainable innovations (Bocken, Short, Rana, & Evans, 2014; Boons & Lüdeke-Freund, 2013; Sosna et al., 2010). Nevertheless, the studies utilizing business model perspective in the sustainability field have remained scarce (Geissdoerfer, Vladimirova, & Evans, 2018) and the relationship between a successful market introduction and sustainable innovation has remained relatively unexplored (Boons & Lüdeke-Freund, 2013; Schaltegger, Hansen, & Lüdeke-Freund, 2016).

I aim to advance this research by adopting business model approach and by investigating how business models can be utilized to successfully commercialize sustainable plastic innovations. Drawing on the widely accepted *"device"* interpretation of business model (Doganova & Eyquem-Renault, 2009), I consider business models as mediating tools that can be aligned with sustainable innovations to compensate the possible disadvantages resulted from the innovations and to support successful market introduction.

Lack of consensus in the field of business model research has resulted to a lack of understanding in the corporate world (Schaltegger & Synnestvedt, 2002). Companies rarely understand their current business models well enough to evaluate their fit with the sustainable innovations opportunities and do not know how to utilize business models in their sustainability efforts (Johnson, Christensen, & Kagermann, 2008). Based on the assumption that appropriately aligned business models enable successful commercialization of sustainable innovations, we need to thoroughly understand how the bio-based plastic opportunities relate to the established business models. This involves

comprehensive evaluation of the barriers that established business models and industrial systems introduce to companies aiming to commercialize the renewable and circular solutions. Consequently, the first research question is defined as followed:

RQ1) What are the barriers preventing established companies to commercialize renewable plastic innovations?

Particularly in the field of sustainable business model development, scholars have argued that even though incremental innovations can allow quite prominent improvements, mere incremental product and technical improvements are not capable of leading to optimization of the wider systems (Schaltegger & Wagner, 2011). Hence, scholars argue that more radical business model reconfigurations are required to create an actual impact and drive transformation. The viability of all business models is defined by the conditions including the *"micro conditions"* (i.e. organizations internal environment and other business models), *"meso conditions"* (i.e. other horizontal and vertical actors in the industry), and *"macro conditions"* (i.e. government, culture, policies, consumers, etc.), in which the business model exists (Lüdeke-Freund et al., 2016). Companies aiming to create sustainable business models need to understand the conditions well enough in order to align the novel models and the conditions in a manner that conflicts are obviated.

While the literature recognizes the importance of adapting business models with both novel technologies and various contextual features, research has given relatively little attention to the actual mechanisms through which the business models support the commercialization of sustainable innovations. Based on the assumption of considering business model as a *"mediating device"*, the following research question focus on how novel business models can support the development and introduction of the renewable and circular plastic innovations while mediating the conflicts derived by established conditions. The objective is to identify business model functions that allow companies to commercialize renewable and circular plastics innovations with outcomes that are sustainable in terms of, not only ecological and social performance, but also economic success. The corresponding research question is defined as followed:

RQ2) How can novel business models support the commercialization of renewable plastic innovations?

In order to align sustainable business models with existing organizational systems, companies usually need to make radical reconfigurations to existing value constellations (Boons, Montalvo, Quist, & Wagner, 2013). As the viability of the radical business model reconfigurations are uncertain in dynamically changing markets, established companies

often aim to mitigate the risks related to disruptive business model innovations by developing novel business models in parallel with the existing ones (Geissdoerfer et al., 2018; Lüdeke-Freund, 2019; Markides, 2013; Sosna et al., 2010). Managing dual business models is a complex task and can result to tradeoffs between established and the novel business models (Markides, 2013).

Prior findings in the extant literature have demonstrated how companies tend to focus on contributing to short-term profits and consequently, the attempts to create novel sustainable business models focusing on long-term results most often end up failing (Geissdoerfer et al., 2018). Scholars have aimed to answer the question of how established companies can react to market changes and sustainably innovate their business while simultaneously contributing to revenues and profits of the existing business (Bucherer et al., 2012; Johnson et al., 2008). Furthermore, initial studies have recognized the importance of showing how the sustainable business models can create value with the innovations and promote competitiveness (Chesbrough & Rosenbloom, 2002; Lüdeke-Freund, 2019; Schaltegger et al., 2012). However, the previous literature yet lacks research on how the competitive advantages from sustainable innovations and business cases for sustainability are generated in different contexts.

The objective of the third research question is to improve incumbents understanding of how the models can be successfully deployed and how the business models for commercializing renewable and circular plastics can provide competitive advantage in the future markets. Consequently, the third research question is defined as followed:

RQ3) How should companies deploy novel business models for renewable and circular plastic innovations to promote competitiveness in future markets?

The research question framework illustrating the relation and intersections of the key concepts for this thesis is depicted in Figure 1.

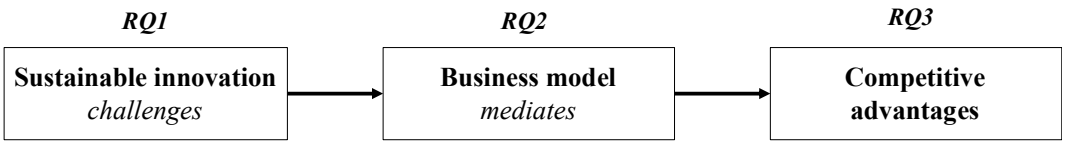

Figure 1: Research question framework

1.3. Research method and key findings

This thesis adopts qualitative research approach to understand the successful deployment of sustainable business models. The study is started with a comprehensive literature review focusing on topics related to sustainable business model and sustainable innovation in order to understand the extant research regarding the relevant concepts. Furthermore, the extant research gaps in the literature are identified to address the research questions for the study, and the theoretical framework to guide the empirical part of the study is developed.

The research adopts a multiple case study design to analyse the actual mechanisms through which the sustainable business models are successfully innovated. The case study focuses on two companies including one oil refining company and one petrochemical company operating in the raw material production side in the plastic industry value chain. The study investigates the barriers that prevent the two companies to commercialize renewable and circular plastic innovations and the ways in which novel business models can support the commercialization of such plastics innovations.

The study provides knowledge regarding sustainable business models for commercializing renewable and circular plastic innovations and increase the understanding of how large companies are able to successfully innovate their business models and drive sustainability to industries. The key findings of the thesis are three-fold: First, the findings identify a wide range of challenges related to renewable and circular plastic innovations that create barriers for companies to commercialize the plastic innovations. These challenges are grouped to four main categories, namely co-creation of environmental, social and economic value; engagement with stakeholders; initially niche technologies and designs; and lack of methods to measure sustainability performance.

Second, by locating four business model functions that demonstrate how sustainable business models can mediate the identified challenges and support successful market introduction of renewable and circular plastics in terms of economic, environmental and social performance. These functions capture features of the business models that (i) improve transparency and traceability, (ii) foster research and development collaboration among various stakeholders, (iii) enhance exploration, and (iv) secure long-term profitability.

Third, the research elaborates how the essential functions of sustainable business models translate into future competitiveness in plastic market by inducing open engagement with various stakeholders and promoting ambidexterity, i.e. the ability to explore and exploit

business models in parallel. The findings suggest that companies are required to continuously manage and adjust the business model functions between accelerating innovation by externally developing competences with the stakeholders and strengthening the industry position by incorporating competences and assets.

1.4. The structure of the thesis

This thesis is structured to six parts. This introduction has briefly described the background and motivation for the research, presented the research questions and objectives for the study, and finally, shortly outlined study method and key findings.

The second part provides a literature review presenting the current state of sustainable business model research and highlights the opportunities and the challenges embedded in sustainable innovations. Major concepts investigated in the study are introduced and a background for understanding organizational sustainability transformation is outlined. Furthermore, the theoretical framework for the study is provided.

The third chapter presents the chosen research approach and outlines a rationale for the chosen methodology. Research process is described, and the data collection and analysis methods are explained. Lastly, the chapter evaluates the quality of the research methodology by analyzing the validity and reliability of the research design.

The fourth chapter describes the case companies in brief and provides the findings of the empirical research. The findings are provided in three chapters following from the three research questions. Furthermore, a summary of the findings is provided.

The fifth part provides the theoretical basis for empirical findings through contrasting the cases with literature. The chapter answers the research questions and outlines an augmented theoretical framework. Furthermore, the chapter elaborates how the findings contribute to existing literature and increase our understanding related to deploying novel business models to commercialize renewable and circular plastics.

Finally, the conclusions part provides practical implications for both managers and theory in detail. Furthermore, the research limitations are addressed and recommendations for further research are outlined.

2. Literature Review

The following literature review provides the theoretical background and an adequate foundation for the empirical research. The review is divided into two parts that present the major concepts and frameworks considered in the study. The objective of this literature review is first, to provide a comprehensive discussion of sustainable business models – the core concept of this research and underline the existing research gaps found in the literature. Second part of the review aims to take an in-depth discussion of the current state of the sustainable transition literature and provide an overview of previous cases and research of commercialization of sustainable innovations. In addition, the theoretical framework for empirical part is outlined.

2.1. Sustainable business model and innovation

In response to growing concerns on various environmental and social issues, the research has expanded rapidly to increase our understanding of the ways in which novel products and technologies enable organizations and societies to become more sustainable (Bocken et al., 2014; Boons & Lüdeke-Freund, 2013). Over the past decades, scholars have recognized changes to the business model of a company as a fundamental approach to realize innovations and successfully introduce novel technologies, products, and services to market (Amit & Zott, 2010; Doganova & Eyquem-Renault, 2009; Teece, 2010). Consequently, scholarly interest towards sustainable business model innovations to drive sustainability into industrial systems has widely increased in recent years (Boons & Lüdeke-Freund, 2013; Lüdeke-Freund, 2010; Schaltegger et al., 2012). Despite the considerable research efforts, the research on the topic has remained fragmented and lacks definitional clarity on the relevant concepts (Geissdoerfer et al., 2018).

Fundamental explanations for the issues can be identified in the literature. First, the concepts of "*business model"* and "*business model innovation"* per se lack theoretical grounding in literature (Teece, 2010; Zott & Amit, 2013). Hence, the progress in sustainable business model research is also procrastinating, as researchers generally depict sustainable business models as extensions to business models with specific environmental and social goals added to it (Evans et al., 2017).

Second, only few cases of more radical business model reconfigurations are known in the extant literature. Research suggest that disruptive sustainable business model innovations

often fail, and companies tend to focus on rather incremental improvements in business models, such as energy savings and material efficiency, which are easy link to cost savings and often "*event driven*" by legislation or subsidies (Geissdoerfer et al., 2018; Schaltegger et al., 2016). Consequently, the empirical research on sustainable business models has remained scarce.

The following sections outline the relevant concepts regarding sustainable innovations and business models in order to give a theoretical grounding for business model function in the research framework.

2.1.1. The concept of sustainable innovation

The increasing role of sustainability has led the way towards innovation centric value creation and provided companies a novel opportunity to add shared value into offerings (Boons & Lüdeke-Freund, 2013; Schaltegger et al., 2012). The progress in the field of sustainable development has claimed to be obstructed by the plurality of various definitions (Boons et al., 2013; Massa et al., 2017).

Many relevant concepts in the field are relatively ambiguous and prior research has been criticized to apply the terms unconcernedly neglecting the lack definitional clarity in the literature (Boons et al., 2013; Seddon et al., 2004). Hence, before investigating the previous research on sustainability innovations and analyzing the challenges related to commercializing novel sustainable solutions, the following section first provides an overview of the main umbrella term of sustainable innovation and specifies the boundaries defining the concept.

Clark and Charter (2007) highlighted three fundamental aspects involved in sustainable innovations by defining the concept followingly:

" processes where sustainability considerations (environmental, social, and financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialization. This applies to products, services, and technologies, as well as to new business and organizational models".

Three fundamental aspects should be underlined in the definition by Clark and Charter. First, sustainable innovation in the definition addresses environmental, social and financial considerations. Rather than focusing on mere environmental considerations (*"eco-innovation"),* sustainable innovation comprehensively addresses social, environmental, and economic considerations. Second, as innovations in general,

sustainability innovations are distinguished from inventions with an additional requirement of successful market introduction (Chesbrough, 2007a). Despite this clarification, the existing research pays relatively little attention to the actual mechanisms through which companies can successfully introduce sustainable inventions to the market (Boons & Lüdeke-Freund, 2013; Lüdeke-Freund et al., 2016).

Third, Clark and Charter (2007) categorize innovations to products, services, processes, technologies, business models, and organizational models. It should be underlined that all the forms of innovation are tightly interrelated with each other, and renewing one usually requires calibration of the other ones (Amit & Zott, 2001; Chesbrough, 2007a). The previous research has mainly focused on product-oriented innovations and organizational development (Adams et al., 2016; Teece, 2007). A product and service innovation can refer to making improvements in the existing offerings, such as adding new features, or to more radical changes, such as developing an entirely new product or service. Technical innovations concern the changes in the exploited technologies, such as implementing energy saving clean technologies. The organizational innovation refers to changes and improvements in the organizational systems, such as knowledge and skill management.

Finally, business model innovations are generally considered to occur in three ways – as new business activities, novel ways to link the activities, or as new parties performing the activities (Amit & Zott, 2012). Since business model innovation refers to creating new ways for a company to create and capture value, it is strongly interrelated to the other forms of innovation and often seen as the most radical way for organization to innovate (Chesbrough, 2010). Business model innovation becomes sustainable as environmental and social concerns are involved in the business activities, or the ways in which they are organized and performed (Clark & Charter, 2007; Evans et al., 2017). However, the business model term as such has evolved into a contested topic, and the term has a tendency to cannibalize other managerial terms, such as strategy (Seddon et al., 2004).

2.1.2. Business model as a concept

In order to exploit business model as a means of creating and deploying sustainable innovations requires an adequate understanding of the unit of analysis. For over a decade, scholars have aimed to reach a generally accepted definition for business model in order to facilitate progress in the research field (Osterwalder, Pigneur, & Tucci, 2005; Teece, 2010; Zott & Amit, 2013). In essence, business models describe how companies create and capture value (Massa et al., 2017; Osterwalder et al., 2005; Zott et al., 2011).

However, academics recognize business models from various approaches and include distinctive elements within value creation and capture. A sampling of some of the most widely exploited approaches for defining the business model are presented in Table 1.

One reason for the lack of definitional clarity for the concept has suggested to result from the strong link between business model and strategy (Johnson et al., 2008). Several strategic processes such as budgeting and planning are usually embodied in business models, and business model can be viewed as a strategic concept itself (Osterwalder & Pigneur, 2012). The endless debate of the relation between the two has made strategy and business model as one of the most imprudently applied terms in the literature (Osterwalder & Pigneur, 2012; Schaltegger et al., 2012; Teece, 2010).

Findings by Seddon et al. (2004) have demonstrated how strategy and business model are ambiguously referred to as overlapping concepts, one inside another, or even as synonyms. Prior literature typically refers to Porter's (1996) definition to describe company strategy as followed:

"strategy involves defining a company's long-term position in the marketplace, making the hard trade-offs about what the company will and will not do to provide value to customers, and forging hard-to-replicate fit among parts of the "activity system" the firm constructs to deliver value to customers, all with a view to making a superior return on investment." (Porter, 1996)

Drawing on Porter's definition, Seddon et al. (2004) specified the relation and the difference between strategy and business model as followed:

"A business model may be defined as an abstract representation of some aspect of a firm's strategy. However, unlike strategy, business models do not consider a firm's competitive positioning."

In turn, many scholars have presented conflicting views. For example, Chesbrough and Rosenbloom (2002) included the task of formulating a competitive strategy as a one separate entity in their business model framework. Particularly, the recent literature concerns business model as the most appropriate link between short-term business activities and long-term profits (Chesbrough, 2010; Schaltegger et al., 2016; Teece, 2007). Whether the strategy of a company is viewed as a part of the business model, or business models are seen as abstractions of strategy, it is clear that the two are strongly interrelated in the literature.

Table 1: Interpretations of business models by different authors.

Authors (Year)	Business model definition	Approach
Amit & Zott (2001)	*"depicts the content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities"*	*Description*
Chesbrough & Rosenbloom (2002)	*"the heuristic logic that connects technical potential with the realization of economic value"*	*Mental map* ***Framework***
Doganova & Eyquem-Renault (2009)	*" a narrative and calculative device that allows entrepreneurs to explore a market and plays a performative role by contributing to the construction of the techno-economic network of an innovation"*	*Device*
Johnson, Christensen & Kagermann (2008)	*"consist of four interlocking elements, that, taken together, create and deliver value."*	*Template* ***Framework***
Osterwalder, Pigneur & Tucci (2005)	"a *conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm."*	*Conceptual tool* ***Framework***
Osterwalder & Pigneur (2010)	"*Business model describes the rationale of how an organization creates, delivers, and captures value."*	*Conceptual tool* ***Framework***
Teece (2010)	*"how the enterprise creates and delivers value to customers, and then converts payments received to profits"*	*Logic*
Zott & Amit (2013)	*"A business model is a template that depicts the way the firm conducts its business. It is crafted by a focal firm's managers in order to best meet the perceived needs of its customers."*	*Template*

Prior literature mostly refers business models as concepts that present a logic or an abstract idea for value creation (e.g. Amit & Zott, 2001; Teece, 2010) or as a framework that provide links between the main business components (Chesbrough & Rosenbloom, 2002; Johnson et al., 2008; Osterwalder & Pigneur, 2010). One of the most commonly

utilized frameworks have been "*a business model canvas"*-template by Osterwalder and Pigneur (2005; 2010). The canvases encompass nine interrelated "*building blocks*" that are grouped and linked based on the causal relations between the blocks. The business model canvas by Osterwalder and Pigneur (2010) is displayed Figure 2. Following section briefly describes how each block are presented in the literature and provides an overview on the concepts included in business model.

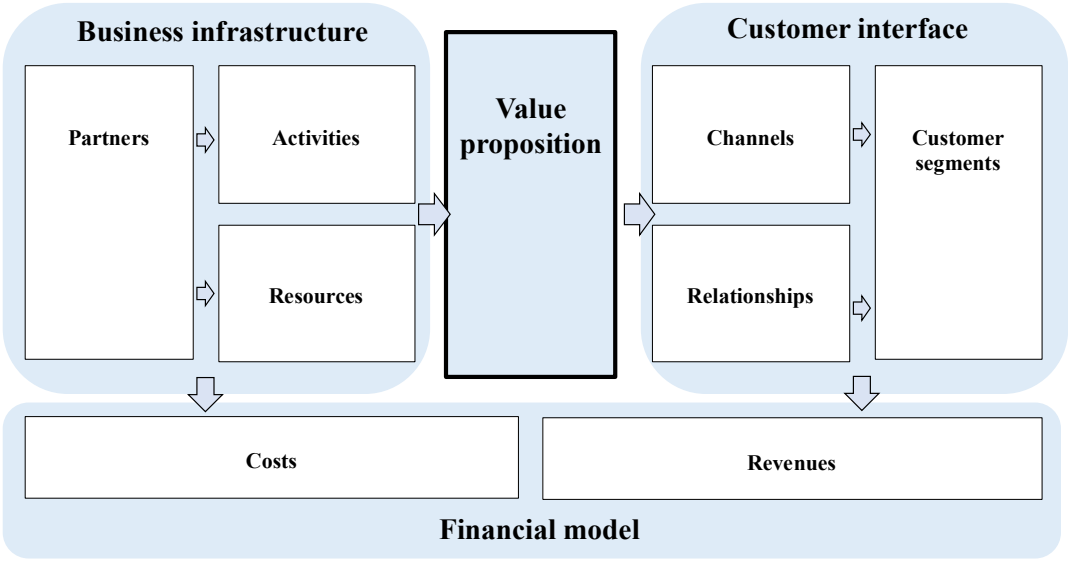

Figure 2: Visualization of the business model canvas by Osterwalder and Pigneur (2010).

Value proposition answers to the question what value is embedded in the product or service offered by the company. All the frameworks analyzed in this literature review have reflected value proposition in the elements of their business model constructs (e.g. Chesbrough & Rosenbloom, 2002; Geissdoerfer et al., 2018; Johnson et al., 2008; Osterwalder et al., 2005; Osterwalder & Pigneur, 2010; Teece, 2010).

The business infrastructure groups business activities and resources as well as third-party activities and resources to develop the value proposition. The business infrastructure of a company concerns how company operates and delivers the value, cooperates with stakeholders and the core capabilities of a company. Osterwalder et al. (2010) underlined three elements to further specify the business infrastructure.

- *Key resources* describe the most essential company assets that enable company to create value to its customers, earn revenues, create and maintain relationships and reach markets. These assets include variety of financial and physical resources and competences, such as people, technologies, facilities, channels and company brand (Johnson et al., 2008)

- *Key activities* define the most important activities to perform in order to successfully operate. Literature often depicts the arrangement of key activities and key resources as *"value configuration"* (Osterwalder et al., 2005).
- *Key partnerships* describe supplier and partner network that enables business model to work. There exist several motivations for a company to create partnerships such as economy of scale, optimization of resources and activities, and reduction of risk. The recognition of key partnerships that enable company to conduct essential activities within its business model has been widely accepted to be one of the most essential tasks of a business model (Amit & Zott, 2010).

Customer interface defines all the channels for distribution and communication. The customer interface answers to question regarding who the customers are, how they are reached and what kind of relationship the company shares with them.

- *Customer segments* include clustering of potential customers, including people, companies and organizations for which a company aims to offer value. Includes identification of needs, behaviors and other characteristics to serve different segments. Some scholars identify customer segments as a part of value proposition (e.g. Bocken, et al., 2014).
- *Channel**s*** describe how company is linked to its customer segments. The channels element also considers how much company should provide a specific product or service to a certain customer at a certain time.
- *Customer relationships* describe the relationship between the company and its current customers and potential future customers. The relationship varies from automated to personal assistance, and key considerations include customer retention and increasing revenue per customer.

Financial model defines the mechanism how value is captured (Teece, 2010). The model summarizes the costs of business infrastructure and the revenues from the customer interface.

- *Revenue streams* describe how a company generates revenue. Revenue streams depend on the pricing model of the company (e.g. fixed pricing, volume dependent, or market dependent pricing, auction, or yield management). A common distinction seen in the literature defines revenue streams as models. For example, Amit and Zott (2001) defined a revenue model as*" the specific models in which a business model enables revenue generation."*
- *Cost structure* includes the operating costs of a business model and describes all the costs incurred from delivering and creating the value. Chesbrough and Rosenbloom (2002) considered further included profit potentials to cost structure.

2.1.3. Sustainable business model archetypes

Given the framework by Osterwalder and Pigneur (2010), scholars in the sustainability field generally highlight the four pillars from the business model canvas (i.e. *value proposition, business infrastructure, customer interface, and financial model)* as the most essential business model elements for sustainable development (Bocken et al., 2016; Boons et al., 2013; Geissdoerfer et al., 2018; Schaltegger et al., 2012). Literature generally depicts sustainable business models as extensions to traditional business models that involve environmental and social goals and concerns to business activities (Bohnsack, Pinkse, & Kolk, 2014; Evans et al., 2017; Joyce & Paquin, 2016). The diverse definitions underline the concern of benefitting all stakeholders rather than only customers and shareholders (e.g. Bocken et al., 2014; Evans, et al., 2017; Geissdoerfer et al., 2018; Schaltegger et al., 2016).

Furthermore, sustainable business models are often categorized in respect to their central sustainability goal and the related activities in order to specify the models in practice. Perhaps the most widely exploited approach for categorization is the archetype presentation by Bocken et al. (2014), displayed in Table 2. The researchers categorized sustainable business models to eight representative archetypes that *"categorize and explain business model innovations for sustainability and provide mechanisms to assist the innovation process for embedding sustainability".*

The archetypes seek to define a generic understanding of sustainable business models and provide a starting point for further research in sustainable business models. Several scholars have exploited the framework and further specified it in their research (Lüdeke-Freund et al., 2016; Ritala, Huotari, Bocken, Albareda, & Puumalainen, 2018). The researchers also underlined that companies should apply the archetypes as combinations to enable greater sustainability efforts.

The archetypes also demonstrate how sustainability is clearly more than just a technically focused challenge. The first three (i.e." *maximize material and energy efficiency", "create value from waste", and "substitute with renewables and natural processes"*) include clear technological orientation. However, the last five are more socially or organizationally oriented. Bocken et al. (2014) further specified that *"delivering functionality", "adopting a stewardship role*", and "*encouraging sufficiency"* include a social innovation component whereas*, "re-purposing the business"* and *"developing scale up solutions"* require organizational innovation.

Table 2: Sustainable business model archetypes by Bocken, et al. (2014).

Archetype	Description/examples
Maximize material and energy efficiency	*"Do more with fewer resources, generating less waste, emissions and pollution"* e.g. lean manufacturing, additive manufacturing, de-materialization of products and/or packaging
Create value from 'waste'	Eliminating waste by turning the waste-streams to useful input, e.g. industrial symbiosis
Substitute with renewables and natural processes	Using renewable energy sources, substituting with renewable resources, slow manufacturing, green chemistry
Deliver functionality, rather than ownership	Product Service Systems (PSS) use-oriented PSS-rental (e.g. car sharing), result-oriented PSS (e.g. Xerox document management, payment per print/copy)
Adopt a stewardship role	*"Proactively engaging with all stakeholder to ensure their long-term health and well-being",* e.g. fair trade, initiatives, biodiversity protection, choice editing by retailers, radical transparency about environmental impacts
Encourage sufficiency	Solutions to reduce consumption and production, such as consumer education, demand management, product longevity, frugal business
Re-purpose the business for society/environment	*"Prioritizing delivery of shareholder value rather than economic profit",* social enterprises with secondary profit motives, non-profit, or "*hybrid*" business models
Develop scale up solutions	Large scale solutions in order to maximize the shareholder value, e.g. franchising and collaborative approaches, such as peer-to-peer, open innovation platforms, and crowd sourcing

The archetypes require different levels of effort from organizations pursuing to improve their environmental and social performance. The business models focusing on technological efficiency are often easier to link to cost advantages and consequently, the sustainable activities of established companies thus far have focused on the efficiency focused business model archetypes (Boons & Lüdeke-Freund, 2013; Ritala et al., 2018). For example, recent studies of large global corporations (S&P 500) have indicated that almost 80% of these organizations' sustainability-oriented activities are technologically focused and classifiable under the environmental innovation archetypes: *"maximize material and energy efficiency", "create value from waste",* and *"substitute with renewables and natural processes* (Ritala et al., 2018). Whereas, the other five archetypes are rare and perceived as less viable.

2.1.4. Business model as a device

Behind the various approaches to reflect business models, researchers have identified a similar logic behind the distinct conceptualizations – business models enable companies to introduce novel innovations to market (Amit & Zott, 2012; Chesbrough, 2007a; Doganova & Eyquem-Renault, 2009). Many scholars have taken a pragmatic approach to business models and consider business models as devices that support the creation and commercialization of the innovations and mediate conflicts between successful market introduction and new innovations (Chesbrough & Rosenbloom, 2002; Doganova & Eyquem-Renault, 2009; Lüdeke-Freund, 2019). The business model as a device approach goes beyond presenting business model as a concept or a framework and assign additional function to business models that mediates between the innovations, different parts of the organizations and its business environment.

Academics recognize several advantages in interpreting business models in action answering the question *"what business models do"* rather than *"what business models are"* (Doganova & Eyquem-Renault, 2009; Osterwalder et al., 2005). For example, Doganova and Eyquem-Renault (2009) conceptualized "*business models as market devices"* that enable organizations to explore a market and introduce innovations to market. Similarly, Chesbrough and Rosenbloom (2002) described the business model as "*a focusing device that mediates between technology development and economic value creation"* and further argued the business model to mediate the challenges that innovations introduced to business.

In turn, business model innovation literature represents an example of an overlapping but slightly different approach to consider the business models' mediating function in innovation processes. The business model innovation approach comprises the mediating device approach in a way that it interprets business models as constructs which should be innovated to maintain competitive advantage in dynamic markets (Bocken et al., 2016; Chesbrough, 2010; Johnson et al., 2008).

Business model innovation as such, has gained its own share of disagreement in definitions and qualifications. Business model innovations are generally depicted to occur in three ways (Amit & Zott, 2012):

1.) As a new *"**activity system content**"* i.e. eliminating and adding novel activities to be performed
2.) As a new *"**activity system structure**"* i.e. novel ways of linking the activities
3.) As a new *"**activity system governance**."* i.e. changing one or more parties that perform any of the activities (e.g. franchising)

Furthermore, the creation of entirely new separate business models accounts for business model innovation in the literature (Amit & Zott, 2012; Sosna, et. al., 2010; Geissdoerfer, et al., 2018). Thus, the form of business model innovation is dependent on the business contexts. For instance, in the context of a start-up, business model innovation always refers to creation of entirely new business model. Accordingly, in the context of incumbent companies, business model innovation can refer to mediating or entirely reconfiguring changes in the established business model, or creation of an entirely new model as a parallel addition to the established one. Geissdoerfer, et al., (2018) clarified the difference by categorizing business model innovation to four innovation types:

1. **Start-ups**, i.e. *new business model is created*
2. **Transformation**, i.e. *a current business model is changed into another one*
3. **Diversification**, i.e. *the current business model stays in place and an additional business model is created*
4. and **Acquisitions**, i.e. *additional business model is identified and acquired*

Despite the lack of agreement and clarity in the field of business model innovation, researchers suggest that in order to maintain competitiveness in markets, companies need to be capable of dynamically reacting to markets with their business models (Teece, 2007), and that all innovations (whether technical or product-oriented) require companies to make at least conforming changes in business models to ensure a successful implementation of the innovation (Amit & Zott, 2012; Chesbrough, 2007b; Zott et al., 2011). The stream of literature conceptualizing business models as mediating devices follow the same underlying logic and strongly overlaps with business model innovation literature (Doganova & Eyquem-Renault, 2009). Considering business models as mediating devices offers a pragmatic approach to business models to focus on business models performative role in innovation process of a company.

Even though scholars identify adaptation of novel business models as a key approach to overcome the issues related to innovations and to support successful market introduction of innovations, recognizing the mediating function of business models is yet not common in the field of sustainable development (Lüdeke-Freund, 2019). The literature has strongly focused on business model innovation as a key approach. For example, Boons and Lüdeke-Freund (2013) defined *sustainable business model innovation* as:

"the adaption of the business model to overcome barriers within the company and its environment to market sustainable process, product, or service innovations",

which entails the idea of seeing business model in action and is hardly distinguishable from the underlying logic of considering business model as a mediating device. Drawing on the literature that recognizes business models as devices provides an opportunity to

fill in various research gaps found in the sustainable innovation and business model literature, including the lack of research focusing on *"implementation of business model innovation processes, its tools and challenges*" (Geissdoerfer et al., 2018).

2.2. Creating sustainable business models

Sustainability oriented innovations have received increasing attention over the past 20 years (Boons & Lüdeke-Freund, 2013; Lüdeke-Freund, 2019; Smith, 2006). Scholars have anticipated that environmental activities will become only a side effect of pure economic rationality in the future as sustainable technologies, regulations, and consumer behaviors evolve (Amit & Zott, 2012; Clark & Charter, 2007). However, the current business environments are not sustainability oriented and make it difficult for companies to reflect sustainability with financial performance. In addition, researchers have further recognized several challenges and additional requirements that sustainable innovations introduce to companies in todays' economically driven business environments (Lüdeke-Freund et al., 2016).

2.2.1. Conditions for sustainable development

Literature commonly recognizes business models as concepts that are defined against the specific conditions and business environments (Teece, 2010; Osterwalder & Pigneur, 2010) and thus, require particular conditions for viability in the business environment (Boons & Mendoza, 2010; Hoppmann, Huenteler, & Girod, 2014; Iles & Martin, 2013). Moreover, scholars suggest that in order to advance the social and environmental performance of a company, organizations need to understand under which conditions they are acting, and under which conditions their actions actually benefit the society (Margolis & Walsh, 2003). Consequently, more than the issues related to business viability and financial performance of sustainability innovations, sustainable business models present an additional challenge for companies to understand how the different sustainability innovations impact the society and environment in their own context (Boons et al., 2013; Stubbs & Cocklin, 2008).

Lüdeke-Freund et al. (2016) demonstrated three overlapping dimensions of the environment that enable sustainable business model innovation to become profitable:

- *Micro conditions, i.e. the organizational models underlying business models*
- *Meso conditions, i.e. the structure of an industry's value chain/network*
- *Macro conditions, i.e. the institutional and socio-political arrangements*

The conditions introduce a variety of barriers for companies deploying the sustainable business model and define the viability of the created model. Regardless of how desirable the sustainable innovation is and how well a company can align its business model with it, companies flounder with the disadvantages related to system incompatibilities, cultural barriers, and several other factors affecting competitive capabilities of the company.

Stubbs and Cocklin (2008) summarized the idea by demonstrating the sustainable business model as a system-level construct that requires participation from all industry stakeholders, and strongly linked firm-level sustainability with its external socio-economic environment. These researchers claimed that a company achieves firm-level sustainability by developing its internal structural and cultural capabilities, and system-level sustainability by building collaboration with the key stakeholders. Following sections briefly introduces the three different conditions and the barriers related to them.

Micro conditions

Micro conditions reflect the certain organizational traits, such as organizational structure, identity, culture, and values that all business models are built on (Lüdeke-Freund et al., 2016; Stubbs & Cocklin, 2008). The micro conditions set up the core logic for value creating and capturing activities and thus, play a central role when established organizations are pursuing to renew their business model (Lüdeke-Freund et al., 2016; Massa et al., 2017).

Preliminary studies regarding organizational traits have suggested company values, business guidelines, deployed performance metrics, and behavioral norms can critically inhibit sustainable innovation (Johnson et al., 2008; Boons & Lüdeke-Freund, 2013). Short termism (i.e. pressure on short term results) is among the most commonly discussed issues that organizational traits introduce for sustainable innovations, since new sustainable business models most often require long-term effort and rarely generate financial gains in the short-term (Lüdeke-Freund, et al., 2016). When the core logic for value creation and strategic orientation of a company is focused around economic success, managers are likely to resist disruptive innovations that might threaten the current systems that is ongoingly capturing value for the company.

Particularly large established firms have been recognized as being resistant towards radical innovations and likely to pursue innovations that are align with the current company structures, competences, and capabilities (Danneels, 2002; Schaltegger & Wagner, 2011; Smith, 2006). Incumbent companies have a tendency to develop business models of increasing stability that become inelastic for change (Johnson et al., 2008; Zott et al., 2011). Complex business model structures, interdependencies, and various lock-in effects resulted from previous business model designs make the introduction of new sustainability considerations a difficult task for the companies (Sosna et al., 2010). Disruptive innovations often require reallocation of resources which can cause tensions within the organizations or have a cannibalizing effect in current business (Zott et al., 2011). Consequently, majority of the existing examples of radical business model innovations in the literature have been established by entrepreneurs, whereas incumbent companies have concentrated on incremental improvements that are not disrupting the existing systems (Schaltegger & Wagner, 2011; Smith, 2006; Boons et al., 2013). Preliminary findings have considered micro conditions as a central issue in innovation processes and there exist an extensive amount of more detailed research dealing with innovative organizational cultures and hierarchical structures that are limiting innovations and leading to resistance and inertia (Sawhney, Walcott Robert, & Arroniz Inigo, 2006).

Meso conditions

Meso conditions refer to the structure of the industry value chain network (Lüdeke-Freund et al., 2016). The structure of the industry value chain, entailing the roles, objectives, relationships, and assets of actors operating in the value chain, has a major influence on the viability and profitability of new innovations (Jacobides, Knudsen, & Augier, 2006).

Particularly in the field of sustainable development, studies have pointed out the importance of considering a variety of industry actors who are involved directly or indirectly to innovations and understanding their interests related to the sustainable innovations (Boons & Lüdeke-Freund, 2013). Creating sustainable business models usually requires extending stakeholder mapping as indirect stakeholders may have a strong power to block a business model innovation (Stubbs & Cocklin, 2008). Larger incumbents attempting to disrupt the current systems can face resistance from upstream and downstream actors while it is simultaneously difficult for new entrepreneurs to scale up sustainable innovations.

Furthermore, preliminary studies have suggested that a company in a young industry is more capable of operating flexibly than a company in long-established mature industry

as the value networks and industry structures are not as complex (Amit & Zott, 2012). Mature markets have a tendency to develop robust and complex value networks with only few dominant actors which makes it difficult for companies to introduce new innovations to market (Jacobides et al., 2006). Studies by Teece (1986) have offered one of the core contributions in the field of investigating how different industry conditions have an impact on innovations. He claims that in order to keep capturing value with the innovation, the innovator needs to have the ability to govern their own capabilities related to value capture, and aim to achieve control over the capabilities related to third-party services and expertise, such as marketing, manufacturing, and software. The ability to generate profits from the innovation is dependent on developing dominant design, gaining control and access to complementary assets and securing the knowledge and technologies required to produce the innovation. Consequently, the company's position, power, and role in the industry value chain has a major effect on the profitability of the innovations developed.

More recently, Jacobides et al. (2006) has contributed to Teece's framework and extended the study by comprehensively addressing the issues regarding industry architectures. According to these authors, industry structures are shaped by great variety of players and structures emerge through collaborative trial-and-error processes. Individual companies aim to shape the industry sectors in a way that it restricts mobility, entry, and competition in its own segment while encouraging competition in its complementary activities. Jacobides et al. (2006) claimed that *"The basic idea is to identify a structure of the sector where the firm has one key strength, and then use this strength as a foot in the door to gain architectural dominance"*.

Consequently, in mature markets, in which many players have aimed to gain architectural dominance and have developed alliances and collaboration for years, new entrants and smaller players have poor capabilities to have a sustainability impact on the industry architectures and profit with sustainable innovations. In case an innovation is successfully commercialized, the innovating companies often fail to obtain profits from their innovations, as the dominant actors in the value chain having the ability to advantage complementary activities or imitate the innovations will deprive the benefits (Teece, 1986). The sustainability of the innovation tends to be dependent on engagement of other industry actors, and in case the other actors, particularly the dominant ones, are not sustainability oriented, they may have a crucial impact on the final sustainability improvements of the innovations (Lüdeke-Freund et al., 2016).

Macro conditions

Macro conditions reflect the social norms, customs, policies, mindsets, regulations, and other socio-political arrangements and routines of the specific context in which the business models are deployed (Lüdeke-Freund et al., 2016). Preliminary findings suggest that macro conditions frame the meaning of sustainability itself, and consequently, challenges companies to define in what respect their innovations are sustainable in different business environments. Furthermore, the macro conditions are highlighted in the sustainability development research as the viability of innovations is strongly linked to the conditions which can either promote sustainable innovations or introduce major obstacles (Schaltegger et al., 2016, Bocken et al., 2014; Geissdoerfer et al., 2018).

Literature has widely recognized the role of public policy makers to support sustainable development (e.g. financing and tariffs) while straining unsustainable dominant designs and framing the context specific meaning for sustainability itself (Hoppmann et al., 2014; Lüdeke-Freund, 2013; Smith, 2006; Stubbs & Cocklin, 2008). Boons et al. (2013) investigated the impact of macro conditions on sustainability and found the criteria for sustainable performance to be "*spatially, temporally, and culturally embedded"*. They claimed that the notion of sustainability itself has various meanings in different contexts and thus, companies are challenged to consider how novel sustainable business models will relate to different business environments.

Furthermore, prior literature has argued that consistent government support for sustainable innovation strongly supports innovation activities and stimulates the growth of sustainable industries (Hoppmann et al., 2014). The eco-innovation market is expected to grow which has motivated governments to promote policies enabling sustainable economic development to improve their competitive stance by creating markets for sustainable innovations (Boons et al., 2013). Public policy makers' role is more than mere regulation, the policies are needed to support sustainable development (Bolton & Hannon, 2016). German feed-in tariff (FIT) system has served as an example of an effective policy making for sustainable development (Hoppmann et al., 2014). The FIT policy mechanisms, which granted a fixed price for power producers in Germany, successfully stimulated the use of renewable energy technologies. In turn, previous studies suggest consumer intention to purchase to be a function of customer segment and public policies to have a major impact on consumer mind-set and attitudes towards sustainability which in turn have an influence on consumer's intention to purchase sustainable products (Lüdeke-Freund et al., 2016; Maloney, Lee, Jackson, & Miller-Spillman, 2014).

2.2.2. Parallel business model implementation to drive sustainability

Subscribing the interpretation of a business model that operates dynamically in its external conditions has led researchers to devote attention towards simultaneously competing several business models (Markides, 2013). In the beginning of developing novel business models, forerunners have to make educated guesses as to what the actual customer needs are and how the revenue streams are associated with different ways of forming and organizing activities (Teece, 2010). Consequently, companies rarely are eager to radically transform established business models. Instead, disruptive business model innovations mostly occur in the form of business model diversifications or business model acquisitions (Bucherer et al., 2012; Geissdoerfer et al., 2018; Markides, 2013). Expanding business model portfolios through first acquiring smaller companies or start-ups is relatively common among large established companies, since smaller actors tend to be more agile and eager to disruptively design and innovate sustainable business models (Lüdeke-Freund et al., 2016; Ritala et al., 2018).

Furthermore, deploying a new business model in parallel helps established companies to mitigate the risks related to renewing the previous model and *"test-drive"* them in their own separate unit (Bucherer et al., 2012; Sosna et al., 2010). Utilizing separate business models can be beneficial for companies, since it enables companies to serve the original markets while making efforts to new emerging markets. Previous research in the field has demonstrated some examples of companies leveraging parallel implementation in business model renewal. For example, a five-year case study of by Sosna et al. (2010) analyzing the organizational learning process behind the process of innovating the business model in the context of dietary product market found parallel implementation as an efficient way to innovate business models in mature markets and demonstrated the implementation as a stage-process. The process was divided to *exploration* in which the initial business model is designed, tested, and developed and *exploitation* in which the viable business model is scaled up and integrated into routines, processes, systems, company culture, and decision-making. Similarly, in context of technology companies, Chesbrough (2007b) demonstrated how different companies have succeeded to bring new innovations into market by first, experimenting new technologies and collaborating with external partners and second, scaling up the suitable model. Chesbrough highlighted the value of open business models that experiment new technologies and ideas in internal product development and allow intellectual property to be commercialized externally.

While the idea of mitigating risks through dual business models may seem attractive, it raises several issues for companies to consider and has evolved to a contested topic in the

literature (Massa et al., 2017; Porter, 1996). Porter (1996) argued that managing multiple conflicting strategies creates inevitable tradeoffs related to reputation, activities, and positioning. When a company is not capable of choosing *"what not to pursue",* the compromises in strategic direction will eat away the previously established competitive advantage by, for example, confusing the customers and reducing the company's credibility. In line with Porter's view, research in the field of business model innovation has recognized that managing incompatible business models can be challenging and lead to trade-offs, especially in the cases in which the value chains of the business models are conflicting (Gibson & Birkinshaw, 2004). The emergence of many conflicts such as issues related to reconfiguring processes and reallocating resources for new business models is probable as the novel models are scaled up (Chesbrough, 2010; Tushman & O'Reilly III, 1996; Zott et al., 2011).

In turn, studies have recognized several advantages in framing the issue of simultaneously managing multiple business models as an "*ambidexterity*" challenge (Markides, 2013). The relatively novel stream of literature investigating "*organizational ambidexterity*", i.e. *"company's ability to pursue two disparate things at the same time"* (Gibson & Birkinshaw, 2004) or more specifically, *"company's ability to simultaneously pursue both incremental and discontinuous innovation results from hosting multiple contradictory structures, processes and cultures"* (Tushman & O'Reilly III, 1996) argues against strict separation of business units and emphasizes collaboration and synergies between separated business units. Although separated units may facilitate faster change and give space for ventures to develop, scholars suggest that units have to be linked through several integrative mechanisms in order to ensure sufficient conditions for future integration.

Markides (2013) suggested that ambidexterity literature can guide researchers also in the business model field, since the literature has defined an overwhelming number of actual mechanisms for companies to manage conflicting demands and elaborated the dependencies between activities and the business environment. Markides demonstrated how the level of integrative mechanisms and level of flexibility in business models is a function of the environment. Dynamic environments require more differentiation and flexibility in business models in order to cope with a flow of opportunities whereas less dynamic environments favor efficiency which requires more structure.

2.2.3. Challenges for creating sustainable business models

Extant literature commonly recognizes the challenges related to creating environmental and social benefits by deploying sustainable business models to be linked to poor economic performance (Schaltegger et al., 2012; Stubbs & Cocklin, 2008). Prior research suggest that companies' strategic orientation tend to focus around economic success and thus, companies often resist sustainable innovations which require long-term efforts and reallocation of resources (Hubbard, 2009; Ritala et al., 2018). Furthermore, rather than focusing on the potential economic disadvantages, recent literature has been able to further point out several challenges related to creating sustainable business models (Evans et al., 2017). Sustainable business models are intrinsically challenging to develop and deploy as the innovations entail specific and problematic characteristics which require additional efforts from the innovating organizations (Boons & Lüdeke-Freund, 2013).

The intrinsic challenges of sustainable innovations have suggested to result from the *"radicalness"* and *"systemness*" of sustainable innovations (Boons et al., 2013). The *"systemness"* concerns the major role of wider socio-technical systems in a company's attempts to sustainably innovate. As increasing sustainability requires system-level changes, companies have to thoroughly consider how the changes are connected to wider systems and how they can influence on environmental and social development (Boons & Lüdeke-Freund, 2013; Clark & Charter, 2007). The *"radicalness"* reflects the widely recognized argument that even though incremental innovations can allow even quite prominent sustainability improvements, mere incremental product and technical improvements are not capable of leading to optimization of wider systems (Schaltegger & Wagner, 2011). Several issues for creating sustainable business models that result from the nature of sustainable innovation, including the "*radicalness"* and "*systemness",* were recognized in this literature review. These challenges were categorized to four key challenges for creating and deploying sustainable business models displayed in Table 3.

First, as academics define sustainable value to integrate environmental, social, and economic value creation, research has addressed the issue of simultaneously creating and balancing among this "*triple-bottom-line*" (Evans et al., 2017; Schaltegger & Synnestvedt, 2002; Stubbs & Cocklin, 2008). Prior research widely concerns sustainable innovations to primarily challenge the financial performance of an organization (Margolis & Walsh, 2003). In addition to the economic disadvantages that the innovations may introduce, also the tradeoffs between environmental and social performance can create significant barriers for companies to create sustainable business models. The final outcome of sustainable innovations is often difficult to entirely anticipate as the meaning of sustainability is dependent on the changing business environments (Boons et al., 2013).

Table 3: Challenges for creating sustainable business models.

Challenge	Description	Authors (Year)
Co-creation of environmental, social and economic value	Simultaneously creating social, environmental and economic benefit, and balancing among the "*triple-bottom-line"* is a complex task and the actual outcomes in terms of sustainability are difficult to anticipate.	Schaltegger et al. (2012), Stubbs & Cocklin (2008), Smith (2006), Iles & Martin (2013)
Engagement with stakeholders	The involvement of different actors in the company value network and extensive interaction between external stakeholders requires additional efforts and new ways of working.	Stubbs & Cocklin (2008), Boons & Lüdeke-Freund (2013)
Initially niche innovations	Technological regimes and dominant designs are not sustainably driven and thus, sustainable innovations are often complex to integrate into business. The innovations are initially developed in niches and targeted to small nascent markets which are not as attractive for larger organizations.	Boons, et al. (2013), Smith (2006) Schaltegger & Wagner (2011), Lüdeke-Freund (2019)
Lack of methods to measure sustainability	The current frameworks and guidelines are rarely sustainably driven and the lack of standard measures and methods to evaluate the sustainability of the sustainable business model and the related supply chain is challenging.	Schaltegger & Burritt (2014), Hubbard (2009), Evans et al. (2017)

Second, whereas companies often have a tendency to prefer operating autonomously and driving their own performance and competitiveness in industries, creating sustainable business requires consideration of wider range of stakeholders (Evans et al., 2017). Creating sustainable business models requires extensive communication throughout the value chain and reconfiguration of the relationships with stakeholders while strongly connecting business processes and long-term value creation (Adams et al., 2016; Schaltegger & Burritt, 2014). Furthermore, successfully creating environmental and social benefit to society requires extensive interaction with societal actors and downstream entities to anticipate the actual sustainability outcomes (Hoppmann et al., 2014; Schaltegger & Wagner, 2011, Iles & Martin, 2013; Boons & Lüdeke-Freund, 2013).

Third, as a direct result of the radicalness of sustainable innovations, the technologies are usually complex to integrate into existing business and are thus initially developed in niches (Lüdeke-Freund, 2019). New-to-market innovations that are disruptive for both producers and consumers rarely have a strong lead user base (Boons et al., 2013). As a result, the risky innovations are initially targeted to smaller niche markets and do not attract larger companies before achieving a strong lead user base and growing into potential future threats (Smith, 2006). In turn, changing technological regimes requires power and resources from the innovating companies to scale-up the developed innovations. Consequently, mainstream market actors have contributed to sustainability innovations with a common pattern: large incumbents enter the nascent market after the innovations by smaller actors have achieved a strong lead-user base and have become a threat for the organizations. The pattern can delay changes when larger companies buy-off the competitors or dispel entrepreneurs as their innovations may be imitated and scaled-up by larger companies. However, incumbents can also support the sustainable development by, for example, helping entrepreneurs to scale-up their innovations. For instance, organic foods industry originated amongst niche activist trying for decades to make the case for organic food (Smith, 2006). After an additional twenty years of pioneering organic producers shaping the market, the niche market started to grow significantly as the mainstream actors entered the market. Similarly, car sharing in Germany was originally initiated by smaller start-ups before larger incumbent firms, such as Deutsche Bahn, integrated the new system into its business and started to offer car sharing solutions (Schaltegger & Wagner, 2011).

Fourth, the existing business modeling frameworks are not sustainability-driven, and there does not exist a commonly accepted standards for measuring the sustainability performance of a company (Lüdeke-Freund, 2013; Lüdeke-Freund, et al., 2016; Evans, et al., 2017). The current business models are primarily concerned with the economic performance of a company and often focus on short-term profits (Geissdoerfer et al., 2018). In contrast, sustainably oriented business model frameworks should be long-term oriented and focus on value creation for wider range of stakeholders (Schaltegger & Burritt, 2014). The systemness of sustainability, and the environmental and social consideration adds the complexity of measurement options, and challenges companies to define an appropriate scope and methods for measuring sustainability performance. Most notably, the systemness of sustainability requires companies to also consider the role and connection of the network of actors in the sustainable value creation process (Hubbard, 2009). The systemic approach to measuring sustainability is intrinsically complex, as it requires a continuity of measuring sustainability performance, defining all actors that are directly and potentially indirectly involved, and collaborating and sharing information between these actors. Despite a variety of scandals reported in the international media,

regarding, for example, child work or water scarcity, the existing research pays little attention towards how sustainable performance of supply chains should be managed (Schaltegger & Burritt, 2014). Furthermore, the extensively broad scope for sustainability measuring simultaneously generates confusion among companies, supply chains, and consumers, and allows companies to choose measures in a manner that puts the company in better light in terms of social responsibility to mislead consumers (Hubbard, 2009; Evans et al., 2017).

2.2.4. Sustainable business case drivers

Sustainable business case drivers refer to "*the links between voluntary sustainability activities and economic success"* (Schaltegger et al., 2012). Prior research has described a wide range of business case drivers that have direct or indirect influence on business performance. Nevertheless, the literature demonstrates how the motivation towards sustainability activities primarily arises from the so called *"event-driven*" drivers that are related to cost-efficiencies and legislation (Lüdeke-Freund et al., 2016; Schaltegger et al., 2012). These activities focus on nondisruptive improvements which rarely introduce any of the challenges for driving sustainability into business models presented in the previous section. Particularly, the majority of sustainability initiatives by large established companies have been directed to incremental innovations, which share a direct link to cost savings or subsidies (Ritala et al., 2018). Companies can recognize the novel activities, such as deploying cleaner technologies or reducing material flows, as strategic moves that automatically save costs while promoting legitimacy.

A growing number of academics have started to focus on the role of business models and its relation to innovation success (Boons et al., 2013; Boons & Lüdeke-Freund, 2013; Lüdeke-Freund, 2019). This research is based on the assumption that sustainable innovations will create the most economic, ecological, and social value when business models are actively managed, and when the specific features of business model support the market introduction of the sustainable innovations (Boons et al., 2013; Lüdeke-Freund, 2019; Schaltegger et al., 2012; Schaltegger et al., 2016). Scholars have suggested that mapping the links between business models and successful business cases for sustainability is beneficial in order to move from single business case for sustainability to complete business model for sustainability (Schaltegger et al., 2012). Whether the initial advantages of the innovations are event-driven or not, aligning the company business model with the innovation will promote more success drivers for business cases coming into being (Chesbrough, 2010; Schaltegger & Wagner, 2011).

Schaltegger et al. (2012) conducted a detailed research on business case drivers and provided comprehensive descriptions of the interrelations between business model elements and the business case drivers. These scholars categorized the advantages into four direct drivers, including *cost reductions, risk reductions, sales and profit margins, and reputation,* and into two indirect drivers, including *attractiveness as an employer* and *capability to innovate.* By depicting the business models through four pillars, value proposition, business infrastructure, customer interface, and financial model, Schaltegger et al. (2012) provided a mapping of the links between the drivers and the business models. They pointed out various examples of potential interrelations between the drivers and the four pillars, i.e. described potential ways how sustainable innovations translated, for instance, into increased sales and profit margins, reduced risks, or into reputation.

Recent studies have found the mapping by Schaltegger et al. (2012) beneficial to understand these interrelations between business model and business case drivers, and argued that companies should comprehensively consider these links in order to successfully create sustainable business models (Bocken et al., 2016; Boons et al., 2013; Lüdeke-Freund, 2019). Understanding the links provides a foundation for improving the overall sustainable business model performance and promotes more competitive advantages than focusing on single and event-driven business cases for sustainability.

Lüdeke-Freund (2019) specified the idea by proposing a business model for sustainability innovation (BMfSI) -framework presented in Figure 3. Lüdeke-Freund argued that whereas sustainability innovations motivate novel business models to enter and diffuse to market, business model creates an additional competitive advantage for companies deploying the innovations. The first arrow between the sustainable innovation and business model illustrates the interrelation between the challenges and objectives of the sustainable innovations and the established business model of a company. The second relationship presents the business cases as the outcomes of business model that has been aligned as a result from the aforementioned relationship. In line with Schaltegger et al. (2012), Lüdecke-Freund (2019) suggested that the drivers are more likely to come into being when business models are actively managed and adjusted in respect to the focal sustainable innovations.

Figure 3: The initial framework for business model for sustainability innovation by Lüdeke-Freund (2019)

2.3. Theoretical synthesis

This literature review has outlined the conceptual background for this thesis. The first chapter introduced the sustainable business model concept and provided an understanding of the primary unit of analysis – the business model of a company. The focus was to gain an overview of the relationship between business model and sustainable innovations. Particularly, the previous literature regarding sustainability of a business model (e.g. Bocken et al., 2014; Boons & Lüdeke-Freund, 2013; Stubbs & Cocklin, 2008) and the business model as a device approach (e.g. Chesbrough & Rosenbloom, 2002; Doganova & Eyquem-Renault, 2009; Lüdeke-Freund, 2019) were of central interest in the first part of the review. This provided a foundation for reflecting sustainable transition of a company by exploiting the business model as a lens to analyze how the long-term sustainability goals of the companies is linked to current activities.

The second chapter reviewed the body of literature regarding the adoption of sustainable innovations and transformation in companies through the lens of sustainable business models. The chapter addressed the question of how companies can exploit sustainable business models to overcome the barriers related to commercializing sustainable innovations. Previous research regarding challenges (e.g. Evans et al., 2017; Lüdeke-Freund, 2019; Schaltegger & Burritt, 2014) and drivers (e.g. Schaltegger et al., 2012) related to sustainable innovation was reviewed to provide a theoretical basis for making assumptions regarding how the potential barriers to commercialize sustainable innovations are realized in the study context.

Collectively, the reviews form a logical view around the relevant concepts and constitute a theoretical framework, displayed in Figure 4, to guide the empirical part of this study. The framework adopts the business model as device approach and comprises various interrelations between business models, and sustainable innovations and business environment.

The rationale of the framework can be described under two assumptions. First, the definitions for business models may vary but in general, literature seems to agree that in its essence business models describe how companies create, deliver, and capture value (Zott et al., 2011), and with different distinctions for this interpretation, business models are widely recognized to comprise the companies' value proposition, business infrastructure, customer interface, and financial model (Osterwalder & Pigneur, 2010). Second, actively managing and renewing the business model will foster economic success with sustainable innovations while increasing environmental and social performance in rapidly changing business environments (Bocken et al., 2014; Chesbrough &

Rosenbloom, 2002; Schaltegger et al., 2012). In the context of deploying sustainable innovations into established systems, the business model of a company is depicted as a device that supports the successful commercialization of new innovations and compensates for the possible disadvantages resulting from the innovations (Chesbrough & Rosenbloom, 2002; Doganova & Eyquem-Renault, 2009; Lüdeke-Freund, 2019; Schaltegger et al., 2012). The novel business model is usually implemented in parallel to existing business systems in order to simultaneously contribute to existing revenues and profits of the established business model (Bucherer et al., 2012; Johnson et al., 2008; Sosna et al., 2010).

By adapting these assumptions, this rest of this thesis focuses on analyzing the conventional and novel business model structures and value chain networks in the plastics industry context. The theoretical framework provides a foundation for understanding how the sustainable plastic innovations relate to existing business models and systems, and how the novel models support the commercialization of sustainable plastic innovations and promote business case for sustainability.

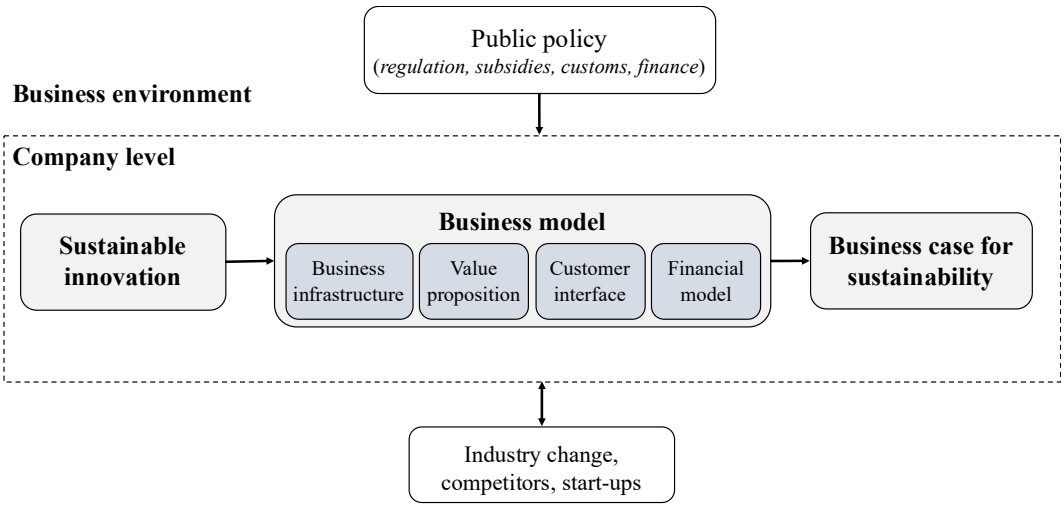

Figure 4: The theoretical framework

3. Methodology

This chapter outlines the details and rationale for research methodology. First, a reasoning for the chosen research approach of multi-case study is provided and the research procedure is described. Then, the data collection and analysis processes are presented, and the evaluation of the reliability and validity of the research procedure is analyzed.

3.1. Research approach and case selection

This study adopted a qualitative research approach to analyze how disruptive sustainable business models for commercializing renewable and circular plastic innovations are deployed to create successful business cases. The selection of the case method was primarily guided by the characteristics of the research questions. Case studies are preferred when 1) the questions concerned are answering to descriptive or explanatory questions focusing on a contemporary phenomenon within its real-life context, 2) when the boundaries between the phenomenon and the context are unclear and 3) when the researcher does not have control over the studied phenomenon (Swanborn, 2010; Yin, 2009). As the research questions posed in chapter 1.2 concern the phenomenon of business model transformation within the plastic industry context, asking *"what"* and *"how"* questions, the case study is an appropriate research strategy.

With a case study approach, the first decision regarding the research design concerns the decision between single and multiple cases. Rather than focusing on a single case, I purposefully selected a multiple case approach in order to gain a more comprehensive insight into the studied phenomenon. Multiple case studies are generally considered as a more appropriate approach to shed a light on the impact of particular factors on focal phenomenon, unless the research objective is an unusual expression of the studied phenomenon (Eisenhardt, 1989). Multiple cases give more reliable results as they allow following replication logic in which the cases are sampled to predict similar (*literal replication)* or contrasting (*theoretical replication)* results for predictable reasons (Yin, 2009).

The objective was to analyze how individual companies can commercialize renewable and circular plastic innovations. Thus, it was necessary that the analyzed companies had the strategic goal to supply renewable and circular solutions to plastic market and preferably already had launched some novel technologies and offerings to market.

Several companies in the plastic industry were identified as filling these criteria and considered for the research. Furthermore, the lack of empirical research on large established companies sustainably innovating their business models motivated the selection to focus on larger companies, with particular focus on companies operating in the area of raw material refinement and plastics production.

Initially, the case sample was narrowed down to three large multinational companies from the raw material production side of the plastic industry value chain, including an oil refining, petrochemical, and a paper and pulp company. The three cases, their business portfolios and renewal strategies were comprehensively analyzed and initial interviews in each case company were conducted. After the initial phase, the strategies and techniques to innovate and deploy business model were reviewed, and the research orientation was specified. In particular, the point of interest was to understand the practical ramifications of the transformation towards bioeconomy and circular economy -based business models and to recognize the barriers and drivers of transformation. Hence, the paper and pulp company was omitted from the sample as the primary business model of the company was bio-based to begin with, and the study sample was narrowed to include the oil refining and the petrochemical company (for detailed descriptions of the case companies, see chapter 4.1).

3.2. Research process

The applied replication approach to multiple case studies adapted from Yin (2003) is illustrated in Figure 5. The case study began with define and design phase in which the objectives for the research were chosen based on the understanding of the contemporary challenges in the research context. The research objectives and questions were defined in an iterative manner, as the understanding of the current state of literature and the existing research gaps accumulated along reviewing the literature. Lastly, based on the literature review, the theoretical framework to guide the empirical part of the research was developed.

After the theoretical framework and research questions were formulated, potential cases were evaluated and selected, and the data collection protocol was designed. The initial cases were selected based on their suitability to research objectives as elaborated in the previous chapter. I chose to utilize interviews as the primary data source for the study and designed an initial interview structure (Appendix 2) to guide the first round of interviews.

After the initial phase of the research and narrowing down the cases as described, the empirical data collection continued in two cases. All interviews in were conducted in April 2020. The data was collected and analyzed in an iterative manner as more interviews and archival data was collected. The first-order concepts from the interview data were identified and complementary data primarily from companies' annual reports, media releases and websites were collected. Finally, the data analysis proceeded in steps iterating between insights from the empirical data and existing literature. The following sections describe the data collection and analysis phases in more detail.

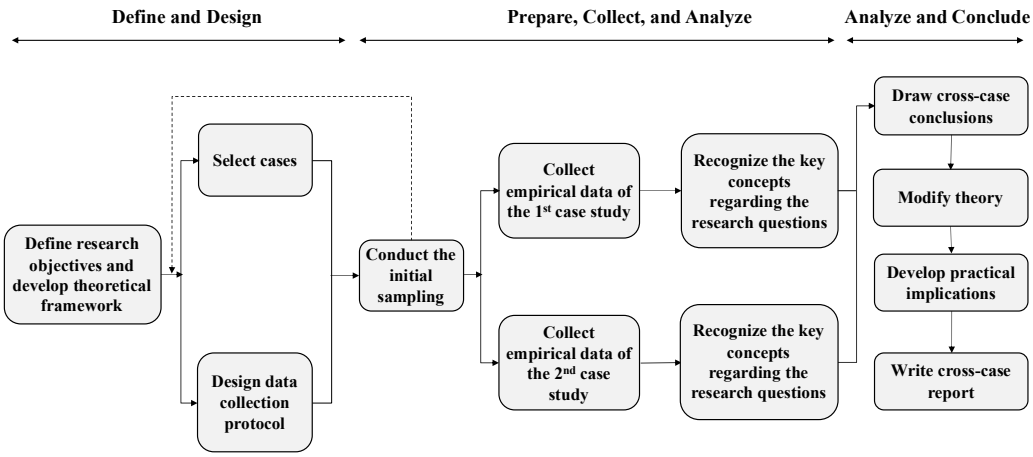

Figure 5: Case study approach: the replication process adapted from Yin (2003).

3.2.1. Data collection

Data collection was carried out through semi-structured interviews which the interview focus areas varied based on interviewees knowledge area (see Table 4). An interview guide (Appendix 2) was utilized as the basis of the interviews. Due to exceptional circumstances[1], the interviews were conducted through video calls. All interviews were audio-recorded which allowed to transcribe the interviews later on and most importantly, allowed the interviewers to focus on listening and asking. A total of five interviews were conducted, including three informants from each case company. Each interview involved

[1] At the time of the interviews, CoVid-19 outbreak was requiring research and work to be conducted remotely.

one or two informants and ranged from 50 to 90 minutes with an average duration of approximately 65 minutes, and a total of 5 hours and 25 minutes. The description of the informant roles and the acronym representing the specific informant and the company (A or B) are provided the Table 4. The acronyms are utilized in the following sections when interview quotes are provided. The chosen interviewees included technical experts and innovation managers from both companies. The Case A informant A3 was interviewed twice in order to ask additional questions, and the interview for informant A1 was a secondary interview.

Table 4: List of the interviews, the informant roles and the sources of archival data.

Interviews		**Archival data**	
Acronym	**Informant Role**	**Sources**	**Pages**
A1	Technology expert & project manager	Annual reports	1585
A2	Head of technology commercialization	Media releases	218
A3	Business development manager	Company websites	
B1	Innovation & licensing manager		
B2	Application technology manager		
B3	Head manager of innovation		
Total duration: 5 h 25 min			

Furthermore, a range of empirical data that improved our understanding of the context of each company was collected from annual reports, media releases, and company websites. The empirical data for the research including the description of the interviews and archival data are provided in Table 4. The comprehensively reviewed company archival data entailed combined annual reports between 2016 and 2019 (i.e. the years in which the companies had pursued growth in renewable and circular plastic markets) from both companies equal to 1585 pages of company reporting. In addition, the company websites and approximately 218 pages of media releases were reviewed in detail.

3.2.2. Data analysis

Clearly defining the unit of analysis for the study allows researcher to position the study to a broader body of knowledge and to define the contribution made (Yin, 2009). In the case studies, I investigated how the established business models relate to the involvement of renewable and circular plastic solutions in company business, and how the novel business models function for commercializing the novel technologies and products.

Hence, the unit of analysis for this thesis is the business model of each company. Business model is investigated as a mediating device that comprises value proposition, business infrastructure, customer interface, and financial model.

The data analysis was conducted under the principle of cross-case synthesis. In cross-case synthesis technique, the findings for each case are first collected separately and then aggregated and compared to other cases which reveals similarities and differences across the cases (Eisenhardt, 1989). The analysis followed a relatively structured format guided by the theoretical framework and the research questions. The process started with a full transcription of each interview and a careful reviewing of the material. This was followed by a thematic analysis that was divided into two parts, the first part focusing on the first research question, and the second part focusing on the second and third research questions.

In the first part of data analysis, I focused on the challenges of commercializing renewable and circular plastics. The challenges were coded based on the categorization for sustainable business model creation challenges elaborated in the literature review (see section 2.2.3). A wide range of challenges were identified, and the identified key challenges were further complemented with archival data. The empirical findings were further refined and categorized, by iterating between the insights from the empirical data and existing literature (see Table 7).

In the second part, the analysis focused on identifying elements of the novel business models for renewable and circular plastic solutions, as well as their deployment and role in the company. This part followed an inductive process in which the findings emerged from the data (Gioia, Corley, & Hamilton, 2013).

The data analysis began by coding sections of the interviews describing the relevant concepts regarding the renewable and circular business in the light of the second and third research question. Furthermore, the empirical material was enriched with the archival data. The objective was to condense the empirical material and aggregate the codes into first-order concepts.

After first-order coding, the codes were aggregated to second-order themes. The second-order themes were identified based on the similarities and differences in the larger number of first-order categories. The purpose of aggregation was to understand the common themes emerging from the empirical data. The aggregation made extensive use of code aggregation tables, seeking to identify similarities in topics to build a consistent data structure. In contrast to identifying first-order categories, the second-order analysis moved into theoretical realm. The focus was on seeking emerging concepts to address the

research questions and understanding how the concepts reflected and accumulated to sustainable business models. The identified themes, referred as business model functions, encompassed: improving transparency and traceability, fostering collaboration for R&D, enhancing exploration, and securing long-term profitability. Finally, the analysis process iterated back and forth between emerging themes and theoretical insights and the themes converged into two aggregate upper-level dimensions: engagement with various stakeholders and business model ambidexterity.

3.3. Research assessment

The quality of the qualitative research is assessed exploiting a general framework provided by Yin (2003). The framework evaluates the construct validity, internal validity, external validity and reliability of research design.

First, the construct validity reflects establishing the correct operational measures for central concepts of the research (Yin, 2003). Construct validity can be improved by using multiple sources of evidence and establishing chain of evidence. This research utilizes multiple interviews and informants from different parts of the studied organizations and the secondary materials available in company websites and reporting. Analyzing multiple data sources provide complementing perspectives to study and improve validity of the results.

Second, the internal validity concerns establishing causal relationships between a treatment and an outcome (Yin, 2003). Yin proposes several techniques for improving internal validity, including triangulating the evidence and contrasting the empirical observations with extant literature that also provided the basis for internal validity in this research. The interviews were the primary data source for empirical study and secondary materials available in company websites and reporting were utilized to verify the internal validity of the results through triangulation. The validity of the results is further improved through pattern matching by comparing empirical findings with the established ones in previous studies (Eisenhardt, 1989). Furthermore, eliminating sources of systemic errors was supported by continuous discussions with the research team that supported eliminating alternative explanations and refining the emergent conceptualizations into consistent results.

Third, external validity of the case study is regarded with the extent to which the results are generalizable (Yin, 2009). The multiple case study and cross-case analysis was exploited to support ensuring external validity of the research (Eisenhardt, 1989). In

addition, this research seeks to improve external validity by continually linking findings with the theories guiding the research and achieving an interplay between the two.

Finally, the reliability of the findings concerns if the operations of a study can be repeated with same results (Yin, 2003). Yin proposes that case study reliability can be improved by exploiting *study protocol* and developing a *case study database.* Concerning the research protocol, this chapter has comprehensively described the applied research process including the applied research methods, justification for case selection, data collection and analysis approaches. Whereas regarding the study database, I collected interview transcriptions and notes in order to verify that all emerging findings can be rooted to raw data. Though, the applied iterative approach and semi-structured interviews decrease the opportunity for replication as the research process in this part is more difficult to describe in great detail.

4. Findings

This chapter introduces the studied case companies and provides findings of the empirical research. After briefly describing the case companies, their business portfolios and strategic goals, the discussion moves on to topics regarding the three research questions. Furthermore, the last chapter synthesizes the empirical findings and reflects them against the posed research questions.

4.1. Case descriptions

Two distinct cases were analyzed in the study. The cases represent organizations that are operating in raw material production side of the plastic industry value chain, one being an oil refining company and the other a petrochemical company. The two focal case companies act sequentially on the upstream part of the plastics value chain and share a buyer-supplier relationship. Furthermore, the companies are strategic partners working closely together to develop advanced and more sustainable solutions for the petrochemical industry.

The plastic industry value chain is provided in Appendix 1, including the position and tasks of each company. To shortly recapitulate, the oil refining companies are the first actors in the industry value chain that source crude oil and natural gas, and more recently, bio-based oils, from markets and crack it to ethylene and other feedstocks provided to petrochemical companies. The petrochemical companies then polymerize the feedstock to petroleum-based polymers, of which the most common are polyethylene (PE) and polypropylene (PP) and supply them for final processors that convert the polymers to various applications (e.g. packaging, automotive, buildings). Finally, product producers and brand-owners source the plastics and sell it to consumers.

4.1.1. Case A

Case company A represents an oil refining company focused on refining oil products in Finland. The company provides conventional oil products refined from fossil-based raw materials and related marketing services to various customers in transportation, aviation, marine, and petrochemical industries. The company divides its business portfolio into

three segments: fossil-derived oil products, renewable diesel and jet fuel, and marketing and services. Respectively, the two first, include oil refining and supplying to large industry customers. Marketing and services entail the station network of the company that distributes the refined oil products to traffic-use.

The business landscape of the company has been changing dramatically over the past decade, as novel regulations and directives, such as the greenhouse gas reduction targets in the European Union and the United States, have motivated the company to shift its growth focus on renewable solutions for transportation and aviation. The company has developed its own technologies to provide renewable oils as *"drop-in"* substitutes for conventional oil refining products, which are compatible with current fuel distribution infrastructures and suitable for conventional engines.

Over the years, the company has diversified its raw material and product portfolios and today, includes renewable fuel products refined mainly from waste and residues, and partly from vegetable oils. The continuously expanding raw material portfolio for waste and residues includes various fats and oils from food industry waste, such as fish fat and palm fatty acid distillates (PFAD). Also, the company utilizes a wide range of vegetable oils, for instance, palm and rapeseed oil. The company has continuously grown its established global platform for ensuring better access to waste and residue materials and advanced its refining technology for renewable products to allow more flexible usage of various mixes of renewable raw materials in refining. Currently, all the renewable production refineries of the company are technically capable to run on 100% waste and residues.

Whereas the company is a relatively small actor in the fossil-based oil refining industry, it has become the world's largest producer of renewable diesel and jet fuel with a total production capacity covering approximately 50% of the world's total capacity. This equals to refining 3M tonnes of renewable diesel and jet fuel annually. However, in comparison to the annual supply of the company, 3M tonnes is less than a quarter of the conventional fossil-derived fuel supply with an annual refining capacity of 14M tonnes.

Brief description of the business in regard to the three segments and the current state of each business segment, including the role of business segment in strategy and operations and the established technological capabilities are presented in Table 5.

Table 5: Description of each business segment and the novel development units, and the current states of each unit of the Case company A.

Business segment	**Description of business**	**State of business**
Fossil-derived oil products	Provides high-quality fossil-derived oil refining products to B2B customers including oil and petrochemical companies and companies marketing fuel and lubricants.	- Primary business with an annual refining capacity of ca. 14M tonnes in 2019 - Over 70 years of experience in the industry - Technology advanced refining technologies in Europe - High supply reliability
Renewable diesel and jet fuel	Provides a renewable *"drop-in"* option (generally combined with fossil-derived products) to oil companies facilitating an up to 90% reduction in greenhouse gas emissions.	- The largest provider of renewable diesel and jet fuel in the world with an annual refining capacity of ca. 3M tonnes in 2019 - Over 10 years of experience in the industry - Globally expanding, particularly to the U.S. - Technology advanced refineries in Europe and Asia - Continuously improving the already high supply reliability
Marketing & Services	Directly sells the refined petroleum products and associated services to end users through its station network in Baltic Sea Region.	- Strategic objective to become the leading provider of fuel solutions in the Baltic Sea region
Renewable and circular plastics	Provides the renewable drop-in solution to petrochemical industry actors and collaborating to develop chemical recycling technologies to utilize waste plastics feedstock in the company fuel, polymer and chemical production.	- Pioneer in renewable chemicals in the global oil refining industry - Objective to become a leader in renewable chemical solutions - Objective to develop recycling capacity to annually utilize over 1M tonnes of waste plastic feedstock by 2030.

In the last few years, the company has recognized the increasing discussion of the global plastic waste challenge and downstream demand for bio-based and circular solutions in the chemical sector. The company is currently pursuing to grow its sustainable business by integrating the renewable business into chemical sectors. The objectives in expanding

the business portfolio include, developing recycling and production technologies to exploit plastic waste as a novel raw material source, and advancing the established drop-in technologies to serve renewable offerings to the petrochemical industry.

The first collaborative actions for delivering renewable plastics were announced already in 2016, and afterwards, the company has started to increasingly focus on research to exploit waste plastics as raw material. Last year, the firm updated a new strategic goal of becoming a global leader in renewable and circular solutions. Company has set up a novel business unit for renewable polymers and chemicals to, firstly, exploit the proprietary refining technology for low-quality and renewable raw materials, and secondly, to supply plastic monomers for chemical companies as straight drop-in substitute to corresponding fossil-fuel-derived monomers. Furthermore, the company continuously explores novel business opportunities to develop its recycling capacity with a goal of annually utilizing over 1M tonnes of waste plastic feedstock in the company fuel, polymer and chemical production by 2030.

4.1.2. Case B

Case B is a petrochemical company focused on supplying polyolefins, base chemicals, and fertilizers. The company provides its polyolefin products to a wide range of industries, including global wire and cable industry, automotive industry and consumer products. The company has over 50 years' experience in consumer products and has established advanced technologies for producing material efficient solutions for packaging and fiber products.

The company is recognized for innovative plastics, chemical, and fertilizer solutions, as well as its pioneering position in developing recycling technologies for polyolefin products. The company started to build a foundation for recycling business in 2016 through acquiring European post-consumer polyolefin recyclate producers. Brief descriptions of the main product offerings of the company, entailing the polyolefins, base chemicals and fertilizers, and the novel business segments related to renewable and circular plastics, and the current state of each segment are displayed in Table 6.

Table 6: Description of the main offerings divided into three business segments and the novel development unit, and the current state of each segment of the Case company B.

Business segment	**Description of business**	**State of business**
Polyolefins	Provides a wide range of high-quality and innovative solutions (e.g. PP & PE) to B2B customers in various industries, including automotive, consumer products, energy, healthcare and pipe using industries.	- Primary business covering 65% of annual revenues in 2019. - Leading provider in Europe and globally expanding (*e.g. novel PE unit under construction in the U.S. with an anticipated production volume of 625,000 t/y*) - Highly advanced technology and industry expertise. - Extensive and advanced manufacturing technology portfolio
Base Chemicals	Provides a wide range of high-quality base chemicals (e.g. ethylene & propylene) and related consultative services (analysis, NPD, process optimization) to B2B customers in wood-based panel, energy, construction, automotive and furniture industries.	- Secondary business (19% of annual revenue in 2019) - Advanced propylene dehydrogenation plants (PHD), steam crackers and transporting systems around Europe. - One of the largest European producers and continuously growing *(e.g. novel PHD plant with a targeted production capacity of 750,000 t/y opened in 2019)*
Fertilizers	Provides a broad range of fertilizers and technical nitrogen to customers in the agricultural industry mostly in Western, Central, and South-East Europe.	- Among the leading fertilizer producers in Europe. - Supplying capacity of 5M tonnes of fertilizers and technical nitrogen products - Wide distribution network in Europe
Renewable and circular plastics	Provides consumer products using renewable feedstock in PP production as a partial replacement and has a recycling technology for producing high-quality compounds from recycled polyolefins.	- Pioneer in recycling among petrochemical companies - Strategic objectives for creating circular and renewable consumer products - Collaborates with various partners to partially replace more fossil-derived feedstocks with renewable feedstocks in different production segments - Continuously advancing and growing its mechanical recycling capacity with a target of 350,000 t/y by 2025

In recent years, the increasing global discussion about plastic waste, the market demand for more sustainable consumer product solutions, and the evolving regulations have given an additional boost for the pioneering development of the company. The company has ongoingly advanced its recycling capacity over the past few years. Furthermore, in 2019, the company entered the bio-based plastic industry by announcing a novel production of renewable PP in collaboration with company A.

The company has announced a novel sustainability strategy entailing a wide range of sustainability objectives for creating value to society and a strong focus on accelerating the circular economy. The company is committed to produce consumer products that are 100 % recyclable, reusable, or produced from renewable sources by 2025. Thus, the company is continuously making prominent investments focusing on three different areas: 1) replacing part of fossil-derived feedstock in commercial production of PP with bio-based feedstock, 2) raising the capacity of its mechanical recycling plants and 3) coordinating projects to advance chemical recycling of post-consumer waste.

4.2. Challenges in commercializing renewable and circular plastic solutions

The following sections describe the challenges related to renewable and circular plastic innovations. A wide range of barriers that prevented companies to commercialize the renewable and circular plastic innovations were identified in research. These barriers were categorized under the four common challenges for creating sustainable business models identified in the literature review (Table 3). The four challenges, namely co-creation of environmental, social and economic value; engagement with stakeholders; initially niche technologies and designs; and lack of methods to measure sustainability performance, created various difficulties and uncertainties for creating sustainable business models for commercializing renewable and circular plastic innovations. The key barriers, mainly regarding reputational risks, tensions between industry actors, lack of technologies and expertise, complexity of assessing life cycles, and operational risks are specified in Table 7.

Table 7: Challenges for creating sustainable business models for commercializing renewable and circular plastic solutions.

Co-creation of environmental, social and economic value - The social and environmental impact of renewable raw material sourcing is complex to evaluate and introduces reputational risks to companies. - The recycled and renewable plastics, in many cases, does not perform as well as conventional plastics.
Engagement with stakeholders - Industry actors are used to "*arm's length*" relationships and may resist to openly share information and enhance collaboration. - Stakeholders vary between small and large organizations which can further cause tensions among collaborative partners. - Bypassing an actor in the value chain to collaborate with a broader range of stakeholders can generate tensions as some industry actors are not willing to change the buyer-supplier value chain structure.
Initially niche technologies and designs - Various renewable plastic innovations are not compatible with dominant designs and technological regimes. - Business environments lack recycling infrastructure for different plastics and even the dominant product designs are often not recyclable. - Business environments lack incentives for growing the market for renewable and recyclable solutions. - Commercializing novel technologies and products requires novel competences and capacity as well as experience in conventional designs and consumers.
Lack of methods to measure sustainability - The value chain lacks common certifications and measuring methods that are appropriately specific to make reliable life cycle assessments. - The evolving regulations introduce operational risks to companies.

4.2.1. Co-creation of environmental, social and economic value

Ensuring the environmental and social performance of the sustainable innovations was regarded as a complex task, since the overall environmental and social impact of exploiting renewable raw materials or recycling technologies was dependent on the responsibility and efficiency of sourcing, manufacturing, distribution and disposal. In contrast, the economic trade-offs were not recognized as a threat, since they were easier to control. Although the production of the renewable and circular materials was more

expensive and could potentially cannibalize profit margins in case customers would not be willing to pay more for renewable and circular solutions. Consequently, the companies were also maintaining the fossil-based production for plastic industry in order to ensure viability and cash flows in the near future.

The social and environmental trade-offs were more complex to evaluate. Procurement of bio-based feedstock requires a wide assessment of potential influence on environmental and social risks, such as deforestation and water scarcity. The appropriate sources for renewable solutions were considered to be further limited by the edibility of several bio-based raw materials, the sourcing of which could increase the issues related to world hunger. Mirroring the concerns of many brand-owners and consumers who were refusing to have edible raw material sources in their products, the focal firms preferred to exploit non-edible raw material sources. Nevertheless, consumers may find it difficult to see the difference regarding which bio-based plastics are produced from edible or non-edible sources.

" ...we primarily exploit waste and residue raw materials and even if we use vegetable oils, they are non-edible. It may often be difficult for a consumer to understand that all plant-based raw materials are not edible." (A2)

Furthermore, ensuring responsible sourcing of renewable materials was considered to be a complex task as the supply chains for renewable materials were extensive and scattered around the world including the developing countries in which the employee rights and safety standards often differ. Thus, some raw materials, such as palm oil, were considered to particularly raise reputational risks for companies. Sustainability of different renewable sources had gained public attention and caused concerns among NGOs and consumers, and novel discussions was further threatening the companies' reputation when deploying novel materials. In many cases, the common buying behavior was regarded to base on impressions of sustainability rather than information.

Informants further underlined that conventional plastics, particularly as a packaging material, offer unparalleled benefits, including compliance with food-security regulations, lightweight, barrier properties and energy efficient manufacturing. The production of fossil-derived plastics had advanced for decades, whereas in many cases, the nascent technologies for recycled and renewable solutions were yet not able to meet the same level of performance. For example, if renewable or recycled plastic packaging is heavier or requires more material per product to meet the same barrier properties, also the distribution creates more emissions, or if the material does not meet the same barrier properties, food may expire faster which results in increasing amount of food waste.

Moreover, mechanically recycling plastics reduces the quality of the material and the recyclates are not allowed to be applied in, for example food packaging. According to the informants, understanding why recycled products should be more expensive may be difficult to consumers if the products do not perform as well as the conventional one. For instance, the informants considered that recycled materials were often assumed to be less expensive when some material functionalities, such as color options, were not comparable to conventional solutions. It is difficult to find a way to communicate a clear message to consumers about how the novel products are "better", and why the products would be even more expensive than the conventional ones.

4.2.2. Engagement with stakeholders

Challenges related to extensive interaction and collaboration with different stakeholders were considered as one of the key issues in commercializing the novel solutions. The need for extensive interaction and collaboration with different stakeholders derived most notably from making reliable life cycle assessments. Moreover, cooperation with various stakeholders was required, for instance, to access the novel technologies for renewable production and recycling, and to understand the market demands for product properties. The challenges preventing companies to successfully collaborate were described to result from the relatively conservative industry actors, complex supply chains, and robust buyer-supplier value chain structures. The arms-length transaction processes that were focused on high sales volumes were seen to restrict companies to building deeper collaborative relationships that depend on trust and information sharing. Rather than embracing open and transparent processes, building up tight barriers through technology licensing and product patents was considered to be more typical for oil refining and petrochemical industries.

Informants regarded that customers for circular and renewable designs were demanding more specific product information including cost, technology and material information which required open communication throughout the value chain and direct communication between upstream and downstream companies. In the relatively conservative industry, actors were more used to arms-length relationships, and in some cases, felt threatened if their supplier was communicating directly with their customer. Even though various actors were eager to collaborate, the actual level of collaboration was considered to remain limited as all actors were protecting their position in the value chain.

Organizations in the industry varied considerably in size, which was considered to require its own balancing and collaborative efforts. The brand-owners varied between small and large, and the oil refining and the petrochemical companies were considerably larger than the raw material suppliers and the converters. The varying sizes of the partners was recognized to further cause tensions, since the management systems, mindsets, power over certain situations and protectiveness towards sensitive information varied among these actors. For instance, smaller partners were often more protective towards intellectual property rights.

"For example, IPR issues become relevant in cooperative relationships, and actors start to fear that someone will patent something essential to gain a position to block the development or demand royalties. IPR might be the most valuable component for a smaller company." (A3)

4.2.3. Initially niche technologies and designs

The technological regimes and dominant designs in plastic industry are yet not circular, and the value chain lacks solutions and infrastructure for various renewable solutions. Although the case companies were active pioneers in renewable and circular plastic industry, the novel technologies (e.g., for chemical recycling) were still relatively nascent and products were developed in niches. Lack of solutions and expertise in the value chain were considered to challenge companies to develop and commercialize the innovations, and lack of incentives and unfinished regulations to decelerate market growth.

In case the bio-based or recycled plastic does not share the same resin as the fossil-based, the production process and technologies may not be compatible as the new resin may have different properties. Consequently, the issues regarding technological incompatibility and material functionality were described as typical challenges when developing the renewable offerings, and the pre-treating, refining and recycling technologies. The case companies considered it essential to design solutions, such as the renewable drop-in, that were compatible with the established product designs, and producing and recycling technologies.

Developing compatible products did not only improve the opportunities to find more customers with the right technologies and scale-up production, but also enhanced the circularity of the designs. A fundamental issue recognized was that the existing recycling infrastructures lack technologies for new polymers as the infrastructures are initially exist only for the dominant polymers. In case there is no commercial recycling infrastructure

for these fractions, they cannot be recycled in the end. In turn, the companies were further challenged to create recyclable solutions that appealed to consumers as some of the current product designs, such as multi-layer or black-color packaging, were often not recyclable.

Informants further underlined that the plastic market was missing incentives that would facilitate market growth for renewable and circular solutions. In comparison to several other industries, such as energy, aviation and transportation, the incentives and regulations for renewable solutions were regarded to boost the market growth and create demand for renewable products. In contrast, the markets for renewable and circular plastics were considered to be dependent on mere consumer demand, as such regulations and incentives did not exist. The informants considered that majority of manufacturing companies were developing the circular solutions as a response to emerging regulations and waiting for the development of policies that would create more attractive market.

Furthermore, developing the nascent technologies for circular and renewable products required novel technical expertise as well as knowledge and experience about the conventional products and customer needs. In order to successfully commercialize solutions, the focal companies needed to access new technical expertise while having the ability to communicate the established knowledge about the applications required in various end-use cases.

"…we need to be able to tell a lot more to attract and retain customers. There are several companies, particularly in mechanical recycling, who are small and who may not have the knowledge and experience about which product properties are required in certain applications." (B2)

4.2.4. Lack of methods to measure sustainability

Lack of standardized measuring systems and models for renewable and recyclable plastics obstructed companies to achieve traceability throughout the value chain and making reliable product life cycle assessments. Furthermore, the open-ended definitions and measures for renewable and circular products were considered to create confusion among industry actors and barriers to deploy novel solutions as the evolving regulations introduced operating risks for the companies.

Making reliable life cycle assessments requires companies throughout the value chain to calculate different measures with a common method. Companies were able to exploit common certifications to ensure that renewable feedstocks were traceable to the point of

origin and sustainably sourced and produced. However, industry actors apply different certifications, which entail different calculation methods that are too flexible to reliably calculate life cycle assessments. First, the lack of common methods to verify and evaluate raw material sources and their environmental impact challenged the industry actors to cooperate more closely throughout the value chain. And second, the flexibility of certifications required further research and specification for assessing the life cycles.

" In order to make life cycle assessments that are reliable and comparable with each other, we need common measuring methods, and currently, both chemical recycling and renewable raw materials are so novel that the established measurement methods do not exist." (A2)

Furthermore, the informants considered that evolving regulations for measurement and definitions introduced an operating risk for companies, as they may have influence on how the demand for renewable products and access to different raw materials develop. Several terms, such as *"waste", "bio-based", "bio-degradable"* and *"recyclable",* lacks regulative status, which causes ambiguities among consumers as well as companies. The changing regulation, especially in the European Union and the United States, was anticipated to have an impact on the development of the market demand, and potentially limit raw material sources for renewable and circular products. Particularly for the oil refining Company A, the fragmented regulation regarding the acceptability and use of waste and residue feedstocks was considered to create uncertainties in novel development of chemical recycling technologies. The company anticipated the regulations to develop in the near future which could have a major impact on the future compliance of the novel business development. For example,

" ...the evolving regulation for chemical recycling is going to answer major questions, such as which processes can be categorized to chemical recycling, and these definitions could have an impact on our ability to access different raw materials. For example, if regulators assess that plastic waste is not allowed to use for these processes it will be a relatively large issue for us" (A2)

4.3. Business models to commercialize renewable and circular plastic solutions

The business models and the entire plastic value chain was considered to require fundamental reforms to commercialize the renewable and circular plastic innovations. The informants described several novel business activities that companies were deploying to create viable business and drive sustainability into the industry. The research identified nine key activities which were aggregated into four fundamental "*business model functions"*: improving transparency and traceability, fostering collaboration for research and development (R&D), enhancing exploration, and securing long-term profitability. These business model functions capture how the novel business models allowed the case companies to introduce renewable and circular materials and technologies to the market. The identified business activities and the located business model functions are demonstrated in Figure 6.

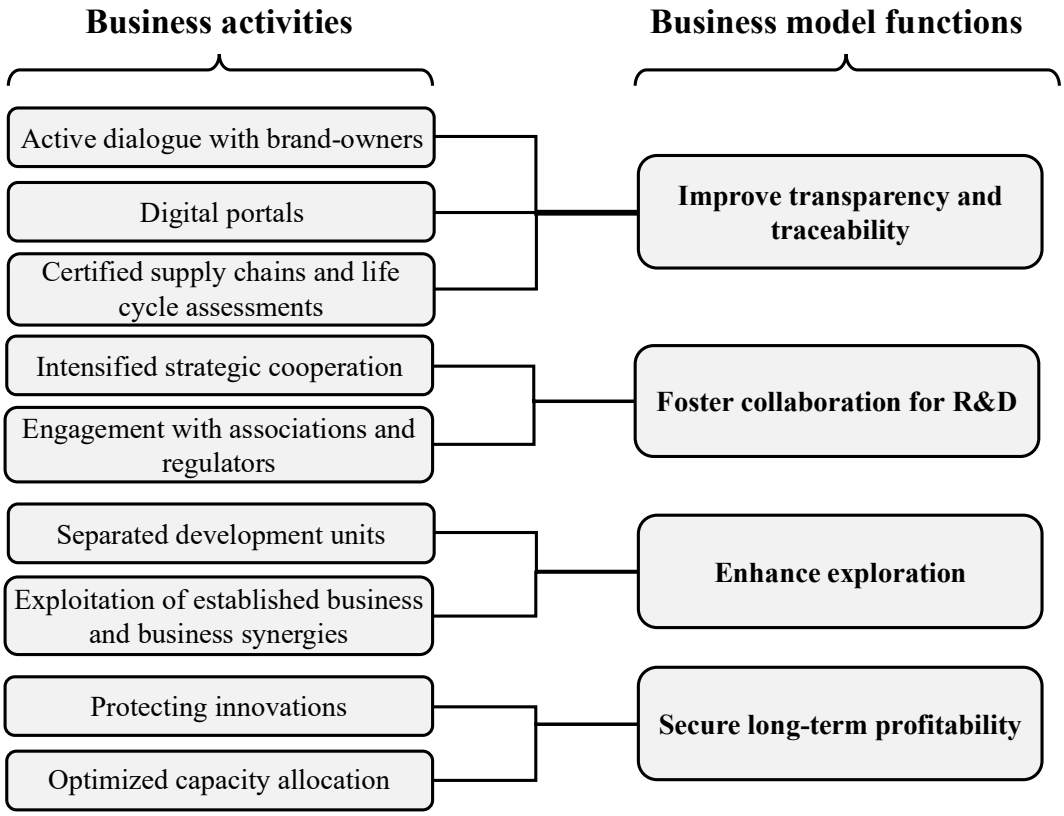

Figure 6: The identified business activities and the business model functions to support commercialization of renewable and circular plastics solutions.

The business model functions focus on the performative role of business models in the process of innovating the renewable and circular plastics and demonstrate the mechanisms through which the companies were able to mediate the conflicts between the innovations and the established business environment. They also reflect the key purpose behind the novel activities deployed in the organizations. The following sections describe the ways in which the different activities were deployed in both case companies and elaborate how the functions supported the commercialization of renewable and circular material and technical innovations.

4.3.1. Improving transparency and traceability

Since evaluating social and environmental impact of renewable raw materials was a complex process and raised reputational risks for companies, reliably assessing and clearly communicating the sustainability of novel products to downstream actors was considered as one of the most essential objectives for companies to focus on. The case informants underlined that creating business models for renewable and circular solutions requires two aspects to be in place: first, mapping out the complex supply chains and second, a comprehensively understanding which information is useful and for whom. Consequently, both companies were aiming to foster collective and transparent information sharing throughout the value chain.

Case A: Mapping out supply chains and reaching to brand-owners

Improving traceability of the renewable products was considered to start from ensuring the social and environmental sustainability of the raw material sources and efficiently communicating the traceability information between stakeholders. Company A supervised its complex supplier network and managed all the core processes for sustainable sourcing of materials, including supplier evaluation, due diligence, and certification documents through its newly developed supplier digital portal. Company had mapped its supplier network and worked for traceability over a decade as the laws for biofuel producers, like the European Union Renewable Energy Directive (EU RED), required all sourced raw materials to be traceable to the point of origin. The company was further committed to go beyond the requirements and was working to achieve a traceable supply chain for its PFAD feedstocks (i.e. a residue from palm oil processing) from palm oil refineries to mills, and ultimately, to plantations. The company stated to aim to create a common approach to tracing palm oil-based waste and residues. Furthermore, the company was actively engaging with the suppliers to communicate *"the company's expectations for sustainability"*.

The company openly shared and communicated the collected information through its *"traceability dashboard"*. The dashboard provided detailed information of raw material sources and the exact coordinates of the palm oil plantations in the supply chain. Furthermore, the standardized certifications, which were communicated through the *"traceability dashboard"*, were applied to facilitate traceability and to enable life cycle assessments throughout the value chain. The highly advanced traceability management and control over wide supplier network were considered to provide a strategic advantage for the company, as reliable certifications were an essential requirement in the renewable plastic markets.

Furthermore, as the market demand was dependent on large brand-owners, the company had started an active dialogue with brand-owners in order to facilitate transparency and identify new business opportunities. The novel dialogue was enabling the company to understand the sustainability criteria of the consumer market and which information was essential for brand-owners. This way, the company was able to identify the information that was required to be transparent and traceable throughout the value chain. In addition, the downstream actors were considered to not be familiar with all the sustainable offerings in the market and communicating the offerings straight to brand-owners was seen as an efficient way to reach novel customers, as the demand was considered to arise from brand-owners and consumer markets. Actors coordinated throughout the value chain, even though the direct customers of the Company A were yet polymer producers.

"For example, we are searching for the right production partners who are able to produce the correct raw materials which the brands are currently using. This allows us to establish the path for the drop-in. If we can supply our raw materials to the brand-owner's polymer producer, then the process already exists. […] So, we gain the novel business with polymer producers through brand-owners." (A3)

Case B: Helping the brand-owners to understand how renewable and circular materials relate to their offerings

Company B underlined the communication between various value chain actors to require increasing efforts in order to facilitate the creation of novel business opportunities. Interactively working with brand-owners was considered as an opportunity to strategically utilize the established understanding of the market needs and how they relate to technologies and product functionalities. Unlike many smaller and newer recycling and technological companies, the Company B had advanced expertise about different product applications and the related material requirements.

Furthermore, the company had created channels for sharing the precise information, including digital portals focused on interacting with customers to improve customer experience and to develop value propositions through collecting and using customer data and identifying novel opportunities for value creation. Particularly, mechanically recycled plastic does not perform as well as virgin plastic in many cases and may call for changes in product designs, such as removing multi-layer materials in order to improve the products' recyclability. Enhancing information flows, getting feedback, and fostering transparency enabled the focal firm to produce better renewable and circular plastics.

"In addition to traditional cooperation, collaborating also with the brand-owners is highlighted, since adding the recycled raw materials to products will have an influence on the appearance of the final products that the brands offer to consumers and also, we need to make sure that we fulfil all the required material qualifications and security criteria." (B2)

The traceability was facilitated by applying standard sustainability certifications for the supplying partners that sourced the renewable raw materials. Furthermore, strict and comprehensive code of conducts required from all strategic partners were exploited to ensure also the social sustainability of the company value chain.

4.3.2. Fostering collaboration for R&D

Research and development for various products and technologies to cultivate the bioeconomy and circular economy was regarded to be built on strategic collaboration. Both companies were cooperating with various partners across the value chain, different industry associations, universities, and regulators. Informants highlighted cultivating the collaboration network and intensifying cooperation with partners as essential activities to develop the renewable and circular solutions as it enabled companies to advance the nascent technologies, identify novel ways to create value to customers, anticipate regulatory trends and speed up the transformation.

Case A: Building R&D of renewable and circular technologies on collaboration

For Company A, the commercialization and development of renewable and circular solutions was underlined to be built on collaboration with various partners. First, in order to make the product circular, the company collaborated with waste collectors and recyclers that were collecting, sorting, and processing the raw materials. Second, the company collaborated with polymer producers to manufacture the renewable polymer

products. The company had doubled its external research expenditures and formed several novel strategic research co-operations. The informants described the R&D collaboration to occur in various forms including, research collaboration and technology development with research institutes, strategic cooperation with technology companies, sustainability workshops with suppliers, production collaboration with downstream partners, engagement with waste collectors and recyclers, and strategic cooperation with local governments, national authorities, and associations.

The increasing research investments were aimed to strengthen the expertise in the fields of chemical and process engineering, bioeconomy, and circular economy. Particularly, the development of novel chemical recycling technologies was emphasized to be built on partnerships and collaboration. The extensive cooperation network for strategic research with waste collectors and recyclers, several universities, and research centers were collaborating to advance chemical recycling of plastic waste with the objective to achieve industrial scale recycling. In turn, enhanced strategic cooperation with different technological companies was focused on advancing the processing of the novel raw materials. The initial setting for collaboration with the some of the waste collector and recycler companies was described to differ from the traditional collaboration with large industry actors as many novel recycling technology developers were yet relatively small. Smaller companies were regarded to require additional efforts to achieve trust between the partners and enhance development and transparent communication.

Furthermore, the company was engaging with NGOs and industry associations to actively participate in the development of the petrochemical industry. And strengthening the collaboration with local and national governments to support the work and decision making of legislators by offering expertise and information from the field and to anticipate changes in market demands and regulatory environment.

Case B: Cooperation to accelerate transition towards circular technologies

The Company B had cooperation with various technology companies in order to advance the established capacity and capabilities for mechanical recycling. Furthermore, similar to Case A, the chemical recycling development was particularly collaboration focused and the informants considered the cooperative development of nascent technologies to accelerate development. In addition to technology companies, the company had collaboration with research institutes and universities providing an access to competences and technologies required for circular production. The extensive collaboration for technological development was emphasized to enable the company to maintain its

pioneering position and was considered to offer novel opportunities to develop leading technologies for circular economy.

"Partnering and working closely together with the external world is extremely important really to speed up the whole process." (B3)

In turn, interactive research with downstream partners to understand which product characteristics and functionalities were essential to customers and collaboratively developing novel products were seen as important factors to guide the technological development. The company had decentralized network of application development and marketing experts working together with downstream partners across Europe to develop the consumer products. In order to improve the product performance and meet the consumer needs as well as developing material solutions which are recyclable, the downstream collaborative partners included designers, retailers, packaging producers, and brand-owners.

Furthermore, the focal firm had started to increasingly engage with various associations and regulators. The extensive engagement and active membership in associations endorsed the commitment to circular economy. Moreover, the interaction with regulatory authorities through different channels and being active member in several associations was suggested to improve the ability to anticipate and monitor regulatory trends and to enable the firm to take part in policy debates.

4.3.3. Enhancing exploration

Companies were exploring novel opportunities and developing the sustainable offerings and technologies in separated business entities to speed up the change while fostering synergies between the units to support the development. Both companies had set up separate business units, teams, and projects to develop and introduce the renewable and circular products to market. The separate units were developing the needed novel competences and capacity for innovations while also focusing on utilizing established assets. Companies had also made business acquisitions to enhance the exploration of renewable and circular business opportunities. Novel business units, business acquisitions, rebranding of the technologies and other set ups to structurally separate the business models for renewable and circular solutions were considered important to accelerate the innovation processes and to highlight the novel efforts towards sustainable plastic manufacturing.

Rather than considering trade-offs between the conventional and novel businesses, both companies were aiming to enhance synergies between the business models and to create superior solutions to market through exploiting existing competences. Consequently, the wide business portfolios required efficient management systems in order to communicate the established capabilities and resources such as knowledge, technology, and budget, between the conventional and novel units. Furthermore, as the companies expected the conventional business to continue operating in parallel, both companies were driving sustainability into established processes by improving material and energy efficiency.

Case A: Exploring novel raw material pools to create business synergies

Company A was focusing the exploration on technology platforms to enable processing of novel raw materials, including renewable waste and residues, and plastic waste. The company had set up novel business units for developing the renewable polymer and chemical innovations and chemical recycling in order to accelerate technological advancement and enhance exploration. For example, the company had set up a new office to Germany last year which was described to serve as a *"global hub*" for the renewable polymers and chemicals business.

Simultaneously, the novel business units were exploiting established competences and collaborating with different production units as the renewable polymer and chemical units were using the raw materials and technologies as the established renewable fuel units. Furthermore, the company was aiming to promote synergies between businesses. The novel business for renewable polymers had already attracted new customers that were also potential customers for the renewable fuel products company had to offer. The informants argued that customers who consider utilizing sustainable plastic products are also interested in other potential ways to become more sustainable.

"We do recognize an interface between the business models. For example, a globally operating brand that wants to use renewable plastics in products and packaging is also considering logistics of the products and comprehensively thinking how to make their offerings more sustainable. Here our fuel offerings for product shipping step into the picture. […] Even though we operate the different products in separated streams, the brand-owners consider sustainability concepts multi-dimensionally." (A3)

Case B: Internally unified and externally separated business models

The informants for Company B described novel business opportunities and markets to be explored in the innovation centers, separate undertakings, external projects, and

acquisitions. Furthermore, novel recycling technology was further separated under its own brand to highlight the established value-add solutions to customers. Initially, the firm had started its recycling business in parallel by acquiring a large recyclate manufacturer. In last few years the company had advanced the technologies and scaled up the acquired mechanical recycling business and also acquired another major plastic recycler to further expand its recycling capacity.

The firm was currently focusing on advancing and innovating technologies for mechanical and chemical recycling and the interview participants were anticipating that novel scaled-up technological outputs to enter markets in next few years. Developing renewable and circular offerings to market was regarded to require exploiting established technological competences and collaborating with marketing units. Collaboration between units enabled development of superior solutions to the market as the company could benefit from its value-adding technological competences. Furthermore, the established experience of material properties, safety and quality management, and the related consumer needs was seen as a strategic advantage in the novel markets in which the entire value chain required detailed information of the innovative materials and consumers had high demands. The innovation centers were underlined to have a good overview on which competences the company already had in respect to technologies, product and application development, marketing, and consumer needs in order to collaborate between the business units.

"If we see the needed competence is not there in the company or if we see that the resource which is carrying the competence is not available to work on a project, then we're reaching out to the external world." (B3)

4.3.4. Securing long-term profitability

As the companies anticipated market growth for renewable and circular solutions, several activities were performed to ensure the capture of long-term profits from the sustainable innovations and competitive position in long-term. These activities included optimizing capacity allocation and securing innovations through, for example, safeguarding access to raw material sources and other complementary assets, and securing intellectual property rights (IPR). Companies' decision-making processes were future focused, as all the projects, acquisitions, and investments related to circular and renewable solutions were justified with long-term profits.

"Although we still generate the most value from virgin polymer products, we will continue to drive the transformation by using the cash flow we generate from our virgin business to invest in our efforts for the circular economy. The transformation process will likely take many years and must be managed in a balanced way." (Case B, CFO, 2019)

Case A: Securing future procurement

The Company A did not see a risk of cannibalizing its conventional oil refining business in the petrochemical sector as the current demand of fossil-derived raw materials was voluminous and expected to grow. However, the limited source of renewable feedstock was considered a future challenge as the markets for various renewable products, including food, energy, fuels, chemicals, and plastics were anticipated to grow. The company had acquired some of the largest collectors and recyclers of used cooking oil and animal fat traders in order to ensure the future raw material sources in the growing markets and provide the company more control and visibility in its supply chain, which was also facilitating traceability and transparency in the complex supply chain. The established supplier base for plant-based oils, waste and residues that the company had expanded over the years and the correspondingly advanced technologies for purifying and flexibly processing various renewable feedstocks were considered as a competitive advantage in the growing market for renewable solutions.

Furthermore, advancing chemical recycling business was aiming to enable production of scalable feedstock for fuel and plastic solutions. In response to exploring the novel raw material pools, the company was continuously advancing and exploring technologies to improve the ability to utilize the various raw materials more flexibly. As the technologies were ongoingly developed, the future profitability of the innovations was further secured through licensing technologies.

The fossil fuel refining markets were expected to remain extremely volatile[2] and emerging regulations were expected to introduce advantages as well as risks to circular and renewable business. The profit margins for renewable fuel refining segment were considered to be exposed to even greater turbulence in comparison to fossil fuel refining margins, since they were dependent on the fossil fuel prices, regional mandates, and incentives. Entering the renewable plastic market and expanding supplier base with

[2] The CoVid-19 pandemic had triggered a crisis for fossil fuel commodities, including a collapse of oil market prices which turned negative for the first time on record on 20th April 2020. The oil price levels are expected to remain low for months which will in turn impact on price competitiveness of renewable oils and recycled plastics.

developing the chemical recycling business were considered to lower operating risks related to legitimacy and also, introduced an opportunity to lower the risks related to turbulent renewable fuel markets. For instance, the company was capable to optimize its revenue streams as the production capacity between the different renewable offerings could be allocated, in respect to market demand, to most profitable business units.

Case B: Licensing technologies and securing intellectual property

Company B considered securing intellectual property rights (IPR) as an essential part of protecting future competitive position as product patents and technology licenses are typically valued intangible assets in petrochemical sector. Furthermore, as novel technologies were developed and licensed, the company was strengthening its leading position in venture-based licensing. In response to mature patent systems in petrochemical sector and the high innovation focus, the company had an extensive patent portfolio, which was continuously expanding along with novel development.

Company actively managed its innovation portfolio in order to ensure designating the right innovation projects and efficient resource allocation. It was underlined that in order to create sustainable solutions, also the economic aspect of each potential undertaking had to be concerned. Consequently, the innovation portfolio managers were responsible to strategically allocate the capacity to sustainable development keeping in mind that at a certain point, the investment would also generate profits. However, the company had also invested in more risky projects which were not primarily focusing on generating profits. Primarily focusing on creating value to society, and secondly, on ensuring economic performance, was a new way of approaching development. For example, the company was building recycling infrastructure in a certain area to create a circular system that could turn into profitable business in the long-term future. In general, the company approached less risky projects that were sustainable also from the economic perspective. However, some higher-risk projects, such as the aforementioned recycling project, were implemented in parallel as it allowed levering the growth of recycling business and also improve stand out reputation as a pioneer. For the relatively conservative petrochemical industry, such high-risk capacity allocations and approaches were abnormal.

”It’s a new approach to be very honest. I mean this is a kind of startup approach. You see a problem, you find a solution for a problem and then you start to scale the solution, when you see the solution is working and during scaling the big issue is then to make it profitable in way that nobody is losing money along the whole circle.” (B3)

4.4. Building competitive advantages with novel business models

The increasing global discussion about plastic waste challenge and the evolving regulations had drawn attention to the growth of the renewable and circular plastic market, and consequently, competition was expected to accelerate. Considering the research objective of analyzing how novel business models can foster competitiveness, the functions of business model were recognized to translate sustainable innovations into economic success and competitive advantages in two ways. First, the business model functions induced open engagement with stakeholders that accelerated the change and mitigated operating risks in various ways. Second, the business model functions supported "*business model ambidexterity"*, that is, the ability to exploit established business models while focusing on exploring novel business opportunities.

The business activities related to improving transparency and traceability and fostering collaboration for R&D were primarily inducing open engagement with stakeholders. In turn, business model ambidexterity was highlighted in the activities related to enhancing exploration and securing long-term profitability. However, the two factors are overlapping and mutually reinforcing. When making strategic decision related to exploring future directions, companies need to continuously balance between whether to expand business portfolios and internalize the novel competences and technologies, or to collaborate with external stakeholders to access the relevant complementary assets. In other words, companies are choosing whether to strengthen the industry position by incorporating competences and assets, or to accelerate innovation by externally developing competences with the stakeholders. In order to maintain competitiveness and sustain long-term growth in the evolving plastic markets, companies are required to excel in both.

The following sections provide a mapping of how the business model functions translated sustainable innovations into competitive advantages. The sections seek to elaborate how engaging with various stakeholders, and ambidextrous exploitation and exploration of business opportunities were considered to allow companies to gain additional strategic advantage in future renewable and circular plastic market.

4.4.1. Collective and open engagement with stakeholders to allow circularity of renewable solutions

Openly engaging with various stakeholders was primarily highlighted in the business model activities related to improving transparency and traceability, and fostering collaboration for R&D. The event chain from the business model, including the activities related to engaging with various stakeholders, to the anticipated future advantages in respect to four business model elements are demonstrated in Figure 7.

Collaborative business infrastructures were considered to create several strategic advantages in current and future markets. First, cooperative and expanded network for R&D was considered to accelerate creation of viable business models and enable developing advanced technologies. Consequently, decentralizing R&D was anticipated to provide a forerunning access to novel raw materials and strengthen the pioneering position in the industry with a positive brand image.

"Developing everything by ourselves would be by far too slow compared to the speed of how our solutions are needed from the society." (B3)

Second, collaboration with the associations, local authorities, and national governments was considered to directly mitigate operating risks as it supported the companies in decision making, helped to anticipate market demands, and allowed firms to participate in policy debates. In addition, exploiting the digital platforms to enhance supply chain traceability and aiming to standardize certifications was recognized to promote compliance.

The intensified **collaboration in customer interface** and improved the use of customer data was considered to enable companies to identify advantageous business opportunities and promote competitiveness from improved opportunities to create superior products to market. Actively interacting with brand-owners to build value propositions enabled companies to identify the most attractive products designs and supported innovation processes. Furthermore, for the oil refining Company A, the novel dialogue with brand-owners was recognized as a new channel for reaching polymer producers, which fostered business growth and provided novel sales opportunities. Whereas, the polymer producer Company B considered intensified interaction with converters and brand-owners to particularly improve customer experience and this way, enhance customer retention and business growth.

"The transformation will create an advantage for us and bring novel business opportunities, since the entire value chain needs to know where the recycled plastics can be used, how safe it is, and how we can ensure the product's quality. The same transparency issues apply to renewable plastics. We already have this expertise that we have built over decades, when we have worked with virgin plastics" (B2)

When considering how the engagement with stakeholders was changing the companies' **financial models,** companies stand-out innovators as active members and founders of various associations and initiatives. Both companies had been increasingly recognized in various sustainability indices and the improved brand reputations was also considered to promote company attractiveness as an employer.

Finally, the resulted **collaborative value propositions** were considered to unfold novel business opportunities and informants considered consultative offerings to be particularly competitive in the renewable and circular plastic markets. Actively interacting with customers and clearly communicating the traceability of raw materials added value into offerings as customers required relatively detailed information about the products' origin and properties.

In conclusion, strategic cooperation was recognized as a foundation for ensuring business growth for renewable and circular solutions, and had a strong influence on companies' business infrastructure, value proposition, customer interface, and financial model. However, engaging with stakeholders and intensifying collaboration required continuous efforts and investments from the companies, and in some cases, provoked novel conflicts, such as tensions between value chain players. The dashed arrow from the competitive advantages to business model functions marked in Figure 7 demonstrates the conflicts that engagement with various stakeholders could potentially provoke in the future markets and require novel activities in business models.

"The initial setting for cooperation with our upstream partners – the chemical recyclers – differs a lot from the downstream setting, as the companies are relatively small. […] Our challenge is to balance between large and small firms, and we are aiming to find a way to collaborate so that the smaller actor does not see us as a threat but a partner." (A2)

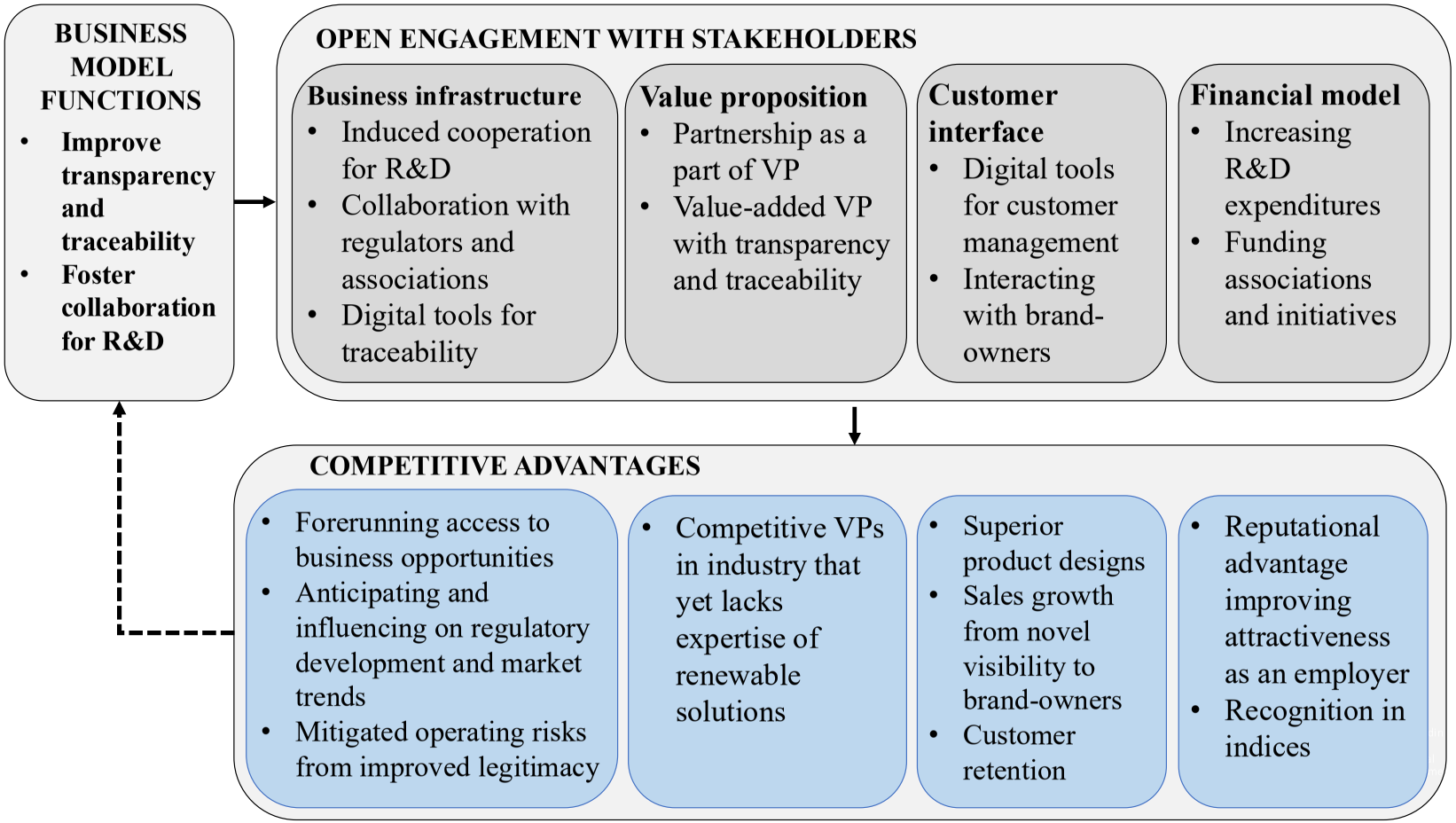

Figure 7: The event chain from deploying business model focused on engaging with various stakeholders to the competitive advantages

4.4.2. Business model ambidexterity to unfold viable innovation

Business model ambidexterity – the focus on exploring novel business opportunities, while exploiting established competences in parallel (Markides, 2013; Tushman & O'Reilly III, 1996) – was primarily induced by the operational activities related to business model functions of enhancing exploration and securing long-term profitability.

The case companies were considered to have a strong position to take an advantage of exploring novel renewable and circular business opportunities as both were able to simultaneously benefit from established business and competences. The ability to interact and drive synergies between units was considered to unfold various advantages in future markets while also, separating the novel development was enhancing exploration and underlining the sustainable development to customers and other stakeholders. The event chain from the business model focused in ambidextrous activities to the anticipated future advantages in respect to four business model elements are demonstrated in Figure 8.

The ambidextrous business infrastructures were described to allow companies to gain various advantages in future markets as they were more complex and harder for competitors to imitate. First, expanding technology and raw material portfolios provided more flexibility in sourcing and production. Exploring novel raw material sources and the related production technologies, and recycling technologies was recognized as an opportunity to mitigate risks related volatile oil prices and offer more control over supply chains, which could strengthen the dominant positions in plastic industry. The expanded technology portfolios created strategic advantage for companies related to strengthened technology position in petrochemical markets. For Company A, exploring technology platforms to advance processing of novel raw material sources was considered to mitigate operating risks and strengthen the future competitive position as a reliable supplier. Whereas, for Company B, pushing the boundaries of technology was recognized to ensure maintaining a strong IPR position and strengthen the company's position as a licensor.

Second, actively managing the separated business units and enhancing integrative mechanisms between units facilitated active exploration and accelerated innovation. The informants considered holding on to the pioneering position in the industry as one of the most valuable strategic advantages in the evolving markets. Furthermore, efficient integrative mechanisms for resource allocation and knowledge sharing allowed saving resources while enhancing the active exploration.

"We have a good overview on which kind of competence we have and where it is located in the company. […] we are at all times, fully leveraging our own experience from the existent business and complementing this with the external capabilities." (B3)

When considering the **customer interface**, strictly separating the novel and conventional business in marketing, and actively promoting the pioneering position through highlighting the novel technologies, for instance, under their own brand was seen to promote the reputational advantages. In turn, as the renewable and circular offerings were attracting novel customers, the interaction between units was enhanced and ambidextrous marketing units were focused in providing various offerings from the wide product portfolios to customers.

"We have gained an entirely new customer base, but it has also been interesting to recognize the interface to other business. […] For example, we have supplied the renewable fuel solutions to brand-owners in addition to renewable plastic solutions." (A3)

Considering the companies' **financial models**, both companies were generating revenues primarily from conventional business, and these cash flows were utilized to finance the separately operated renewable and circular polymer business. The optimized capacity allocation that was strongly correlating with the market demand was able to mitigate the risks related to large development investments. Significant investments to exploring novel opportunities, and acquiring complementary assets was considered to strengthen the future competitive position related to control over relevant resources.

Furthermore, the informants considered the **ambidextrous value propositions** to be competitive in future markets. Utilizing established market understanding, technological advancement, cash flows from conventional business, existing customer channels, and other established resources was considered to enable development of superior products and technologies. Particularly, Company B considered its established knowledge regarding the plastic market and the various applications for plastics to serve a competitive advantage when offering solutions to customers. Whereas, Company A utilized its established capacity to gain advantage from supply reliability which was difficult to achieve in renewable markets.

"The established drop-in solutions enable us to move business forward promptly and make a commitment to brand-owners that we will be able to reliably supply the feedstock as we have secured the volume and capacity required." (A3)

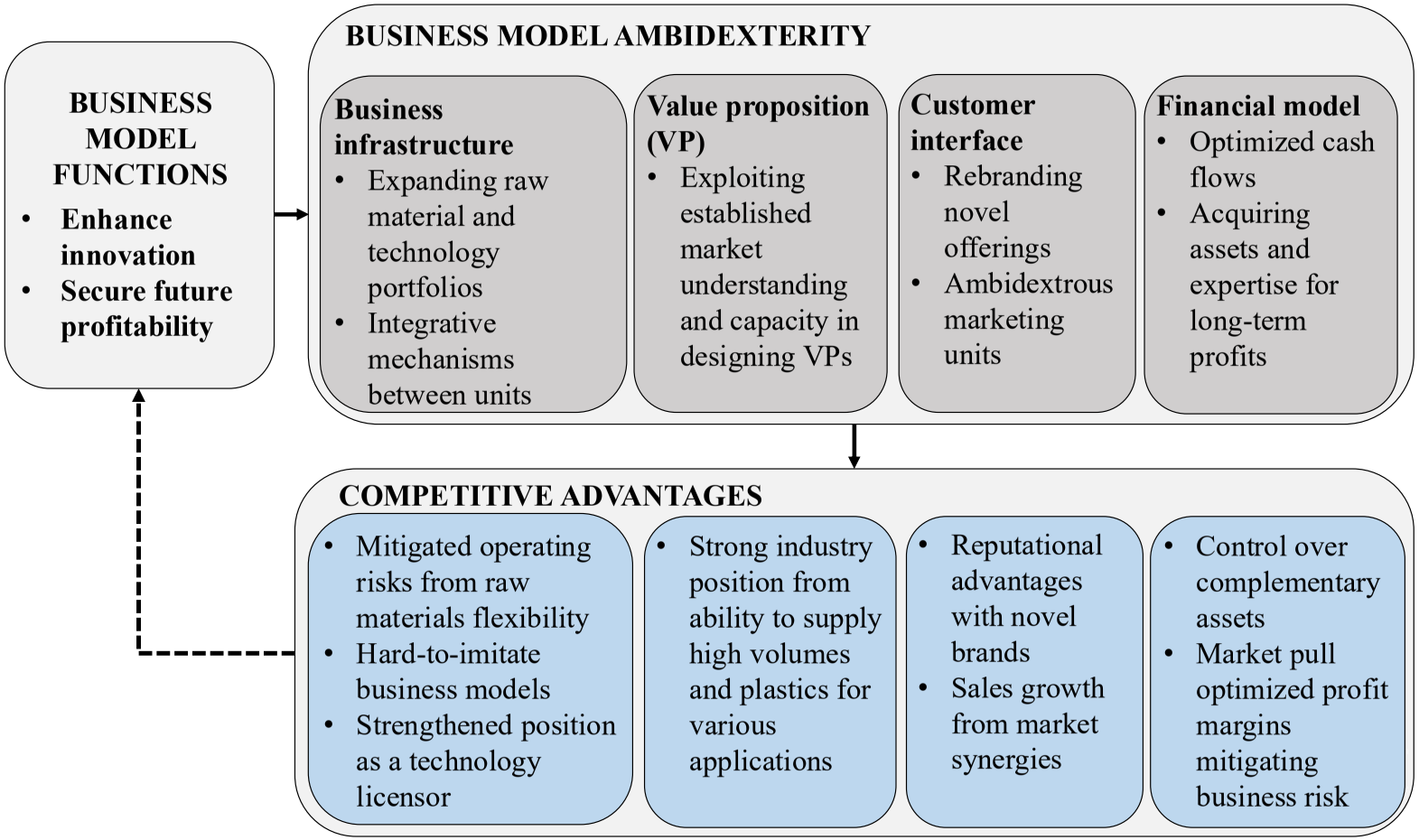

Figure 8: The event chain from deploying business model ambidexterity to the competitive advantages

In conclusion, exploring novel technologies and raw material pools was considered to strengthen the competitive position in dynamic market environments and promote the pioneering position in providing more sustainable plastic solutions. The renewable and the circular market development was recognized as "*a growth opportunity rather than a threat*". However, the production of renewable plastic solutions was yet only marginal in comparison to conventional production, and it was difficult to evaluate how the dynamics between business models would develop in the future, and if more business model conflicts would arise as the solutions were scaled up. The conflicts that business model ambidexterity can potentially provoke in the future is marked with the dashed arrow from the competitive advantages to business model functions in Figure 8. Managing broad business model portfolios and driving ambidexterity into novel business models requires balancing between exploring innovation and exploiting efficiency and expertise.

4.5. Summary of the findings

Three research questions guided the research process. This thesis focused on understanding the key barriers actually preventing companies to commercialize renewable and circular innovations, and the mechanisms through which the sustainable innovations are successfully commercialized to plastic market. The findings of the study are three-fold.

First, the findings delineated a wide range of challenges that were categorized under co-creation of environmental, social and economic value; engagement with stakeholders; initially niche technologies and designs; and lack of methods to measure sustainability performance. The challenges created various barriers preventing the companies to commercialize the renewable and circular innovations. For instance, the need to extensively engage with stakeholders caused tensions between industry actors, the lack of methods to measure sustainability created operational risks related to evolving regulations, and the complexity of governing environmental and social trade-offs created reputational risks. The results also indicated that these barriers and novel ones could be expected to accrue as the renewable and circular production was scaled up.

Second, the research studied the novel business activities in the focal companies and analyzed the objectives behind these activities to understand the essential business model functions that support the commercialization of plastic innovations. Combining the insights from the two case studies, the findings identified four business model functions – improving transparency and traceability, fostering collaboration for R&D, enhancing exploration and securing long-term profitability – that supported the successful

commercialization of renewable and circular plastic innovations. The functions reflect the mechanisms through which companies are able to successfully commercialize the disruptive plastic innovations.

Finally, the study focused on evaluating the links between the key business model functions and competitive advantages in order to reflect the benefits related to deploying the novel business model functions. By converging the business model functions to two key focus areas, the empirical results suggest that the benefits primarily result from open engagement with various stakeholders and business model ambidexterity. More specifically, the findings outline a mapping of the links between the highlighted competitive advantages and the elements of the business model, i.e. the value proposition, business infrastructure, customer interface, and financial model, in which the functions of business models are represented from diverse perspectives. The findings describe various links between the business models and competitive advantages, including mitigated operating risks, accelerated change and growth and reputational advantages. The findings indicate that companies need to excel in both, engagement with various stakeholders and business model ambidexterity and to balance between the two in respect to the drivers they aim to promote. When introducing the novel solutions to market, companies need to make decisions regarding whether to develop the novel solutions in collaboration with external partners to accelerate innovation, or to invest in complementary assets to incorporate the relevant competences to strengthen the industry position.

5. Discussion

This chapter provides the theoretical basis for empirical findings through contrasting the cases with literature and seeks to answer the three research questions posed for the study. The chapter outlines how the findings increased our understanding related to deploying novel business models to commercialize renewable and circular plastics and provides the augmented research framework.

5.1. Answering the research questions

This thesis seeks to increase understanding of how companies can create profitable business cases business with renewable and circular plastic innovations. To address the study objective, the study formulated three research questions and adopted a multiple case study approach analyzing the operational activities and business models of two large industrial material producers operating in plastic industry. The following sections reflect the empirical findings against the posed research questions, aim to verify these findings against the previous results in literature and provide the answers to the research questions of the study.

What are the barriers preventing established companies to commercialize renewable and circular plastic innovations?

The findings provide insight on the various barriers that emerge when established organizations set out to commercialize renewable and circular plastics. The sustainable innovations introduce several challenges that create barriers for companies to commercialize the renewable and circular plastic innovations. Drawing on the literature review, this thesis proposes a four-layered categorization for the challenges, namely co-creation of environmental, social and economic value; engagement with stakeholders; initially niche technologies and designs; and lack of methods to measure sustainability performance.

The first barriers result from the difficulties to simultaneously create environmental, social and economic value. The findings demonstrate how companies aiming to utilize bio-based materials in production are more concerned of the environmental and social trade-offs than economic losses. The companies have the ability to control and optimize the capacity and resource allocation based on the market demands. Even though the

renewable materials and production technologies are yet more expensive and implementation costs of technologies are high, managing the potential disadvantages related to economic performance is a relatively straightforward process. In contrast, the complexity of the petrochemical industry supply chains makes controlling the social and environmental outcomes of the innovations more difficult and introduces reputational risks to companies. This is supported by previous findings in the literature suggesting that the tradeoffs and challenges related to environmental and social performance can create significant barriers for companies to pursue radical sustainability innovations, as the environmental and social performance are highly context-sensitive (Boons & Lüdeke-Freund, 2013; Evans et al., 2017; Tomei & Helliwell, 2016). The empirical findings further indicate that whether the companies' bio-based raw materials are from high or low risk sources, or from edible or non-edible sources, consumers usually find it difficult to see the difference. Consequently, companies are exposed to reputational risks regarding various controversial topics that have raised public discussion in recent years, such as competing with bio-based feedstock, creating higher food prices, deforestation and water scarcity. Similarities in research on energy and transportation fields can be identified, since the increasing demand for bio-based feedstocks in these major industries has narrowed the socially and politically acceptable alternatives to fossil-derived feedstocks (Tomei & Helliwell, 2016).

The second key issue related to creating sustainable business models demonstrated in the empirical findings concerns the reconfiguration of the relationships between the industry stakeholders and more frequent and open communication throughout the value chain. A key observation of the findings suggests that reconfiguring the roles of different industry actors and the extensive engagement that the sustainable innovations require can cause tensions between actors. The identified tensions were related to for instance, cost transparency, IPRs, and novel cooperation between brand-owners, i.e. the customers' customers. Previous findings in sustainability literature have provided supporting evidence arguing that in comparison to business models in general, the creation of sustainable business model requires extensive engagement with various stakeholders (Adams et al., 2016; Evans et al., 2017; Lüdeke-Freund et al., 2016). These results go beyond previous findings in the sustainability literature and provide additional insights on the actual ways in which the extensive engagement with stakeholders challenges the companies. In line with the studies by Teece (1986) and Jacobides et al. (2006), mature markets have a tendency to develop robust value networks with only few dominant actors, and each industry player aims to strengthen company position and role in the industry value chain in a way that it restricts mobility, entry and competition in the focal segment while encouraging competition in its complementary activities. Petrochemical sector represents an example of such industry, with robust buyer-supplier relationships between

the actors and the highly mature and routine IP protection processes. The established relationships and industry procedures tend to create conflicts when innovating actors aim to develop intensified collaboration and reconfigure the value chain towards a circular structure.

The third barriers the empirical findings identify reflect the challenges related to initially niche market for renewable and circular plastics. In comparison to the highly advanced technologies and expertise, and matured value chains and infrastructures for producing and recycling fossil-derived plastics, the corresponding systems for novel polymers are yet nascent. Particularly, the industrial scale recycling infrastructures are still missing in many parts of the world and designed for conventional plastic products. This challenges the companies to design and limit the bio-based production to solutions that are compatible with the established recycling infrastructure. Otherwise, the materials are not going to be recycled. Previous literature has recognized a similar pattern suggesting that changing the technological regimes requires power and resources from the innovating companies to scale-up the developed innovations (Boons & Lüdeke-Freund, 2013; Smith, 2006). The previous examples found in the sustainability literature have described how the large and powerful organizations have transformed the organic food and car sharing industries to mainstream markets (Schaltegger & Wagner, 2011; Smith, 2006). The petrochemical industry complements these studies with a significantly more complex and interrelated industrial system. Creating circular value chains that are able to exploit various renewable materials will require a long-term focus even from the most powerful and dominant actors.

The final barriers related to creating the novel business models reflect the lack of standardized methods and systems to measure the bio-based content and assess life cycles, and the lack of definitional clarity regarding relevant terms such as "*recycled*" and "*bio-based*". The plastic industry lacks standardized methods to trace supply chains and defining the correct measures is a complex task as companies are required to consider a wide range of environmental and social issues to which renewable raw materials may have an influence in, such as deforestation, water scarcity, labor rights and ethical working conditions. Previous literature has recognized the same issues regarding complexity of sustainability measures, and defining the correct measures to balance between economic, environmental and social performance (Hubbard, 2009). The findings demonstrate how some of the issues can be avoided by exploiting international standardizations. However, the established certifications are yet too flexible to calculate reliable life cycle assessments. The findings contribute to scarce research on sustainability performance of supply chains (Schaltegger & Burritt, 2014) and provide practical examples of the significant issues related to assessing sustainability performance throughout complex supply chains. The findings further complement the previous

research by demonstrating how public policy makers can have a crucial influence on the business legitimacy, market demands and overall performance of the sustainable innovations, and thus, create an operating risk for sustainable innovators. The evolving regulation, especially in European Union and the United States can have a major impact on the development of the market demand and acceptability of raw material sources for renewable and circular products. For example, the regulation regarding the acceptability and use of waste and residue feedstocks is yet incomplete, which creates various uncertainties for developing the chemical recycling technologies.

How can novel business models support the commercialization of renewable plastic innovations?

This thesis adopts a pragmatic approach to analyzing the business models considering business models as devices that 1) support market introduction of the sustainable innovations, 2) mediate the conflicts between sustainable innovations and business conditions and 3) create the link between innovations and business case drivers (Doganova & Eyquem-Renault, 2009; Lüdeke-Freund, 2019; Schaltegger et al., 2016). The findings identified four key business model functions, including improving transparency and traceability, fostering collaboration for R&D, enhancing exploration, and securing long-term profitability, that supported the successful commercialization of renewable and circular plastic innovations. The business model functions reflect the key purpose behind the various business activities that the findings identified in companies' sustainable business models. The functions capture the mechanisms through which the renewable and circular innovations are successfully introduced to the market. The findings suggest that in order to create profitable business case for renewable and circular plastic innovations, companies are required to take these four business model functions under development, i.e. undertake novel business activities to create transparent and traceable value chains, foster collaboration for R&D, enhance exploration of novel business opportunities and secure long-term profitability.

The findings indicate that business models for commercializing renewable and circular solutions should be built on close cooperation with various industry actors, universities, associations and regulators. The results are consistent with the extant literature on sustainable business models suggesting that creating sustainable value requires extensively engaging with a broader range of stakeholders (Schaltegger et al., 2016). Moreover, the findings substantially add to the previous research on sustainable business models by highlighting the need to openly communicate and share information between partners. The results argue that openness regarding cost transparency and sharing intellectual property should be considered in the novel business models in order to

successfully design and develop the renewable and circular offerings and technologies in collaboration. Supporting these findings, previous evidence in general innovation literature has argued that innovation has become an open process which requires interactive development with various actors and open business model for sharing information, feedback and technologies (Chesbrough, 2007b; Chesbrough, 2010; Zott et al., 2011).

Furthermore, the empirical results demonstrate how companies need to collaborate to deploy entirely novel tracing processes to plastic industry. The findings provide examples of practical techniques to improve traceability in order to create value chains that actually provide environmental and social benefits to society. The findings indicate that 1) digital portals are an efficient tool to enhance communication throughout the value chain and manage supply networks, 2) developing standardized performance measures in cooperation with public policy makers and industry actors is needed to ensure traceability and compliance of innovations, and 3) active dialogue with brand-owners is necessary in order to understand which information is relevant for consumers.

In turn, the results also reveal protecting innovations and securing profitability as essential parts of developing novel solutions in the petrochemical industry. In line with suggestions by Teece (1986), companies can protect the profitability of an innovation by traditionally licensing technologies and filing patents, and also, through investing in gaining control over the complementary assets. The findings indicate that in many cases, in which the external asset required for developing the sustainable solutions can be considered essential in future markets, companies should consider investing in incorporation of the complementary assets. The results indicate that depending on the competitive position of the company, acquiring business to gain control over advanced technologies and supply networks can be recommended, and that companies should base their investment decisions on the long-term considerations. The findings add to established understanding on the mechanisms required for creating successful sustainable business models by providing information about balancing between the encouraging open information sharing and internally controlling the innovations.

Finally, the findings reveal that the novel business models for renewable and circular plastic innovations can benefit from the established conventional business models in various ways and provide information of the appropriate mechanisms to manage the business model portfolios. First, in order to ensure business viability and short-term cash flows that can be invested in novel development, it is beneficial to maintain and exploit the conventional business models for fossil-derived production. Second, the findings suggest that the novel business models should aim to leverage established competences and technologies to save innovation costs and aim to drive synergies between the novel

and conventional business models. Third, the results suggest that in some cases, it can be advantageous to still strictly separate business units to develop and market the renewable and circular innovations to enhance the novel development. For instance, the findings indicate that companies can benefit from rebranding the sustainable technologies to highlight the sustainability efforts in customer interface. The findings add to the growing body of literature on business model ambidexterity, and resonate favorably with the previous research on ambidextrous organizations suggesting that separated business units for exploring novel business opportunities enhance exploration while parallel focus on exploiting the established business models promotes synergies between the models (Gibson & Birkinshaw, 2004; Tushman & O'Reilly III, 1996).

How should companies deploy novel business models for renewable and circular plastic innovations to create competitive advantage in future markets?

The third research question follows from the assumption that economic success and competitive advantage depends on the active management of the business model functions, and their sufficient adjustment with the sustainable innovations (Chesbrough, 2010; Schaltegger & Wagner, 2011; Schaltegger et al., 2012). The empirical findings indicate two fundamental ways – engaging with various stakeholders and business model ambidexterity – through which the business model functions translated into economic success and competitive advantages. The results suggest that companies need to excel in both and balance between the two in order to promote competitiveness. Particularly, engaging with various stakeholders accelerates innovation processes and enhance growth. In turn, business model ambidexterity enables companies to leverage existing competences, capacity and revenue streams between the models. The business case drivers resulted from business model ambidexterity are particularly highlighted when novel business models are deployed by investing to incorporating complementary assets, such as knowledge or technologies.

To further specify the answer to the question of *"how"* the business models should be deployed, companies need to first, consider which of the two advantages they hope to underline in novel business activities. In other words, companies are choosing whether to strengthen the industry position by incorporating competences and assets, or to accelerate innovation by externally developing competences with the stakeholders. Second, companies need to continue driving collaborative processes to business activities and ambidexterity to business models in order to promote competitive advantages of the business model innovations for renewable and circular plastics. The findings augment previous research suggesting that in some cases, innovators should encourage imitation and *"open innovation*" (Chesbrough, 2007b) in order to benefit from asset appreciation,

whereas in other cases, companies should focus on creating *"architectural advantage*" by investing on complementary assets (Jacobides et al., 2006; Teece, 1986).

When considering the advantages gained from stakeholder engagement, the findings substantiate with previous research suggesting *"the power of openness in terms of value creation resets largely with the inherent characteristic of knowledge"* (Chesbrough, 2007b). The empirical results regarding the engagement with various stakeholders suggest that business infrastructures that focus on cooperating with industry actors and research institutes accelerate R&D and allow companies to gain access to certain competences, expertise and knowledge that support the creation of superior products to markets and will lead to increasing returns. The results indicate that collaboration is a key approach to maintaining the forerunner position in the evolving plastic market and promoting the company reputation as a sustainability pioneer and an innovator. Furthermore, involving local and national governments and associations to cooperation networks mitigates the operating risks related to evolving regulations and market demands, which further supports company decision-making regarding growth directions and for example, whether to invest in incorporating complementary assets or not. Furthermore, the findings augment previous research by Schaltegger et al. (2012) by demonstrating how the benefits gained from the reputational advantages, in the context of upstream actors of supply chain, reflect to indirect success drivers related to company *attractiveness as an employer.*

In turn, when considering the advantages related to business model ambidexterity, the results suggest that ambidextrously managed business infrastructures can create significant advantages related to hard-to-imitate business models while mitigating operating risks and providing novel growth opportunities. Furthermore, the results confirm previous findings in the literature suggesting that, in some cases, investing on gaining control over complementary assets, such as technologies and feedstock sources, is a more advantageous way to innovate the business model as it allows creating hard-to-imitate models to the evolving market (Jacobides et al., 2006; Teece, 1986). The findings substantially add to these results by providing information of the actual ambidextrous mechanisms that enable creating the hard-to-imitate models and most notably, by demonstrating a mapping of the links between the advantages and the ambidextrous business infrastructures, customer interfaces, financial models and value propositions. In addition, in line with previous sustainability development research, the findings indicate that the investments in complementary assets, along with decision-making regarding innovating the sustainable business models, need to concentrate on long-term profits and advantages (Geissdoerfer et al., 2018). The results argue that ambidextrous financial models should be focused on long-term profits and aim to maximize future advantages

by optimizing the investments between improving established efficiency and exploring novel opportunities, and by acquiring complementary assets that will fundamentally strengthen the companies positions in future markets. The extant literature on organizational ambidexterity supports these findings by considering ambidexterity as a key driver of company long-term performance (Gibson & Birkinshaw, 2004).

5.2. Contributions to existing literature

The study contributes to existing knowledge of sustainable business models and substantially complements the sustainable innovation literature. Most notably, the findings significantly add to our understanding of how sustainable business models are created to successfully develop and commercialize sustainable innovations. The empirical results extend the 'device' interpretation of business models in sustainable innovation context and augment the initial business model for sustainable innovations framework by Lüdeke-Freund (2019).

Furthermore, the findings of the study converge into two key observations regarding the novel business models, and substantially increase the current understanding how large companies are able to successfully innovate their business models. The findings suggest that large established companies are able to create successful business cases by actively managing the business model functions to balance between 1) externally developing innovations in intensified and open cooperation with a broad range of stakeholders, and 2) business model ambidexterity to exploit and explore competences and leverage complementary assets.

The results significantly increase the current understanding of how large companies can successfully innovate sustainable business models and shape mature industry architectures. For over a century, the petrochemical industry has created stable structures with restricted mobility and high barriers to entry, and in such industries, a radical reconfiguration of relationships and value networks is relatively uncommon and arduous (Jacobides et al., 2006). The study complements the few examples in the extant literature investigating the actual mechanisms that enable successful market introduction of sustainable innovations and systemic reforms in established value chains. Furthermore, the findings confirm the previous results in the literature suggesting that companies should simultaneously aim to benefit from creating hard-to-imitate models and investing in complementary assets while in some cases, encourage imitation (Chesbrough, 2010; Teece, 1986).

5.2.1. Extending the business model for sustainable innovations framework

The findings add to current understanding of how business models for sustainable innovations are created and exploited to successfully introduce the sustainable innovations to market. The initially adopted theoretical framework and the approach to analyze the business models was based on the assumption that challenges related to sustainable innovations require companies to deploy novel business models which, in turn, enables the creation of additional competitive advantages and the business case for the sustainability innovation (Lüdeke-Freund, 2019). Following this assumption, the empirical findings significantly augment the initial framework by adding novel elements to it that provide additional understanding regarding how the business model are created in real-life contexts. The augmented framework and the findings including the key barriers, business model functions and business case drivers are displayed in Figure 9.

The results demonstrate a wide range of challenges that made the commercialization of renewable and circular solutions particularly difficult and risky. The empirical findings add to existing understanding of how the challenges for creating sustainable business models are realized in the plastic industry contexts (Evans et al., 2017; Iles & Martin, 2013; Schaltegger & Wagner, 2011). For instance, the need to extensively engage with various stakeholders can cause tensions between industry actors, and the lack of standardized methods to measure the sustainability makes governing the complex supply chains challenging and creates operational risks related to evolving regulations.

The findings provide empirical support for the "device" interpretation of business model as a mediating function that *"goes beyond creating economic value from technology and creates a fit between strategy, organisation, innovations, and a firm's business environment "*(Lüdeke-Freund, 2019). In particular, the findings present four business model functions that capture the mechanisms that contribute to the successful commercialization of sustainable innovations. These functions are highlighted with two novel building blocks inside the business model to separately represent the open engagement with stakeholders and business model ambidexterity that the functions induce. The business model functions significantly add to current understanding of how the business models mediate between sustainable innovations and commercialization (e.g., Chesbrough & Rosenbloom, 2002; Doganova & Eyquem-Renault, 2009; Lüdeke-Freund, 2019). The functions explicate how the business models create feasible business cases for sustainable innovations at a more granular level than previous studies focused on theoretical framing (Lüdeke-Freund, 2019), sustainable business model archetypes (Bocken et al., 2014) and sustainable business case drivers (Schaltegger et al., 2012).

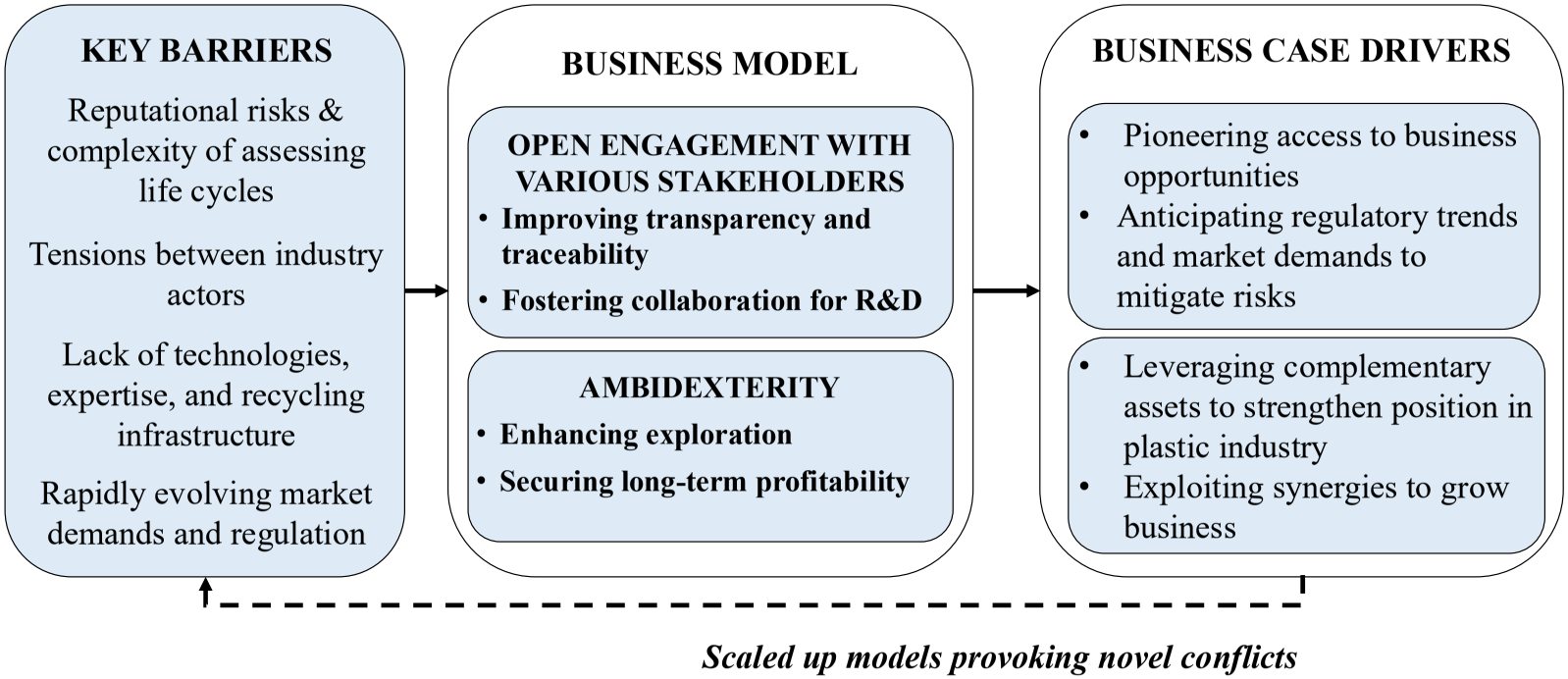

Figure 9: The extended business model for sustainable innovation framework including the key research results.

In addition, the extended framework displays a novel dashed arrow from the business case drivers to the key barriers, indicating that novel challenges can be expected to accrue as the novel business models are deployed and production of renewable and circular plastics is scaled up. As suggested in prior literature, innovating business models is always an uncertain process and the dynamically evolving market environments will continue to require companies to continuously explore novel ways to create and capture value (Chesbrough, 2007a; Teece, 2010).

5.2.2. Open innovation to create sustainable value to a broader range of stakeholders

The findings indicate that creating value to a broader range of stakeholders, from the business models perspective, means the adoption of a new, more open business model for licensing technologies, and sharing information and feedback. The results demonstrate how companies need to openly collaborate to promote circularity and share knowledge to accelerate transformation. Previous research commonly agrees that successfully transforming the existing unsustainable technology regimes and dominant product designs to sustainable options requires companies to broaden their existing stakeholder networks (Boons & Lüdeke-Freund, 2013; Hoppmann et al., 2014; Iles & Martin, 2013), and further challenges companies to make an effort to extensively interact with the various stakeholders (Evans et al., 2017). This research significantly broadens the current knowledge regarding these topics by providing a pragmatic business model approach to analyzing the process of intensifying cooperation and reconfiguring stakeholder networks. In contrast with the persisting views of start-ups and small businesses being more capable to successfully undertake the more radical innovations (Bocken et al., 2014; Ritala et al., 2018), the findings argue that in the sustainable innovation context, the large companies gain a great advantage from not only their resources and power, but particularly from their ability to openly innovate.

Previous research in the field of sustainable business model innovation has focused on the issue that mature companies tend to develop business models of increasing stability, and are unlikely to undertake sustainable innovations, apart from incremental improvements in energy and material efficiency, which are easy to link to cost savings (Ritala et al., 2018; Schaltegger et al., 2016). While the extant literature acknowledges that large companies will almost certainly have a significant role in sustainable transformation, as they are more able to drive sustainability in scale, the little research regarding the topic has focused on a common pattern suggesting that large companies

implement disruptive sustainable innovations only when they are forced by novel competition (Schaltegger & Wagner, 2011; Smith, 2006).

The empirical results are in contrast to previous research that suggests smaller companies are more capable to radically innovate sustainable business models as their organizational structures and designs tend be more flexible (Ritala et al., 2018). Whereas smaller companies tend to have more agile and reactive systems, the findings indicate that large companies are more able to openly share information, flexibly experiment with novel technologies, and invest in sustainable innovations at a much larger scale than small start-ups. The results argue that large companies tend to be less threatened to transparently share sensitive information and be more capable to openly collaborate with various actors.

The findings are supported by previous evidence in innovation literature stating that innovation has become an open process (Amit & Zott, 2001; Chesbrough, 2007b; Zott et al., 2011). Particularly, the results substantiate previous findings by Chesbrough (2007b; 2010) demonstrating how companies find it essential to actively search and exploit outside ideas to enhance innovation processes and allow intellectual property to be commercialized externally. As presented by Chesbrough, companies are able to succeed in bringing new innovations into market by first, experimenting new technologies and collaborating with external partners and second, scaling up the suitable model.

As open innovation, system-level change, and collaborative mindset have particular importance in the field of creating sustainable business models (Boons & Lüdeke-Freund, 2013; Iles & Martin, 2013), it may be that established companies can be more capable to efficiently collaborate and explore novel technologies. Moreover, in line with previous suggestions in sustainability research, large companies are more capable to ultimately drive sustainability in industries, such as the petrochemical, in which the large initial investments to technologies and facilities are causing high barriers to entry. In conclusion, the findings implicate that in the context of petrochemical industry, the large companies are more capable to create successful sustainable business model innovations – when they are motivated to do so.

5.2.3. Business model ambidexterity to create hard-to-imitate capabilities and drive sustainability in scale

A significant contribution to the extant literature of this study regards demonstrating how incumbents can successfully deploy sustainable business models by exploiting business model ambidexterity, and the mechanisms through which they can drive sustainability in

scale to highly mature industry. The novel business models for renewable and circular plastic innovations require radical business model reconfiguration that entails various uncertainties and large investments. In line with previous research in sustainable business model innovation, the results suggest that established companies should aim to mitigate the risks related to disruptive innovations by diversifying business models (Geissdoerfer et al., 2018; Sosna et al., 2010). The results go beyond these findings and provide insight of how the diversified business models translate to competitive advantages through business model ambidexterity.

Directly supporting prior findings from petrochemical industry by Iles and Martin (2013), this study indicates how setting up experimental business units in parallel with renewable and circular plastic solutions, and creating separate business entities by acquiring smaller firms, can accelerate the development of novel sustainable business models and mitigate risks related to uncertain prospects for bio-based plastics. The findings provide an additional insight that separating the novel business models at the customer interface by, for example, rebranding novel technologies, highlights the novel sustainability improvements to stakeholders and strengthens the reputational advantages.

In turn, the findings indicate that the novel sustainable business models can significantly benefit from the conventional business, and vice versa. Results suggest that companies should manage the novel business infrastructures ambidextrously to create hard-to-imitate business models while saving resources. Previous literature in organizational ambidexterity supports the findings by arguing against strictly separating business units and emphasizing integrative mechanisms between the units (Gibson & Birkinshaw, 2004; Markides, 2013; Tushman & O'Reilly III, 1996). The cases strongly highlight the importance of integrative links between novel and conventional business units and advanced product and innovation portfolio management. The results demonstrate how efficient knowledge management between novel and conventional units supports optimized capacity allocation and efficient decision-making. Furthermore, the findings show how exploiting established market understanding improves the potentials to develop superior products to the nascent market that lacks expertise regarding how various product applications and market demands relate to technologies and raw materials.

Furthermore, the study substantially adds to our understanding of sustainably transforming mature industries. The petrochemical industry presents an example of a highly mature industry in which the robust positions of different actors throughout the value chain and established buyer-supplier relationships disrupt transparent communication throughout the value chain. Shaping the industry practices requires long period of time and powerful organizations motivated to make radical reconfigurations to

the uncollaborative and complex value chains. Previous literature on sustainable business model innovation has highlighted that sustainable value cannot be created autonomously and requires collaborative relationships (Bocken et al., 2014; Schaltegger et al., 2016). However, the existing research pays little attention to the mechanisms regarding how companies can aim to maintain and strengthen their market position when creating shared value. By approaching the issue from business model perspective, the findings indicate that companies should simultaneously aim to benefit from cooperating openly, while controlling the mobility of industry by focusing on creating hard-to-imitate business models and investing in complementary assets.

Previous research on profiting from innovations (Teece, 1986) and constructing industry architectures (Jacobides et al., 2006) provides support to the findings. Teece (1986) argued that the ability to generate profit from the innovation is dependent on developing *dominant design*, *securing the knowledge and technologies,* and gaining control and access to *complementary assets*. The findings add considerable insights for the three concepts as both cases demonstrate how business model diversification can help companies to secure knowledge and technologies, access complementary assets and facilitate creation of dominant designs. First, the companies exploit the established competences and expertise to maximize the value created to customers. Utilizing and cultivating the established competences in this manner provides the opportunity to create superior solutions to market (i.e. *dominant designs)*. Second, imitating the advanced expertise, technologies and broad partner networks which have developed over decades in the established organizations is extremely difficult for novel competitors (i.e. *securing innovation*). Particularly, in the petrochemical industry context, companies have established common practices for securing intellectual properties and able to "*tightly"* protect the innovations (Teece, 1986). Third, the findings provided further support that separately developing innovations and even acquiring subsidiaries efficiently accelerates affiliating complementary assets like relevant technologies. For instance, Company A had acquired waste and residue collector businesses to gain more control over future raw material sources, whereas Company B had acquired recycling and waste collector companies to access the essential technologies to build foundation for novel recycling business.

The findings provide a foundation for understandings how companies can drive sustainability to mature industries, and successfully create and scale-up sustainable business models. The successfulness of driving sustainability to industry lies on the ability to balance between externally developing the novel technologies and knowledge in cooperation with various strategic partners, and internally advancing established competences and investing to complementary assets. The results suggest that companies

are required to have strong focus on long-term profits, efficient knowledge management to identify synergies between business units, and ability to extensively collaborate with various actors. The large organizations are able to exploit their established position and partner networks in novel markets to accelerate growth with collaboration, and extant cash flows to make high investments in order to gain the control over complementary assets and achieve a dominant position in future markets.

6. Conclusions

This chapter provides an overview of the practical implications and the limitations of the study. After evaluating the implications and limitations and the empirical cases through the lens of previous research, the gaps in the existing literature and potential avenues for future research are addressed.

6.1. Practical implications

The insights of the study related to sustainable business models for commercializing renewable and circular plastics have practical relevance for companies operating in production side of petrochemical industry value chain. Key areas of managerial attention are the likely barriers related to commercializing the renewable and circular plastic innovations and the potential profitable business cases resulted from the innovations. Most notably, the key contribution of this study relates to outlining four key business model functions that mediate between the barriers and commercialization of the innovations and translate the innovations into profitable business cases.

The first function highlights the importance of creating transparent and traceable value chains for renewable and circular plastic offerings. The market for sustainable plastic solutions requires fundamentally more information about the origin of the used raw materials. Companies are required to extensively interact with a variety of stakeholders, manage wide raw material supplier networks, and create standardized measuring systems to achieve traceable value chains. More specifically, digital portals were discovered as advantageous tools for improving and managing traceability.

The second function guides companies to consider how they can expand stakeholder and collaboration networks and instructs companies to build their R&D for renewable and circular solutions on collaboration. Cooperation with industry actors is necessary to accelerate the development and create plastic solutions that are actually circular, whereas engaging with local and national governments and associations supports decision-making, helps companies to anticipate how the nascent market will evolve, and offers an opportunity to participate in policy debates.

The third function focuses on enhancing exploration and illustrates how companies should manage diversified business models. The findings guide companies to separate the sustainability development to novel business units in order to accelerate the exploration of novel business opportunities, and to rebrand the novel technologies in order to highlight the sustainability contributions to customers to gain reputational advantages. In turn, the results provide information of the likely synergies between the conventional and novel business models, and guide companies to also promote collaboration and knowledge sharing between business units.

The fourth function underlines the importance of securing long-term profitability and draws attention to the ways to manage the wide business portfolios in a manner that future profits are secured. The findings provide knowledge for considering in which situations it is advantageous to incorporate the competences and complementary assets rather than externally access the complementary assets through partners. The markets for renewable and circular plastic solutions are anticipated to radically grow, and thus, protecting the unique technologies and gaining control over limited raw material sources will be beneficial in future markets.

These four functions provide a link between the challenges and business case drivers for commercializing renewable and circular solutions in the plastic industry context. To sum up, companies can accelerate innovation by developing competences with the stakeholders and strengthen their industry position by incorporating competences and assets. In order to translate the sustainable innovations into competitive advantages and economic success companies are required to excel in both and, in many cases, balance between the two.

6.2. Limitations

The core limitations of this study concern the empirical data, methodology, and research context. Firstly, the quality of results is exposed to subjective biases of the informants and the researcher, which are difficult to eliminate. The findings largely rely on the ability of the researcher to correctly capture the informant's perspective through interviewing and observation (Eisenhardt, 1989). Furthermore, the study was conducted in limited project time, whereas the study focuses on sustainable business model implementation, which is a relatively long-term phenomenon in organizations. Hence, the results rely on retrospective interviews which can only provide informants' judgements of the past occurrences. Continuing with the research would provide the advantage of conducting

interviews in different points in time and enable to collect data of how the adopted business models perform in real-life context (Yin, 2009).

Secondly, the research methodology and context constitute limitations for the research results. The lack of standard methods for analyzing in qualitative studies generally questions the validity and reliability of results (Yin, 2009). In case research, the selection of cases always has an influence on the generalizability of findings. The case companies represent upstream industry actors in the plastics value chain operating primarily in Europe. The requirements for successful commercialization of sustainable solutions may vary in different business environments, since the regulations and consumer awareness regarding plastic challenges as well as the recycling infrastructures and production technologies are considerably advanced in Europe. Furthermore, the generalizability of the results is limited to upstream actors in the plastic industry value chain. The challenges, business model functions and business case drivers for commercialization of sustainable innovations may greatly vary in the context of other industry actors, such as brand-owners and converters. I recommend conducting a similar empirical research in a diversity of companies and varying business environments in order to gain a deeper and more generalizable understanding of how commercialization of sustainable innovations is manifested in different industry contexts.

6.3. Future Research

This study makes a number of suggestions for future research. First, the research adopted a business model as a device approach to analyze two large raw material producers aiming to commercialize renewable and circular plastic innovations. The business model as a device approach was discovered advantageous and exploiting the approach in different contexts is desirable for future work. Future investigations are necessary for developing a more generalizable understanding of sustainable business model creation and deployment. More research on the actual processes through which sustainable business models are successfully created in various companies, including detailed studies of upstream and downstream actors in the plastic industry, would fundamentally complement this study, and potentially validate the conclusions regarding the actual mechanisms through which sustainable business models can be innovated with successful outcomes.

Second, another interesting question relates to open innovation processes in sustainable business model creation. A majority of the sustainable innovation examples found in literature have focused on start-ups and small companies, as the extant literature

highlights the role of flexible and agile company structures and recognizes smaller actors more capable to successfully create radical business model innovations (Ritala et al., 2018). However, by linking previous findings from sustainable business model innovation literature and studies on open innovation (Chesbrough, 2007b), the empirical evidence argued that smaller actors were less prepared to openly share information which influenced their ability to contiguously cooperate and create sustainable business models. Conducting a more nuanced research on how the larger and smaller actors play a role in transforming the industry with their sustainable business models offers an interesting avenue for future research.

Third, previous research on business model innovation has recognized ambidexterity literature to offer an advantageous framing for approaching the challenges regarding competing business models (Markides, 2013). I apply this idea to explore how ambidextrous business models can support companies to deploy sustainable business models. The ambidexterity literature provides a wide range of more specific proposals and actual mechanisms for companies to exploit in order to manage conflicting demands. Taking a closer view on organizational systems and approaching the issues regarding commercializing renewable and circular plastic solutions as an ambidexterity issue would greatly complement this research. Furthermore, given the lack of business model ambidexterity research, future studies could examine in more detail how business model ambidexterity is realized in established organizations.

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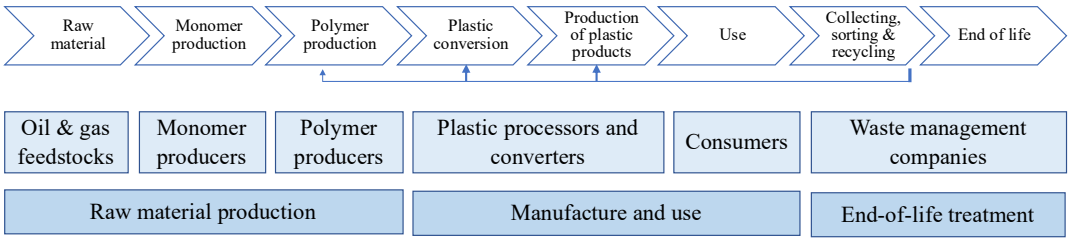
Appendix 1

Plastic industry value chain



Appendix 2

Interview structure

1. **Introductions**
   - Asking for permission to record the interview and clarifying the confidentiality of the interview.
   - Introduction of the interviewers, research project and the master's thesis context.
   - Introduction of the interviewees and company in brief
2. **Description of the established business model**
   - What are the main offerings the company supplies to plastic industry?
   - What competences do you hold in the area of plastics?
   - What are the main value creating components in your business model?
3. **Description of the novel business model for sustainable plastics**
   - Description of the value proposition of the sustainable business model.
   - Description of the business infrastructure of the sustainable business model.
   - Description of the customer interface of the sustainable business model.
   - Description of the financial model of the sustainable business model.
   - How does choosing sustainable offering affect to company's logic of value creation and capture?
4. **Main challenges and benefits of bio-based plastics**
   - What have been the main challenges you have confronted when introducing new bioplastic innovations to market? How are you corresponding to these challenges?
   - What are the main barriers preventing the company to further scale up the current development?
   - How do you specify to your customers in what respect your products are sustainable?
   - What kind of benefits does the company expect to gain from the offerings?
5. **The role of sustainable business model in the company and strategic objectives for sustainability performance**
   - How do you expect the role of the new sustainable business models in your company to evolve in the future?
   - What kind of R&D activities you do in area of plastics?
   - How has the new business models for renewable and circular solutions affected to your current business? Disadvantages? Synergies?
   - What is your company's position in the renewable and circular value chain?
   - What are the assets and capabilities required to maintain competitive advantage in the industry?
6. **Ending questions**
   - Do you have any other important concepts or issues that have not yet been discussed in the interview?
   - Can you recommend knowledgeable individuals that we could interview for the project?