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Samuli Patala

ADVANCING SUSTAINABILITY-ORIENTED INNOVATIONS IN INDUSTRIAL MARKETS

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in the Suvorov auditorium of Technopolis at Lappeenranta University of Technology, Lappeenranta, Finland on the 9th of September, 2016, at noon.

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Abstract

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Sustainability has become a new imperative for industrial firms as the global limits of environmental impacts are becoming more evident. Scarcity of natural resources, tightening environmental regulations and consumer preferences are among the mechanisms which drive firms to improve their sustainability. Although there isn't a clear correlation on how corporate sustainability performance effects financial performance, there are many examples of firms incurring large losses when sustainability is neglected and firms lose legitimacy. However, for some firms, sustainability can also be a source of competitive advantage.

This study focuses on advancing sustainability-oriented innovations. If firms are to make sustainability a competitive advantage, it requires a shift from insular innovations focused on the operational footprint of the firm towards systemic innovations focused on the strategic handprint of the firm. This study examines how to accomplish this shift through two key activities: demonstrating the value of sustainability-oriented innovations and building collaborative networks to develop the innovations. This study was conducted through a mixed methods study comprised of two multiple case studies covering 35 organizations, an analysis of 32 firms' corporate press releases, and a qualitative Delphi study with 40 informants.

The findings of the study characterize advancing sustainable innovation as a multi-stage process. Firms should build effective value propositions which demonstrate the customer and societal value of their offerings in order to gain customer acceptance and build legitimacy with their wider stakeholder networks. They should also create collaborative networks with business partners, public sector and societal actors to develop new innovations. The findings introduce a framework to build sustainable value propositions for industrial offerings. They also elaborate four forms of networks for sustainability collaboration and identify polycentric governance forms for managing these networks. Lastly, they identify the barriers to sustainability-oriented innovations and explore how these can be overcome. The findings help managers and policy-makers create and promote sustainability-oriented innovations with a higher potential for impact.

Keywords: sustainability-oriented innovation, corporate sustainability collaborative networks, value proposition, legitimacy, industrial marketing, institutional theory, network theory

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Completing a doctoral thesis is a long and arduous journey which requires willpower and perseverance. It is also a journey full of learning, self-development as well as moments of enlightenment and joy. Luckily, that journey doesn't need to be taken alone. Here I would like to thank all those people whose help and support made this thesis possible.

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Secondly, I wish to thank the distinguished reviewers of the thesis, Associate Professor Nancy Bocken and Professor Aino Halinen-Kaila. They have given thorough feedback and insightful suggestions, which have served to improve the thesis in its final stages.

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Samuli Patala
August 23, 2016
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Contents

List of publications

This thesis is based on the following papers. The right to include the papers in this dissertation have been granted by the publishers.

PUBLICATION I

Patala, S; Jalkala, A; Keränen, J; Väisänen, S; Tuominen, V and Soukka, R. 2016. A framework for building sustainable value propositions in industrial markets. *Industrial Marketing Management*, forthcoming.

The author of this thesis was responsible for the research plan and had primary responsibility for collecting the data, analyzing the findings and drawing conclusions. Two of the co-authors were also involved in the data collection and analysis. The paper was written jointly with the co-authors, and the main author took primary responsibility for revising the paper during the peer review process. The paper was published following a double blind review on the full paper.

PUBLICATION II

Patala, S., Korpivaara, I., Kuitunen, A., Jalkala, A., Soppe, B. 2016. Legitimacy under institutional change: How incumbents borrow clean rhetoric for dirty technologies. *76th Annual Meeting of the Academy of Management, Anaheim, California, 5-9.8.2016. The manuscript is currently under peer-review for an academic journal.*

The author was responsible for the research plan and had primary responsibility for collecting the data, analyzing the findings and drawing conclusions. Two of the co-authors were also involved in the data collection and analysis. The paper was written jointly with the co-authors. The paper was accepted for conference proceedings following a double blind review on the full paper.

PUBLICATION III

Patala, S; Hämäläinen, S; Jalkala, A and Pesonen, H. 2014. Towards a broader perspective on the forms of eco-industrial networks. *Journal of Cleaner Production* Vol. 82, No. 1, pp. 166-178.

The author was one of the co-authors, who were jointly responsible for collecting and analyzing the literature used for the paper. The paper was written jointly with the co-authors, and the main author took primary responsibility for revising the paper during the peer review process. The paper was published following a double blind review on the full paper.

PUBLICATION IV

Patala, S., Hämäläinen, S., Oinonen, M., Salmi, A. 2016. Governance of cross-sectoral sustainability collaboration: a polycentric perspective. *GRONEN 2016, Hamburg, Germany, 25-27.5.2016. The manuscript attached to this thesis has been revised after the conference, and is currently under peer-review for an academic journal.*

The author was responsible for the research plan and had the primary responsibility for collecting the data, analyzing the findings and drawing conclusions. Two of the co-authors were also involved in the data collection and analysis. The paper was written jointly with the co-authors, and the main author took primary responsibility for revising the paper during the peer review process. The paper was published following a double blind review on the full paper.

PUBLICATION V

Laukkanen, M; Patala, S. 2014. Analysing barriers to sustainable business model innovations: innovation systems approach. *International Journal of Innovation Management*, Vol. 18, No. 6.

The first author had the primary responsibility for the research plan and data collection. The data analysis and writing the paper were jointly conducted with the co-author. The authors had joint responsibility for revising the paper during the peer review process. The paper was published following a double blind review on the full paper.

1 INTRODUCTION

1.1 Research background

Sustainability has become a critical issue for humanity. Increased knowledge about the environmental limits of our planet has made it evident that humankind is using resources and causing environmental harm at a pace that threatens our long-term survival (Rockström et al., 2009). In addition, there is increased demand for societal well-being and universal human rights. Much of the cause behind these impacts as well as the potential to change them is rooted in the industrial world, which is the engine of capitalism. There is thus an increasing need for firms to integrate environmental and social sustainability into their operations, although that has to be conducted against the background of a variety of contradictory pressures arising from regulators, stakeholders and the need to maintain a competitive business (Porter et al., 2007).

Industrial firms have adopted various methods through which they can improve their environmental and social sustainability. Environmental management systems, corporate social responsibility programs and life-cycle assessment tools are example of operational methods that aim to improve sustainability (O'Rourke, 2014). Sustainability is also increasingly a strategic concern, a potential source of competitive advantage (Berns et al., 2009) and a driver of innovation activities (Nidumolu et al., 2009). Some firms create organizational and inter-organizational innovations which improve their own sustainability. These activities fall under the wider field of *sustainability-oriented innovations* (SOI). For example, firms such as Unilever, Bodyshop and Patagonia have made sustainability a key focus of their strategy and have consequently captured market share due to sustainability-oriented consumers. Other firms have achieved this by creating products, services and solutions which improve the sustainability of their customers' processes, simultaneously creating business and societal benefits (Porter and Kramer, 2011). For example, firms in the wider cleantech field[1] create commercial offerings which improve environmental sustainability in various ways.

Even though the societal need for more sustainability-oriented innovations is relatively well-known, these innovations are not being developed and adopted at the rate that they should be in order to adequately curb environmental impacts. For example, analysts have estimated that the world is losing ecosystem services in the range of $2–5 trillion per year (O'Shea et al., 2013). IPCC analysts estimate that investments in low-carbon technologies are set to rise by several billion dollars per year until 2030 if global warming is to be limited to 2°C (IPCC, 2015). Despite the need for long-term thinking regarding sustainability, firms often focus on short-term profitability, which is driven by stock markets. This short-term view is also reflected in many sustainability-oriented innovations, which focus on minor efficiency gains in operations and consequent cost or

[1] Includes various industries such as renewable energy, sustainable mobility, waste management, water treatment, material and energy efficiency and the circular economy

risk decreases (Senge, 2010). This focus on footprint reduction has been at the core of many corporate sustainability initiatives (Lubin and Esty, 2010). However, developing innovations with major sustainability impacts often calls for a strategic view (Senge, 2010) and a focus on "handprints" i.e. net positive impacts to environmental and social sustainability (Phansey, 2015). These type of innovations can also offer business benefits through new customer acquisitions or by building completely new markets, although these benefits are usually realized over a longer term (Lubin and Esty, 2010).

Developing sustainability-oriented innovations can seldom be accomplished in isolation. An insular view of sustainability-oriented innovations, focusing only on the firm and its internal operations, generally results in incremental innovations with limited impact (Adams et al., 2015). Most of the environmental and social impacts of producing a product are generated through a supply chain, and the seller of the product has only a limited capability to improve sustainability on their own (The Economist, 2014). Furthermore, firms often have to collaborate and build networks with customers, NGOs, regulators and public sector actors to build legitimacy for their activities and new innovations. This allows firms to develop more progressive innovations which have the potential for wider systemic change (Adams et al., 2015). This thesis focuses on advancing sustainability-oriented innovation, i.e. the shift from insular innovations focused on reducing a firm's operational footprint to systemic innovations focused on the strategic sustainability handprint of the firm, as picture in Figure 1.

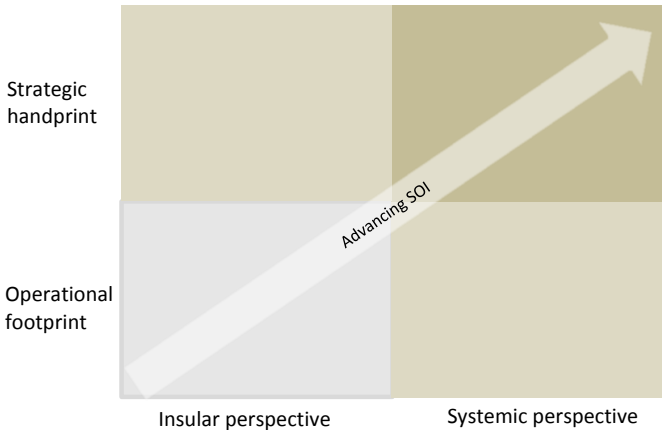


Figure 1: Focus of the thesis

This introductory section first introduces the research gaps the thesis will address. It then states the research objectives and research questions. Third, it articulates the position of the conceptual background of the thesis. Lastly, it finishes with an outline of the rest of the thesis.

1.2 Research gaps

Much of the corporate sustainability literature had traditionally focused on how firms can alter themselves to become more sustainable. In essence, there is a strong focus on decreasing the *operational footprint* of the environmental and social impacts of firms. Rather less attention has been paid to the *strategic handprint*, or how firms can create products and services which have a positive impact on the environment and on societies. In order to accomplish this, firms must create products and services that resonate with customers in addition to providing environmental and social benefits. This requires that firms are able to make sustainability an organization-wide consideration and integrate it with strategic and operational marketing activities.

The marketing field is traditionally associated with creating and delivering customer value. The literature in marketing has addressed the topic of sustainability mostly from a consumer marketing standpoint, focusing on issues such as green consumer behavior (Gupta and Ogden, 2009), green branding (Chen, 2010), the impacts of green marketing strategies (Leonidou et al., 2013) and green product design (Olson, 2013). What is lacking in this field of marketing is a comprehensive understanding of the marketing activities of *industrial firms undertaking sustainable innovation*. This is surprising, especially given the large role of industry in contributing to environmental issues, such as climate change (Sprengel and Busch, 2011) , and the overall larger size of industrial markets compared to consumer markets. Prevailing theories in industrial marketing consider the understanding of *value creation* in supplier-customer relationships to be a central issue. Supplier-customer relations are also embedded in complex inter-organizational networks, which include other firms, public sector organizations, NGOs and consumers. Understanding and managing these *networks* is another critical skill for industrial marketers. Yet so far, the topic of sustainable innovation has been under addressed in the research streams focusing on *value creation* and *inter-organizational networks*. This study focuses on these two gaps.

First, the understanding of customer value is vital for the successful commercialization and diffusion of sustainable innovations. The value creation literature stream has recently made important advances in understanding the complex nature of customer value, i.e. the value created for customers (Frow and Payne, 2011; Keränen and Jalkala, 2013; Skålén et al., 2014). Customer value is created in the processes of the customer organization, the actors' perceptions of the organization as well as through the relationship between the supplier and customer. Customer value can include different dimensions, such as economic, functional, social and emotional value. However, aside from a few studies, environmental and social value have not been considered in customer value research. Furthermore, firms also need to communicate value to their stakeholder network (Frow and Payne, 2011), which is especially relevant for sustainable innovations that bring societal benefits. Customer value has been suggested to be a key strategic orientation for firms (Slater, 1997) and it can help firms achieve key supplier status in an increasingly competitive market (Ulaga and Eggert, 2006). Developing new customer value

propositions is considered to be an important source of innovation according to the service-dominant logic in marketing (Skålén et al., 2014). Similarly, as firms undertaking sustainability initiatives have to assess and quantify the footprint of their own operations, they should also demonstrate the sustainability impacts that their products and services will create during their use, i.e. demonstrate sustainable customer value.

Second, sustainable innovations are often created in collaboration within inter-organizational networks. The management and understanding of inter-organizational networks is another key research area within industrial marketing, as firms' actions are enabled and constrained by the networks of business and non-business relations that they are embedded in (Håkansson and Snehota, 1995; Möller and Rajala, 2007; Ritter et al., 2004). Networks of business relations Studies in industrial marketing that focus on sustainability in inter-organizational networks are relatively rare, and have focused on sustainable supply chain management (Gupta et al., 2014) or networks focused on specific environmental issues (Ritvala and Salmi, 2010). What is lacking is a more comprehensive understanding of the role of inter-organizational networks in advancing sustainable innovations. In an increasingly inter-connected world, networks are vital for both the creation and commercialization of new innovations (Aarikka-Stenroos et al., 2014; Dhanaraj and Parkhe, 2006).

1.3 Objective and research questions

To address the aforementioned research gaps, the **overall purpose of this thesis is to explore the methods for advancing sustainability-oriented innovations (SOI) in industrial markets**. This overall purpose can be divided into two subtopics: the *value and legitimacy* of SOI and the *collaborative networks* required to advance SOI. These two subtopics are further divided into five different research objectives, which are addressed in separate research projects: 1) understanding how sustainability can be integrated into customer value propositions for industrial offerings, 2) exploring how industrial firms legitimize (un)sustainable innovations to their stakeholders, 3) exploring the role and form of collaborative networks in advancing sustainable innovations, 4) identifying the governance models for these networks and 5) identifying the systemic barriers to sustainable innovations and the methods for overcoming them. The research subtopics, research questions, objectives and individual publications are listed in Table 1.

Table 1: Research objectives and questions

Research subtopic	Research question	Objectives	Method	Publi-cation
Value and legitimacy of sustainable innovations	1) How can firms develop sustainable value propositions to demonstrate the economic, environmental and social value of their sustainability-oriented innovations to customers?	To explore the process of creating sustainable value propositions and form a normative framework for their creation	Case study	I

	2) What kind of rhetorical legitimacy strategies do incumbents firms use to justify investments into (un)sustainable technologies under conditions of institutional change?	To understand how firms legitimize their (un)sustainable actions during institutional change	Content analysis	II
The role of collaborative networks in advancing sustainability-oriented innovations	3) What forms of inter-organizational networks with the potential to advance environmental sustainability can be identified in the literature and what are the principal operational logics and architecture of these network forms?	To identify the forms and structures of collaborative sustainability networks	Systematic literature review	III
	4) How can polycentric governance facilitate sustainability collaboration and what are the archetypes of different polycentric governance models?	To understand the polycentric governance of sustainability collaboration	Case study	IV
	5) What are the key barriers to sustainable business model innovation and how can societal change towards sustainable business models be promoted?	To identify barriers to sustainable innovations and how the innovation system actors can overcome them	Delphi study	V

Overall, the core of the thesis consists of five separate research projects which answer the five research questions in their respective publications. The findings of the individual publications and their contribution for advancing SOI are summarized in this overview section. The first two research questions are focused on the value and legitimacy of SOI. The *first research question* explores the process of creating sustainable value propositions, i.e. how suppliers can demonstrate the customer value of sustainable offerings. The *second research question* takes the point of view of the adopter of a SOI and examines how industrial firms can legitimize their new, (un)sustainable investments under conditions of institutional change. The concept of business value is generally concerned with the benefits given and received by different parties in business relations (e.g. value received by customers). Legitimacy in turn is related to the wider societal perceptions of a company and its actions. Having legitimacy with important stakeholders (e.g. government, employees, local communities) is vital for retaining an organization's license to operate.

The other three research questions are related to the role played by collaborative networks in advancing sustainability-oriented innovations. The *third research question* focuses on the roles of inter-organizational networks in advancing SOI and analyzes the different forms of these networks. The *fourth research question* expands on question three and explores the role of polycentric governance models in collaborative networks that focus on advancing SOI. Lastly, the *fifth research question* identifies the potential systemic barriers facing sustainable innovations and analyzes how they can be overcome by the different network actors.

1.4 Conceptual background

The *sustainability-oriented innovation* field, which forms the first of the two primary theoretical backgrounds for this thesis, is rooted in the wider field of research in corporate sustainability. Corporate sustainability is an emerging field that is closely related to other areas focusing on the relationships of businesses to wider society and nature and is concerned with issues such as corporate social responsibility (CSR), business ethics, and environmental management. Corporate sustainability aims to integrate the analysis of both the economic and social impacts of a firm's activities (Montiel, 2008). Many industries are emerging in markets where the products and services provided by firms are designed to improve sustainability. The wider cleantech field offers many examples of innovations designed to improve environmental sustainability[2]. In addition to technologies, various types of sustainable business model innovations have been identified (Bocken et al., 2014). For firms undertaking this type of innovation, their locus of competitive advantage lies in products and services which offer improvements to the state of the natural environment or which add to societal wellbeing. While environmental and social dimensions of sustainability are interrelated and both can improve the wellbeing of societies, there are considerable differences in the practices and drivers associated with them. This thesis therefore focuses primarily on *environmental sustainability.*

Second, this thesis emphasizes the commercialization of SOI, rather than their creation. For this purpose, the *second* primary theoretical grounding of the thesis is marketing theory. Marketing is concerned with the profitable creation of customer value through business offerings, and the commercialization of new innovations is often dependent on effective marketing activities (Aarikka-Stenroos and Sandberg, 2012; Chiesa and Frattini, 2011). Specifically, as the context of the study is resource-intensive industries, in which there are major opportunities for improving environmental sustainability, the thesis is grounded in the field of *industrial marketing*. Industrial marketing focuses on interactions and relationships among groups of firms marketing goods and services to each other, rather than consumers. This overall thesis is grounded primarily in the subfield of *sustainable industrial marketing* (Gupta et al., 2014), but the individual publications also utilize theories on *customer value* (Ulaga and Eggert, 2006) and *business networks* (Möller and Halinen, 1999; Möller and Rajala, 2007).

As a secondary theoretical background, this thesis also applies some insights from organizational theories. Organizational theories encompass a wide area of studies concerning the functioning, structure and behavior of organizations. Organizational theories have a wide range of applications in management studies, and their application has been shown to have considerable potential for sustainability research in connection to marketing (Connelly et al., 2011). Therefore, this study borrows ideas from *network theory* (Ahuja et al., 2012) for the study of the role of inter-organizational networks in

[2] Cleantech includes industries such as renewable energy, waste management, wastewater treatment, sustainable mobility and industrial efficiency-improving technologies.

sustainability. The thesis also applies *institutional theory* to the study of legitimacy, which is a central concept of this theoretical stream (Scott, 2014; Suchman, 1995). The theoretical positioning of the study is depicted in Figure 2.

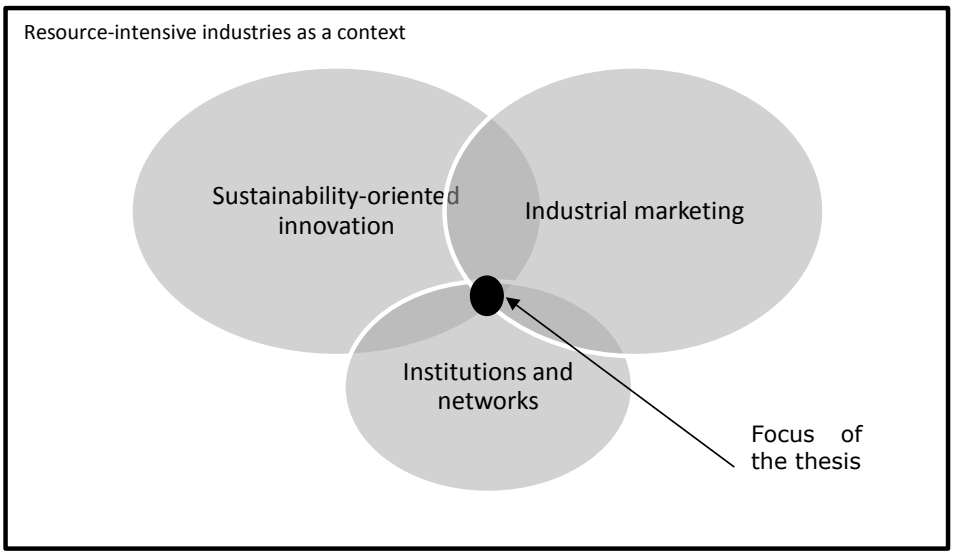


Figure 2: The theoretical positioning of the study

Contextually, the thesis focuses on resource-intensive industries. This industry context is especially suitable for examination as SOI have the potential to considerably improve ecological performance in these sectors, particularly in energy intensive and natural resource intensive industries, such as power generation, mining and metal refining and forest industry (Energetics, 2004). These mature industries consume scarce resources, and are under considerable pressure to restructure their operations by developing and adopting sustainable innovations. More specifically, the major industries where data is collected for this thesis include energy production, mining & metals refining, automotive production, forest industry as well as waste management.

1.5 Outline of the thesis

This thesis is divided into two main parts. Part I provides an overview of the study and Part II includes the individual publications, which address the objectives of the study. Part I begins with an introduction in chapter 1, which details the research background, research gap and the objectives and research questions of the study. Chapter 2 summarizes the current knowledge on the theoretical literature streams which form the background for

the thesis: sustainable innovation, sustainable marketing and organizational theory. Chapter 3 details the methodological choices, research methods, data collection and analyses related to the empirical part of this thesis. Chapter 4 summarizes the objectives, key findings and contributions from each of the individual publications. Chapter 5 ends Part I with the main contributions of the thesis, implications for managers and policy-makers, the limitations of the study as well as future research directions. The outline of the thesis is pictured in Figure 3.

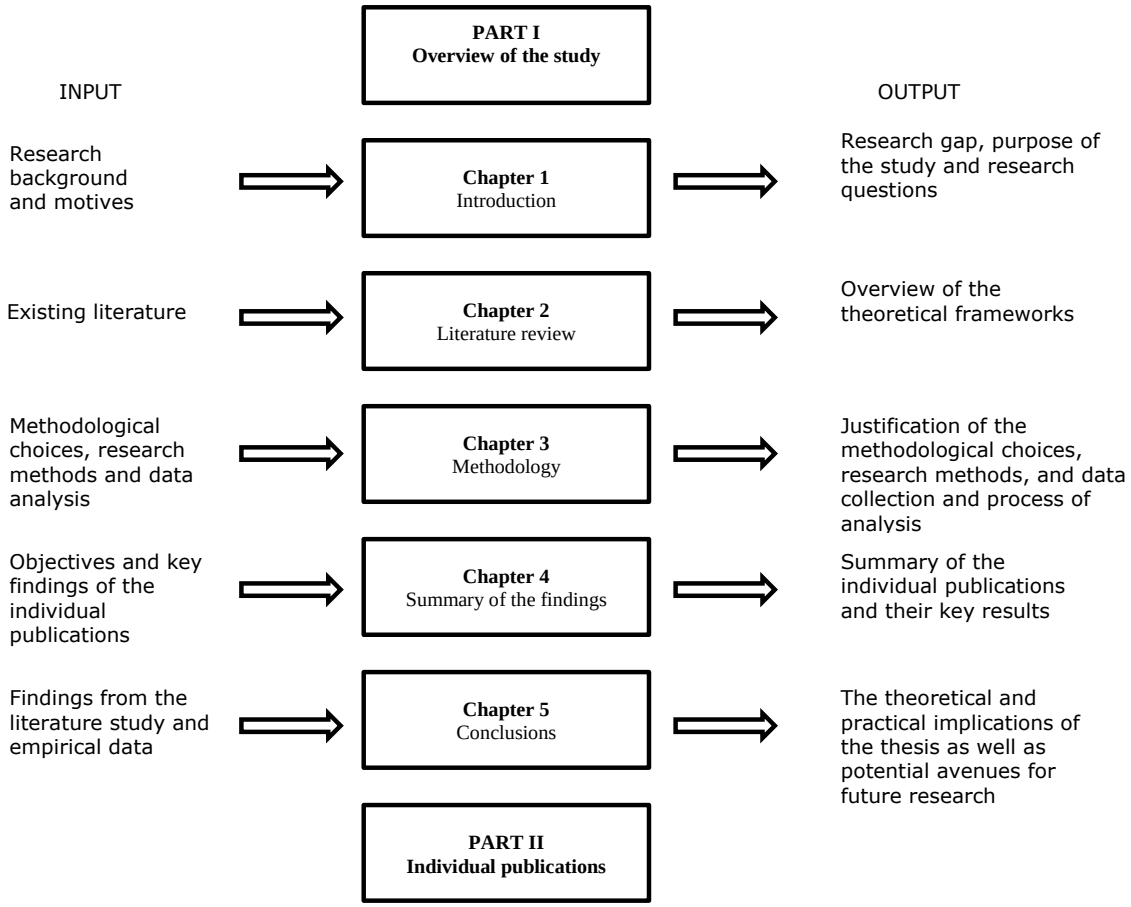


Figure 3: *Outline of the study*

2 LITERATURE REVIEW

This section will detail the theoretical background of the thesis. It is divided into three different subsections, corresponding to the three major streams of research in which the thesis is positioned: sustainability-oriented innovation (SOI), industrial marketing and organizational theory. The first section focusing on SOI will first detail the macro-scale drivers which create the need for the development of SOI. It will then continue by analyzing the characteristics and forms of SOI and finish by assessing the outcomes of SOI. The second subsection will focus on industrial marketing, and will review the current understanding of sustainability in industrial marketing. The third section will focus on the organizational theories relevant to the thesis topics. More specifically, it will detail the background with respect to the institutional and network theories that are utilized in the individual publications.

2.1 Sustainability-oriented innovation

The period of global development since the Industrial Revolutions has started to become known as the Anthropocene, a period where human actions are the main drivers of environmental change (Hoffman and Jennings, 2015; Zalasiewicz et al., 2010). A key basis for this term is the increased awareness of the limits of the planet in terms of resource use. A comprehensive study by Rockström et al. (2009) identified nine planetary boundaries, or categories of environmental impacts which have or will have a critical effect on human wellbeing and the functioning of ecosystems (Figure 4). In three of these categories, the safe limits for humanity have already been breached: biodiversity loss, the nitrogen cycle and climate change. Recent IPCC reports show that human-made missions during the industrial era have led to atmospheric CO_2 –levels unprecedented in human history (IPCC, 2015). The loss of biodiversity and ecosystem services has been growing rapidly, with the extinction of rate of species being at a level of 100-1000 times the normal background extinction rate (Steffen et al., 2015) Several others are approaching their safe limits: ocean acidification, freshwater use, change in land use and the phosphorus cycle.

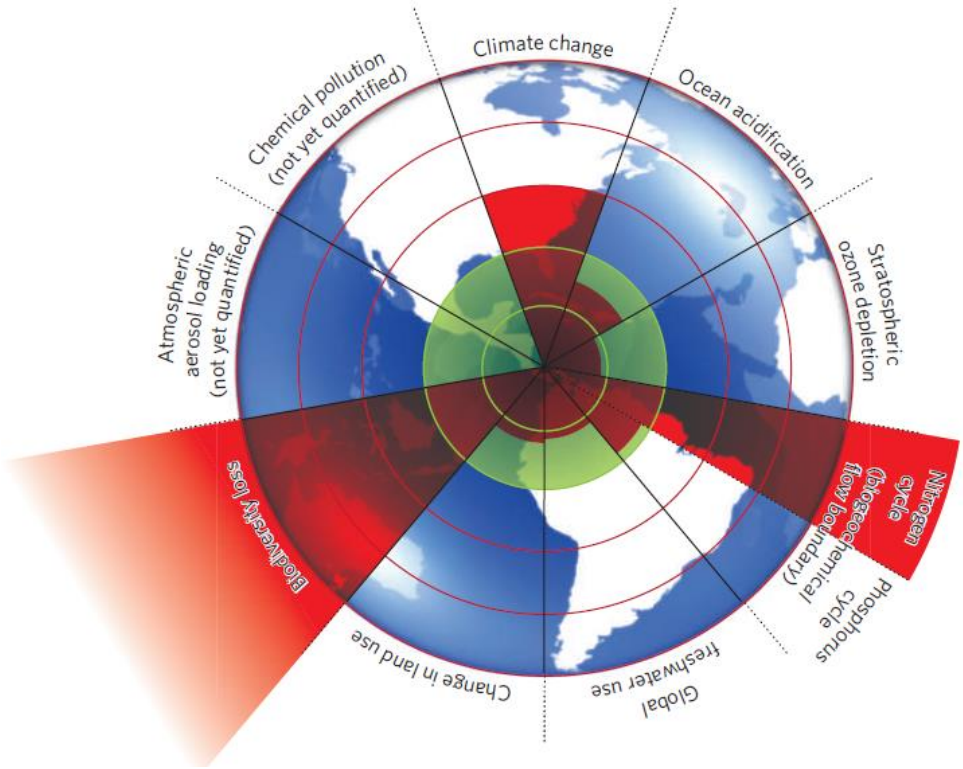


Figure 4: Planetary boundaries (Rockström et al., 2009)

The need to manage environmental and social impacts is also driving change in the business and management fields (Whiteman et al., 2013). Sustainability is considered a new strategic imperative and a potential source of competitive advantage (Berns et al., 2009; Porter et al., 2007). There is an increasing need for firms to integrate sustainability into their operations, due to various regulatory, stakeholder and competitive pressures (Porter et al., 2007). Sustainability is also increasingly a driver of the innovation activities of firms (Nidumolu et al., 2009) aiming to create products, services and solutions which result in shared value, i.e. the simultaneous provision of sustainability and business benefits (Porter and Kramer, 2011).

At the same time, sustainability-oriented innovations are not being developed and adopted rapidly enough to prevent large-scale environmental disasters. Analysts have estimated that the current levels of global production and consumption consume natural resources

50% quicker than ecosystems have the ability to regenerate, and that the environmental costs externalized each year from global production systems amount to approximately USD 4.7 trillion (O'Shea, T., et al., 2013 and Trucost, 2013). In the energy sector, the International Energy Agency (IEA, 2014) estimates that $53 trillion of cumulative investment in energy supply and energy efficiency is required by 2035 to limit warming to below 2°C. Yet, since 2010, coal-fired generation has grown more than all the non-fossil sources combined and the energy sector accounts for nearly 70% of all greenhouse gas emissions (IEA, 2014).

There are several interlinked fields of research in management which concern the relationships of business to wider society and the natural environment, and all consider sustainability to some degree. The *business ethics* literature is concerned with the ethical aspects and moral principle aspects of management, including their responsibility towards society (Surie and Ashley, 2008). The *corporate social responsibility* (CSR) literature is primarily concerned with the relationship of firms to various social issues and the promotion of societal wellbeing, but also sometimes addresses environmental concerns (Ketola, 2008). The *organizations and the natural environment* literature has it grounds in organizational theory, and is primarily concerned with the environmental aspects of sustainability and the relationship of organizations to the natural environment nature (Bansal and Gao, 2006). Last, the *corporate sustainability* literature aims to incorporate both environmental and social sustainability in corporate behavior (Montiel, 2008).

What is common for much of the research conducted in these research streams is the focus on responsibility or the obligation of firms to act sustainably. The primary concern is often on decreasing the footprint of the firm's activities on environmental and social systems. However, as evidenced by many businesses which have created a competitive advantage and shared value through their activities, sustainability can also be a business opportunity. The cleantech field is an example of firms creating new business by making industries more sustainable (Landry, 2007). Similarly, many consumer firms, such as Patagonia, The Body Shop and Unilever have made sustainability a key characteristic of their operations and have realized many new business opportunities due to that. These firms have focused on their sustainability handprint, i.e. how to create good rather than avoid doing harm.

The SOI field especially focuses on how firms make intentional changes in their organizations, processes, products and services to serve the specific purpose of creating social and environmental value in addition to economic profits (Adams et al., 2015). Sustainability-oriented innovation can take many forms, ranging from incremental innovations aimed at e.g. pollution prevention to large-scale radical innovations that can have an impact on large societal systems (Adams et al., 2015; Lubin and Esty, 2010). The next two subsections will detail the key characteristics and forms of SOI as well as the outcomes achieved by SOI.

2.1.1 Forms and characteristics of sustainability-oriented innovation

Many studies in the literature on SOI have attempted to define the characteristics of SOI and create classifications for different types of SOI. Several researchers have proposed that it is a process that occurs in stages (Adams et al., 2015; Lubin and Esty, 2010; Nidumolu et al., 2009). In a recent review, Adams et al (2015) characterizes SOI in three different stages of sustainability. The first stage is focused on operational optimization, where the focus is on reducing the environmental and social harm of operations by making incremental improvements in efficiency – while following a business-as-usual policy (Nidumolu et al., 2009). These kinds of innovations can provide value for the innovator in the form of decreased costs, but their potential for sustainable change is often limited (Lubin and Esty, 2010). An example of this type of innovation is 3M's Pollution Prevention Pays program. This program has been operating for 40 years as of 2015, and has prevented 2.0 million tons of pollutants and saved 3M $1.9 billion USD (3M, 2016).

The second stage focuses on organizational transformation, i.e. creating new sustainability-oriented products and services to produce shared value creation (Adams et al., 2015; Klewitz and Hansen, 2014; Nidumolu et al., 2009). A firm can capture new market opportunities through the SOI by catering to customers who want or require more sustainable products or services. For example, Dow has shifted its business from conventional chemicals into advanced materials and the high-tech energy technologies used in fields such as solar energy (Lubin and Esty, 2010). This shift to more advanced SOI also requires companies to collaborate with their supply chains and other stakeholders, such as NGOs, on sustainability issues (Nidumolu et al., 2009). Unilever is an example of a firm that has collaborated with its supply chain partners to make products such as coffee, tea and palm oil more sustainable (Nidumolu et al., 2009). Unilever has also collaborated with societal actors. Notably, it launched the Marine Stewardship Council (MSC) together with WWF to promote sustainable fishery practices.

The third stage, systems building, extends beyond the firm's boundaries to drive wider societal change towards sustainability. In essence, it focuses on new business models and wider collaboration with other organizations to create a net positive impact for sustainable development. These innovations have the greatest potential to improve sustainability, but often require the largest effort to achieve organizational change (Adams et al., 2015; Lubin and Esty, 2010). For example, Waste Management, based in the USA, has changed its business model from being a simple waste transporter to actively working with its customers to both reduce waste and realize added value from it (Nidumolu et al., 2009). Many innovations at this stage also aim at creating new platforms for network partners which aim to transform entire industries. For instance, Nike was one of the founding members of the LAUNCH platform, which aims at tackling various sustainability challenges through new innovations (LAUNCH, 2016).

Two key characteristics of stage one set incremental SOI apart from the more radical SOI in stages two and three. The first one concerns the level of importance in the organization. The innovations in the first stage are generally *operational* innovations while the more

advanced innovations are increasingly *strategic* (Lubin and Esty, 2010). In essence, this signifies a shift from footprint thinking to handprint thinking. The second key characteristic is the scale of the impact of the innovations. Incremental SOI are often *insular*, e.g. their impacts are usually limited to a firm's internal operations or the immediate supply chain (Adams et al., 2015). More radical SOI are increasingly *systemic* (Boons and Lüdeke-Freund, 2013), i.e. they consider multiple stakeholders and they can impact on the larger systems of organizations.

A stream of research in the SOI literature has studied sustainable business models as heuristics frameworks for incorporating sustainability into a firm's core operating logic (Bocken et al., 2014; Boons and Lüdeke-Freund, 2013). In this stream, sustainable value is defined as the bundle of measurable value provided by an offering, which includes environmental and/or social value in addition to economic value (Bocken et al., 2013; Boons and Lüdeke-Freund, 2013). Sustainable business models need to be able to turn the potential disvalue of environmental and social impacts into additional value for ecologically oriented customers (Jolink and Niesten, 2015). It also reflects business-society dialogue concerning the balance of economic, ecological and social needs since the values are temporally or spatially determined (Boons and Lüdeke-Freund, 2013).

SOI can be classified according to their type, or whether they are focused on technological, organizational or social/institutional change (Jay and Gerard, 2015). *Technological* innovations are aimed at developing new technological changes which impact sustainability, and it include innovations aimed at creating new products and services which improve sustainability (product innovation), improving production processes to improve sustainability (process innovation) and developing new infrastructure which improves sustainability (infrastructure innovation) (Jay and Gerard, 2015). *Organizational* innovations in turn is related to novel configurations in a firm's functions such as R&D, product development, etc. aimed at improving sustainability. (Jay and Gerard, 2015). Business model innovation can be defined as an example of organizational innovation, although in a broader sense business model innovation can also encompass the other forms of SOI (Bocken et al., 2014) *Institutional and social innovations* involve novel changes in the public sector's sphere such as regulatory changes as well as changes in the social sphere including customer consumption preferences and various norms aimed at improving sustainability (Jay and Gerard, 2015). The scale and impact of SOI generally increases going from technological to organizational to institutional/social innovations, but many SOI are likely to incorporate multiple innovation types (Jay and Gerard, 2015). For instance novel inter-organizational collaborations such as industrial symbioses and green supply chains often include elements of both organizational and technological innovation. More advanced SOI with a high impact are likely to incorporate all three innovation types (Jay and Gerard, 2015)

A recent study by Bocken et al. (2014) further classifies SOI into eight archetypes through the impacts of innovations on the business models of firms. These archetypes are summarized in Table 2. The first three archetypes are technologically oriented and focus

on innovation in products and manufacturing processes. *Maximizing material and energy efficiency* aims at eliminating emissions and optimizing the use of resources through techniques such as lean manufacturing and low-carbon manufacturing. *Creating value from waste* aims to eliminate the whole concept of waste by turning existing waste streams into useful and valuable input for other production processes, using methods such as industrial symbiosis. *Substituting with renewables and natural processes* addresses resource constraints associated with non-renewable resources, and aims at increasing sustainability through the increased use of renewable energy sources, such as wind and solar, as well as nature-inspired processes, such as green chemistry.

The next three archetypes are socially oriented innovations that focus on changing consumer behavior and creating innovations in the products and services offered to customers. *Delivering functionality rather than ownership* is based on the literature on Product Service Systems (Beuren et al., 2013), which is concerned with reducing consumption by offering a combination of products and services that reduce material use when compared to the same functionality provided by physical products. *Adopting a stewardship role* aims to ensure the long-term health and wellbeing of stakeholders, while maximizing positive social and environmental impacts through upstream and downstream stewardship, as is the case with fair trade products. *Encouraging sufficiency* seeks to reduce both production and demand-side consumption by ensuring product durability and longevity, and responsible product distribution and promotion (Bocken et al., 2014).

The last two archetypes seek wider organizational and cultural changes in business practices. *Re-purposing the business for society and the environment* aims to prioritize the delivery of social and environmental benefits rather than economic profit maximization through close integration between firms, local communities and other stakeholders. Examples of this archetype include for example social enterprises, non-profit initiatives and base-of-the-pyramid initiatives aiming at improving well-being in poor countries. Ultimately, *developing scale-up solutions* aims to maximize benefits by delivering sustainable solutions on a large scale, to maximize economies-of-scale (Bocken et al., 2014). They address the issue that while radical innovations for sustainability are often developed in start-ups and SMEs, these organizations seldom have the resources to scale up the innovation to have larger impact. Scale-up solutions include models such as licensing and franchising as well as novel approaches such as open innovation, crowdsourcing and crowdfunding which often utilize the Internet for rapid scale-up of new innovations.

Table 2: Archetypes of SOI

Innovation type	*SOI archetype*	*Aim*	*Examples*
Technological	*Maximize material and energy efficiency*	Optimized use of resources; 'do more with fewer resources'	Low carbon manufacturing; Lean manufacturing; Dematerialization (of products/ packaging); Increased functionality (to reduce total number of products required)
	Create value from waste	Elimination of the concept of waste; reduced waste and virgin material use	End-of-life strategies (reuse, refurbish, remanufacture, recycle); Closed-loop supply chain management; Cradle-to-cradle; Industrial symbiosis
	Substitute with renewables and natural processes	Reduced use of non-renewable resources, emissions associated with burning fossil fuels, and synthetic waste to land-fill	Substitute with renewable resources; Move from non-renewable to renewable energy sources; Renewables-based energy innovations; Biomimicry; Green chemistry
Social	*Deliver functionality rather than ownership*	Maximized use of products; business focus on satisfying user needs without users having to own physical products	Product-oriented product service systems; Use-oriented product service systems; Result-oriented product service systems
	Adopt a stewardship role	Stakeholders' long-term health and wellbeing, and maximized positive social/environmental impacts through upstream and downstream stewardship	Ethical trade; Fair trade; Biodiversity protection; Resource stewardship; Radical transparency regarding environmental/social impacts; Consumer care
	Encourage sufficiency	Reduced production and consumption; reduced overconsumption on the systems level	Consumer/user education; Product durability and longevity; Responsible product distribution and promotion; Market places for second-hand goods; Shared ownership; Collaborative consumption
Organizational	*Re-purpose the business for society/environment*	Prioritized delivery of social and environmental benefits (rather than economic profit maximization)	Not for profit; Social business; Hybrid business; Base of pyramid solutions; Alternative ownership: cooperatives and collectives
	Develop scale-up solutions	Maximized benefits for society and the environment by delivering sustainable solutions on a large scale	Licensing; Franchising; Collaborative models; Co-creation; Open innovation; Crowdsourcing, Crowdfunding

To summarize, SOI can take many different forms and the focus of innovation can be on creating more sustainable products and services, improving the sustainability of wider industrial processes or achieving social and organizational change to reorient organizations towards sustainability. The sustainability aims of SOI range from incremental improvements to shared value creation and ultimately to net positive impacts on environmental and societal wellbeing. In general, the higher stages of SOI require an

increasingly systemic view in order to incorporate business networks, customers, public sector and other stake-holders into collaborative activities for new innovations.

2.1.2 The outcomes of sustainability-oriented innovation

At the macro level, increased awareness of planetary limits (Rockström et al., 2009). and the resulting impacts of environmental disasters make a clear case for increasing sustainability from a financial standpoint and well as a practical standpoint (Stern, 2008). However, at the micro-level of corporations the business case for sustainability is not entirely clear. Basic market logic would suggest that internalizing the externalities generated by firms would incur costs for them. At the same time, the underlying logic of sustainability suggests that it will pay off in the long-term (Slawinski and Bansal, 2015). Therefore, a great deal of research has attempted to find a link between corporate sustainability and improved market performance (for a review, see (Orlitzky et al., 2003).

Studies on the business case of sustainability suggest that while there is no clear correlation between corporate sustainability and corporate financial performance, there are some aspects of operations where sustainability makes clear business sense (Henderson, 2015; Schaltegger et al., 2012). SOI can pay off in several ways in the short term. The first is through *cutting costs* through more efficient resource use. This can be the result of improved eco-efficiency, i.e. reducing the costs of using material, energy or services (Ambec and Lanoie, 2008). It can also result from improving the productivity of employees through a better corporate image which can help to attract more productive employees or increase the motivation of existing employees (Branco and Rodrigues, 2006). Third, it can result in lower costs for capital as investors are increasingly considering sustainability as a criterion in their investment decisions (Ambec and Lanoie, 2008).

Firms can also *reduce their business risks* by adopting SOI. Firms face various risks related to sustainability, such as risks from changing regulations, the risk of litigation for environmental and social damage, the risks of paying clean-up costs for environmental accidents as well as the risks of losing their reputation or license-to-operate (Dickson and Chang, 2015; Hockerts, 2015). Examples such as the Volkswagen emissions scandal in 2015 (BBC, 2015) or the BP Deepwater Horizon Oil Spill in 2010 are examples of the extent of risks that firms can face when their sustainability performance is not up to par.

Firms can also use SOI to *capture market share from sustainability-oriented customer segments*. Sustainable products and services can be sold for a premium price compared to alternatives. A sustainable brand can also help attract and acquire new customers. Third, it can help in customer retention – if customers feel increased loyalty to a sustainable brand. Finally, a sustainable brand may help suppliers attract and increase customers and customer revenue (Dickson and Chang, 2015; Hockerts, 2015).

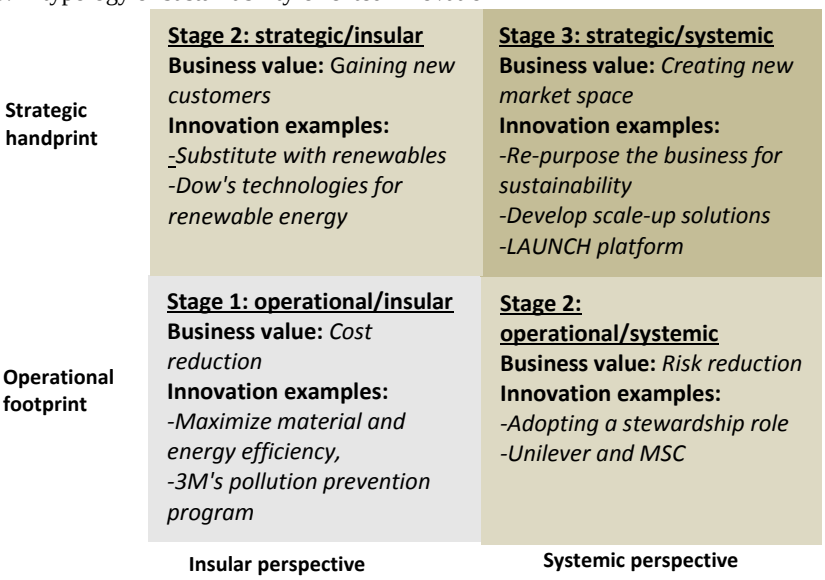
On a long-term basis, sustainable innovations can be seen as a method to hedge risk against change in the business environment and *create competences to survive in the future* business environment (Henderson, 2015; Hockerts, 2015). If the regulatory environment or customer demands drastic change in the future, corporations need to be prepared for this beforehand. An example of this risk-hedging would an energy utility with a large existing portfolio of fossil-fuel based production investing in renewable energy. Future business opportunities could include, for example, cleantech ventures or base of the pyramid initiatives, which aim at meeting the unmet needs of low-income populations (Hockerts, 2015). SOI can thus have a high impact on the future competitive advantages of a firm. Table 3 summarizes the business benefits of SOI.

Table 3: The business benefits of SOI (Ambec and Lanoie, 2008; Henderson, 2015; Hockerts, 2015)

Capturing new customers through improved brand	**Creating new market space**
Premium Pricing Customer Acquisition Customer Retention Share of Wallet	Commercialization of Sustainability Competencies Cleantech Venturing Base of the Pyramid
Increased operational efficiency	**Decreased operational risks**
Eco-efficiency Employee Productivity Cost of Capital	Accident Risk Litigation Risk Regulatory Risk Campaign Risk Reputation Risk License to Operate

Figure 5 summarizes the literature on sustainability and on sustainability-oriented innovation. SOI can be considered to occur in stages from incremental to more radical innovations. Two important characteristics of more advanced SOI are the shift from operational to strategic innovations and a shift from insular to systemic innovations. Stage 1 innovations typically have an operational focus and an insular perspective. Stage 2 innovations can take two forms: strategic innovations with an insular perspective and operational innovations with a systemic perspective. Stage 3 innovations are characterized by a strategic focus and systemic perspective. Various archetypes for SOI have been identified, including technological, social and organizational innovations. The business benefits provided by SOI are also often different depending on the type of innovation. Stage 1 innovations provide operational cost reductions, stage 2 innovations provide decreased operational risks or new customers and stage 3 innovations aim to create a completely new market space.

Figure 5: A typology of sustainability-oriented innovation



Despite the apparent benefits, many challenges still exist to the development and adoption of SOI. One of these is the value potential of sustainable offerings. Firms do not always adopt SOI even though the financial benefits for doing so are clear, as evidenced by the energy efficiency paradox (DeCanio, 1998) Studies have shown that firms which are able to effectively demonstrate and communicate the advantages of their sustainable offerings are in a better position to advance SOI (Pinkse and Dommisse, 2009; Ramirez et al., 2014). Suppliers of SOI also need to be careful about how they communicate sustainability. Customers can also perceive sustainability in a negative light, if the other attributes of the offering do not resonate with the characteristics of sustainability. For example, sustainability liability has been recognized as an issue for offerings which simultaneously promote strength-related attributes (Luchs et al., 2010). Publication I explores how different economic, environmental and social sustainability attributes can be demonstrated to customer in order to improve the adoption of SOI.

Another challenge is that SOI do not always result in increased sustainability. For example, Jevons' paradox states that the improved relative efficiency of production in many industrial processes has actually led to a rebound effect, where the absolute consumption of materials increases as a result of the increased demand and efficiency of production (Alcott, 2005). Firms undertaking these innovations need to thus take a systemic view to assess the outcomes and consider the needs of multiple network partners. In essence, firms need *collaborative relationships and networks* to develop and commercialize SOI (Rizzi et al., 2013). These are explored in publications II and III.

Some firms also engage in outward sustainable behavior such as green PR and corporate communications but do so without substantial action to back up their public image. Such concerns have resulted in customer skepticism towards greenwashing, or unsubstantiated sustainability claims for commercial offerings. Firms therefore need to thus use various strategies in order to gain *legitimacy* from their stakeholders for SOI (Parguel et al., 2011). Legitimacy strategies are explored in publication II.

2.2 Sustainability in the industrial marketing literature

Much of the academic interest in marketing sustainability-oriented innovations has focused on consumer marketing. Due to the multidisciplinary nature of sustainability, scholars have addressed sustainable marketing in a variety of research streams, including *green marketing* (Kalafatis et al., 1999), *environmental marketing* (Peattie, 1995), *ecological marketing* (Fisk, 1974; Henion and Kinnear, 1976) and *enviropreunial marketing* (Menon and Menon, 1997). Given that sustainability is concerned with meeting customers' economic, environmental and social needs (Brundtland and Khalid, 1987), this research has largely focused on how to create value for the customer and society while reducing environmental impacts (Brezet and Hemel, 1997), and how to incorporate environmental and social criteria into marketing activities (Chamorro et al., 2009; Leonidou and Leonidou, 2011). Another related research stream in marketing, *macromarketing*, focuses on the impacts of marketing to the surrounding society and the natural environment (Fisk, 1982).

In the industrial marketing literature, research on sustainability has been considerably scarcer than in consumer marketing. The key studies on sustainability in industrial marketing are listed in Table 4. These are based on a systematic review of recent articles in key journals in in the area of industrial marketing[3]. The studies have, thus far, focused largely on *green/sustainable supply chain management*, which is focused on the actions required to make industrial supply chains more sustainable. While green supply chain management is an important research area in the supply chain management literature (Quarshie et al., 2016), it has also received considerable attention in the industrial marketing field due to the importance of inter-organizational relations and networks. The relationship between green (consumer) marketing and the need to make supply chains more sustainable is a key issue that has been addressed in many studies. More specifically, these studies have focused on how to reduce the environmental impacts of a firm's

[3] The database search covered four key journals in the field: *Industrial Marketing Management, Journal of Marketing, Journal of the Academy of Marketing Science* and *Journal of Business Research.* The journals were selected by two criteria: relevance to the field of industrial marketing and having an impact factor higher than 1,5. The time period covered the years 2008-2016. Used keywords included "Sustainability OR sustainable development AND B2B OR business-to-business" One key study outside of the time period (Drumwright, 1994) was added through an analysis of the references of the found articles

operations and the signal sent to external stakeholders regarding commitment to environmental values (Gupta et al., 2014; Sharma et al., 2010). Some studies have also focused on the relationship of sustainability to a firm's *public image*. Advancing SOI can be boosted by green branding activities (Kumar and Christodoulopoulou, 2014; Sheth and Sinha, 2015). Sustainability can also have an impact on a firm's reputation (Hoejmose et al., 2014) as well as its legitimacy (Czinkota et al., 2014).

Several studies have also examined the customer side of the *adoption of sustainable offerings*. A study by Drumwright (1994) found that sustainability can be a key buying criteria for organizational buyers. In investigating customer perceived barriers to adopting environmentally sustainable offerings in industrial markets, Ramirez et al. (Ramirez et al., 2014) found that the inability of suppliers to communicate their economic and environmental benefits to their customers was a major factor that reduced their customers' willingness to buy. On a broader scale, suppliers of SOI often need to engage in market-shaping practices to encourage demand and build supportive infrastructure for sustainable offerings (Doganova and Karnøe, 2015; Onyas and Ryan, 2015). The integration of sustainability considerations into new product development (NPD) has also received some attention in the literature (Genç and Di Benedetto, 2015; Sharma and Iyer, 2012)

A few studies have also advanced a *network-level view* of sustainability. Sustainability can play a role in the co-creation of value in business networks, as suppliers create sustainable value together with both direct customers and end customers (Lacoste, 2016). Network mobilization can also play key roles in the collaboration between various actors (firms, public sector organizations, NGOs) when solving specific environmental issues (Ritvala and Salmi, 2011, 2010). Several of the studies on sustainable supply chains also utilize the network perspective to analyze their supply chains (Brindley and Oxborrow, 2014; Chan et al., 2012; Lee and Lam, 2012; Mariadoss et al., 2011).

Table 4: Key studies focusing on sustainability in B2B marketing

Study	Type of study	Objectives	Focus area and key concepts	Publication name
Sustainable supply chain management focus				
(Bourlakis et al., 2014)	Empirical, survey	Performance measurement	Sustainable supply chains	Industrial Marketing Management
(Brindley and Oxborrow, 2014)	Empirical, case study	Exploring sustainable procurement requirements, green marketing needs and impacts on SCM practices	Sustainable supply chains, green marketing	Industrial Marketing Management
(Chan et al., 2012)	Empirical, survey	Exploring the relationships between environmental orientation, GSCM and corporate performance	GSCM, environmental orientation	Industrial Marketing Management
(Cheng and Sheu, 2012)	Empirical, survey	Exploring the impact of the relationship orientation on GSCM	Green supply chain management GSCM, inter-organizational relationships	Industrial Marketing Management

(Hoejmose et al., 2012)	Empirical, survey	Exploring GSCM in B2C and B2B markets and the role of top management and trust in GSCM practices	GSCM, trust, environmental management	Industrial Marketing Management
(Hoejmose et al., 2014)	Empirical, case study	Examining the relationship between responsible supply chain management and corporate reputation	Responsible supply chain management, reputation	Industrial Marketing Management
(Lee and Lam, 2012)	Empirical, case study	Exploring the role of reverse logistics in sustainable industrial marketing	Reverse logistics, closed-loop supply chains, green marketing	Industrial Marketing Management
(Liu et al., 2012)	Empirical, interview study	Forming a normative framework for the integration of green marketing and sustainable supply chains	Sustainable supply chain management, green marketing	Industrial Marketing Management
(Sharma et al., 2010)	Conceptual	Exploring the role of marketing in sustainable supply chains and forming a framework for sustainability in B2B marketing	Sustainability, green marketing, recycling, build-to-order, repair, reverse logistics	Industrial Marketing Management
(Oruezabala and Rico, 2012)	Empirical, interview study	Investigating the impact of sustainable public procurement on supplier management	Sustainability, public procurement	Industrial Marketing Management
Public image, branding and legitimacy				
(Czinkota et al., 2014)	Conceptual	Exploring the relationships between legitimacy, reputation, branding and GSCM	Legitimacy, sustainable supply chains, curative marketing	Industrial Marketing Management
(Homburg et al., 2013)	Empirical, survey	Exploring the role of CSR in B2B markets	CSR, B2B marketing, customer-company identification, trust	Journal of Marketing
(Kumar and Christodoulopoulou, 2014)	Conceptual	Exploring the role of branding in promoting sustainability	Sustainability, branding	Industrial Marketing Management
(Sheth and Sinha, 2015)	Empirical, case study	Exploring how sustainability can be leveraged to build reputation in emerging markets	Emerging markets, B2B branding, corporate reputation, sustainability marketing	Industrial Marketing Management
Adoption of sustainable offerings				
(Doganova and Karnøe, 2015)	Empirical, case study	Exploring the construction of markets for clean technologies	Cleantech, sustainability, market innovation	Industrial Marketing Management
(Drumwright, 1994)	Empirical, case study	Exploring the role of sustainability criteria in organizational buying behavior	Socially responsible organizational buying	Journal of Marketing
(Onyas and Ryan, 2015)	Empirical, ethnography	Exploring the transformation of a mainstream market into a new sustainability market;	Market innovation, agencements, agencing	Industrial Marketing Management
(Ramirez et al., 2014)	Empirical, interview study	Identifying the barriers and bridges to the adoption of sustainable offerings	Environmentally-sustainable offerings, adoption	Industrial Marketing Management
Sustainability and business networks				

(Lacoste, 2016)	Empirical, case study	Exploring the co-creation of sustainable value in B2B-markets	Value co-creation, business networks	Industrial Marketing Management
(Ritvala and Salmi, 2010)	Empirical, case study	Exploring the role of networks in solving environmental issues	Mobilization, environmental issues, value-based networks	Industrial Marketing Management
(Ritvala and Salmi, 2011)	Empirical, case study	Exploring the target firms of network mobilization for environmental issues	Mobilization, environmental issues, value-based networks	Industrial Marketing Management
Sustainable marketing resources and capabilities				
(Crittenden et al., 2011)	Conceptual	Forming a market-oriented sustainability framework	Sustainability, market orientation, CSR, resource-advantage theory	Journal of the Academy of Marketing Science
(Mariadoss et al., 2011)	Empirical, case study	Exploring the relationships between marketing capabilities, innovation-based sustainability strategies, sustainable behavior and competitive advantage	Marketing capabilities, innovation, sustainability, B2B firms	Industrial Marketing Management
(Ruyter et al., 2009)	Empirical, survey	Exploring the antecedents and consequences of environmental stewardship in frontline business-to-business (B2B) teams	Environmental stewardship, boundary-spanning teams	Journal of the Academy of Marketing Science
Reviews and definitions of sustainable marketing				
(Chabowski et al., 2011)	Review	Reviewing sustainability research in marketing and forming a research agenda	Corporate sustainability, corporate social responsibility (CSR), corporate environmental responsibility	Journal of the Academy of Marketing Science
(Closs et al., 2011)	Empirical, grounded theory	Defining the dimensions of sustainability activities	Corporate sustainability, dimensions of sustainability	Journal of the Academy of Marketing Science
(Connelly et al., 2011)	Conceptual	Forming a theory toolbox for sustainability research	Sustainability, organizational theory	Journal of the Academy of Marketing Science
Sustainability and new product development (NPD)				
(Genç and Di Benedetto, 2015)	Empirical, survey	Examining the integration of environmental specialists into new product development teams	Sustainable new product development, cross-functional integration	Industrial Marketing Management
(Sharma and Iyer, 2012)	Conceptual	Exploring the role of resource-constrained development approaches in green product development	Sustainability, green marketing, frugal engineering, new product development	Industrial Marketing Management

However, what still remains relatively less well understood is the role of technology suppliers in sustainable marketing (Chan et al., 2012). Technology suppliers thus often fall outside the core activities related to greening a supply chain, and their role has been recognized to be under-researched (Chan et al., 2012). Their role can however be vital, since many manufacturers invest in green technologies to reduce the environmental footprint of their products (Chan et al., 2012). But the current frameworks in green marketing related to greening the supply chain and green communications do not

sufficiently address the technology supplier's activities in improving the sustainability of industrial processes. Suppliers of sustainable technologies need to be able to convincingly demonstrate the value of their offerings to their customers. In industrial markets, the uncertainty concerning customer value is likely to be higher, since sustainable offerings may involve novel and expensive technologies, high information asymmetry between supplier and buyer, and intangible benefits that are difficult to evaluate (Schweitzer & Aurich, 2010).

The conventional view in industrial marketing is that suppliers use *customer value propositions* to demonstrate and communicate the value a supplier's offerings delivers to customers (Anderson et al., 2006; Ballantyne et al., 2011). A value proposition reflects a firm's core strategy of how it will serve its customers (Lehmann & Winer, 2008). In essence, a customer value proposition defines how a firm's resources and offerings translate into value for its customer. In the industrial marketing literature, *customer value propositions* are considered to be marketing messages (Ballantyne et al., 2011). Conventionally, customer value propositions have been defined as statements of the benefits of a particular product or service (Rintamäki et al., 2007). Therefore, one of the objectives of this thesis is to explore how sustainability can be integrated into the value propositions of industrial offerings, which is explored in publication I.

Furthermore, SOI has been theorized to have an impact on a firm's *legitimacy* to its customers, supply chain partners and the wider stakeholder network. Legitimacy is a requirement for an organization, as it cannot survive without acceptance from its major stakeholders (Czinkota et al., 2014). Legitimacy building is a vital process for building markets for new innovations (Humphreys, 2010), and new innovations which involve a higher amount of legitimation work from innovators are more successful (Rao et al., 2008). While the need to manage the legitimacy of SOI has been implicitly acknowledged in the literature on market shaping (Doganova and Karnøe, 2015), there is still a lack of research on the specific strategies of legitimacy management in relation to SOI. This thesis thus addresses this topic through the second research question. The theoretical background on legitimacy, as seen through the lens of the neo-institutional theory, will be reviewed in more detail in the next subsection (see section 2.3.1).

In addition, the use of the network perspective has a long tradition in industrial marketing. For instance, the industrial network approach (INA) views business relationships as interdependent systems of actor bonds, resource links and activity ties (Håkansson and Snehota, 1995). Firms need to manage bundles of interconnected relationships with customers, suppliers, public sector organizations and other parties in order to achieve their goals in the market (Ritter et al., 2004). There is also an emerging research stream focusing on innovation through network collaboration. Firms are increasingly dependent on external partners for the purpose of both developing (Dhanaraj and Parkhe, 2006; Fichter, 2009) and commercializing (Aarikka-Stenroos et al., 2014; Chiesa and Frattini, 2011) new innovations. Powerful firms can act as orchestrators in their innovation networks (Dhanaraj and Parkhe, 2006). Various networks actors, such as customers,

distributors, expert partners, policymakers and public sector organizations are needed to facilitate the innovation process.

The network perspective has been utilized in some studies that focus on sustainability in the B2B context, but a comprehensive view on the role of networks in advancing SOI is lacking. Aside from green supply chain management practices, network organizing in regards to sustainability has been lacking in industrial marketing research. More specifically, there is a need to explore the different forms of networks that can advance SOI, and the governance forms of those networks. For instance, industrial symbiosis is another network form organizing aiming at improved sustainability. This phenomenon has received considerable attention in the literature on SOI, but has been neglected in marketing research. This limits the understanding of how industrial firms may improve sustainability in their value networks. In addition, sustainability collaboration in networks often has to accommodate for a wider variety of stakeholder interests compared to traditional business networks that have been of interest to industrial marketing scholars. Novel governance arrangements are thus needed to accommodate this. The third and fourth research questions in this study will focus specifically on the role of networks for SOI and their governance. More theoretical backgrounds from network theory will be presented in section 2.3.2.

To summarize, sustainability in B2B marketing is mostly considered from a supply chain 'greening' perspective and improved product sustainability is used as a marketing message to be sent to end customers, generally consumers. Several research gaps exist in the literature on issues recognized as critical within industrial marketing, but thus far they have not been adequately addressed in the context of SOI. The SOI context has several characteristics which differ from other industrial markets, namely the high business complexity of the involved actors, their dependence on regulations, the strong impacts on stakeholder interests as well as multidimensional value creation. In the next section, the theoretical background of the thesis will be further deepened with insights from organizational theories relevant to the research areas.

2.3 Organizational theories in sustainability research

Organizational theories have been of considerable interest to management and business scholars studying sustainability in various fields, such as strategic management (Sharma and Vredenburg, 1998), environmental management (Hoffman, 2003), marketing (Connelly et al., 2011) and supply chain management (Tachizawa and Wong, 2015). For example, Connelly et al. (2011) examined nine different organizational theories and their implications for studying sustainability in marketing. These included theories related to the emergence and purpose of the firm and the creation of competitive advantage, the role of upper management and the owners of the firm, and the relationship of the firm to its external environment. An emerging stream of literature on *organizations and the natural environment* focuses on the intersection of organizational theory with studies of environmental sustainability.

Since the primary focus of this study is on advancing sustainable innovation, it focuses mainly on the role of proactive organizations and their ability to influence other organizations in the environment they are operating in. For this purpose, two organizational theories related to the relationship of the firm to its external environment were specifically chosen to further develop the theoretical background of this thesis: institutional theory and network theory. The section is structured as follows. The next two subsections will first discuss the background of the theory in question, and will then discuss how the theory has been previously applied in the context of sustainability-oriented innovations.

2.3.1 **Institutional theory**

The study of institutions has been of interest to economists, sociologists and political theorists. All of these disciplines have a somewhat different view of institutions, but overall they view institutions as mechanisms which provide social order in society (Scott, 2014). This subsection will detail two streams of institutional theory which have been applied in the thesis: *neo-institutional theory and economic institutionalism*. Lastly, it will discuss their *application* in the context of sustainability-oriented innovation.

Neo-institutional theory

The sociological branch of institutional theory, or the *neo-institutional theory*, has emerged in recent decades as a highly influential theory with which to explain the relationship between organizations and their social context (Dimaggio & Powell 1991; Scott, 2014). In this view, institutions can be defined through the three pillars of institutionalism that provide stability for social activities: the *regulative*, *normative* and *cultural-cognitive* elements (Scott, 2014). Organizations adapt to these elements in order to establish themselves as socially acceptable or legitimate actors (Suchmann 1995). It can be said that the prime proposition of institutional theory is that in order to survive, organizations must gain *legitimacy* by earning it from their constituents, e.g. business partners, public sector, wider society, etc. (Connelly et al., 2011).

Legitimacy can be defined as "an assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman, 1995). In general, organizations first attempt to gain legitimacy from their key stakeholders, such as customers, owners and the government; and afterwards they expanded their legitimized activities to macro-scale audiences, such as wider society (Johnson et al., 2006).

Various categorizations of legitimacy have been suggested by the existing research (Deephouse and Suchman, 2013). One of the most commonly used was proposed by Suchmann (1995). He divided legitimacy into pragmatic, moral and cognitive elements. *Pragmatic legitimacy* rests primarily on instrumental logic and the self-interest of individuals and organizations (Suchman, 1995). In this form, the legitimacy of an action or organization is determined by how it provides value to its constituents. Pragmatic

legitimacy is the widely accepted basis for evaluating market organizations, whose actions are primarily evaluated by how much value they bring to shareholders. *Moral legitimacy* is determined by whether or not the action or organization is congruent with the norms and moral values of the social environment and is therefore "the right thing to do" (Suchman, 1995). Moral legitimacy provides much of the basis for corporate social responsibility, in which market organizations undertake activities outside of their core business in order to meet stakeholder expectations of what is considered societally correct. Lastly, *cognitive legitimacy* refers to the degree to which an action or organization is understood and known by society (Suchman, 1995). A high degree of cognitive legitimacy means that an action is simply considered the natural state of things by the evaluator, and the alternatives are not even considered. This differentiates cognitive legitimacy from the other two forms as it does not require conscious judgment from the evaluator (Suchman, 1995). In a capitalist society, the market can be considered to have high cognitive legitimacy as the basis for exchange.

As organizations strive for legitimacy in their environment, they become homogenous and similar to each other. This happens through the forces of isomorphism, which make institutions stable and persistent (Dimaggio & Powell, 1983). The mechanisms of isomorphism can be divided into three broad categories: *coercive isomorphism* stemming from pressures exerted by those regulators and other actors that an organization is dependent on for resources; *normative isomorphism* originating from influential actors in the field, such as consultants, media and trade associations; and *mimetic* isomorphism which originates from organizations imitating those competitors who are the perceived leaders in the field (Dimaggio & Powell, 1983; Scott, 2014). Table 5 summarizes the pillars of institutions, their mechanisms of isomorphism and the primary bases of legitimacy.

Table 5: The three pillars of institutions (Scott, 2014)

	Regulative	**Normative**	**Cultural-cognitive**
Logic	Instrumentality	Appropriateness	Orthodoxy
Mechanisms of isomorphism	Coercive	Normative	Mimetic
Basis of legitimacy	Pragmatic	Moral	Cognitive

Legitimacy management refers to organizations attempting to increase their own legitimacy either by conforming to existing expectations or attempting to change them. Organizations may seek to legitimate themselves either substantially or symbolically (Suchman, 1995; Ashforth & Gibbs, 1990). Substantive management refers to concrete and material change in an organization's processes and activities, which can involve, for

example, a firm undertaking a local community development project in order to increase legitimacy within its local community. Symbolic management involves portraying socially accepted norms and values and transforming the meaning of acts primarily through corporate narratives (Ashforth & Gibbs, 1990). Firms conduct various forms of symbolic management, for example, in their annual reports and media press releases.

Economic institutionalism

The sociological view of institutionalism is not the only branch of institutional studies with considerable influence in the management field. The study of institutions has also been of interest to scholars in economic institutional studies. *Evolutionary economics* in particular is a stream of research which views institutions as vital parts of economic and technological development (Nelson, 2008; Nelson and Nelson, 2002). Evolutionary economists view institutions as the routines, or *social technologies* required to utilize physical technologies. For example, the coordination processes and division of labor associated with an industrial process are the social technologies which complement the physical technologies in the process (Nelson and Nelson, 2002). Institutions can be thus considered the wider governance structures which define the rules of the game in economic systems (North, 1990; Williamson, 1998).

The stream of research on economic institutionalism has given rise to interest in *innovations systems*, which are the wider societal structures that support new innovations (Bergek et al., 2008; Nelson and Nelson, 2002). Innovation systems are comprised of the various actors, their networks of relationships and the supporting institutions for specific innovations (Bergek et al., 2008). These structural elements provide various functions in an innovation system, such as entrepreneurship for new innovations, knowledge development, legitimation and resource mobilization (Bergek et al., 2008; Hekkert et al., 2007). The functions directly influence the development, diffusion and use of new technology, and thus the performance of the innovation system (Bergek et al., 2008).

Institutional theories and sustainability

Institutional theories have received considerable interest from scholars studying sustainability. The neo-institutional theory has been applied by researchers interested in examining field-level change in the uptake of sustainability practices (Hardy and Maguire, 2010; Hoffman, 1999; Jennings and Zandbergen, 1995), and by researchers interested in more micro-level institutional processes, such as organization-level change (Battilana and Dorado, 2010), the management of the legitimacy of organizations (Joutsenvirta and Vaara, 2015) and the activities of institutional entrepreneurs (Wijen and Ansari, 2007). On the macro-level, previous research has focused on how sustainability issues can form novel fields outside of the traditional ones that focus on specific industries (Hoffman, 1999). These fields can generate and diffuse new sustainability-oriented innovations, such as environmental management methods (Jennings and Zandbergen, 1995), or pollution prevention activities, within organizations (Hardy and Maguire, 2010)

From the organizational point of view, organizations face competing logics regarding action: namely the logic of market organization, emphasizing business efficiency, which conflicts with the logic that an organization should consider societal and environmental values (Greenwood et al., 2015). Those two logics place competing and contradictory demands on firms because they have to maximize their business efficiency and shareholder value, while at the same time minimizing their negative impacts and maximizing their positive impacts in their environmental and societal dimensions. These competing logics have led some organizations to adopt a *hybrid logic* and purposefully combine business goals with societal and environmental ones (Greenwood et al., 2015). Hybridity in the context of sustainability-oriented innovations will be discussed in publications II and III.

With the demands arising from conflicting institutional logics, firms have to undertake various substantive and symbolic action to manage their legitimacy (Bansal and Clelland, 2004; Bansal and Roth, 2000). This legitimacy management can decrease their operational risks, while the voluntary disclosure of sustainability information can be seen positively by stakeholders (Bansal and Clelland, 2004). Firms might also be drawn to legitimacy struggles in cases where their sustainability performance is questioned by stakeholders. Firms thus have to undertake defensive legitimation strategies in order to prevent a decline in their legitimacy (Joutsenvirta and Vaara, 2015). Publication II focuses specifically on legitimation strategies regarding SOI adopters.

The economic branch of institutional theory has received considerable interest from scholars studying sustainability transitions (Geels, 2005; Hekkert et al., 2007). Following this stream of research, SOI represent niche technologies which require active innovation systems in order to be diffused at the regime-level, or adopted within the incumbent industry structure (Geels, 2011). Their diffusions can require considerable effort from the different actors involved in the innovations system, as the existing institutional frameworks often favor the incumbents (Geels, 2011). This is evidenced, for example, by the carbon lock-in effect, where systemic institutional forces support fossil fuel-based infrastructures despite their known environmental externalities and the existence of alternative technologies such as renewable energy (Unruh, 2000). In essence, various barriers arising from existing institutional structures hinder the diffusion of SOI and innovation system actors need to actively work to overcome these barriers. Innovations systems and the barriers to SOI are discussed further in publication V.

2.3.2 Network theory and network governance

There is an extensive body of knowledge on how networks can contribute to the creation of various types of outcomes. Networks enable organizations to access resources that might otherwise be difficult to develop or acquire (Ahuja et al., 2012; Gulati et al., 2000). They transfer information that gives rise to attitude similarity, imitation and the generation of innovations (Ahuja, 2000; Brass et al., 2004). Thus, networks are powerful carriers of new norms, values and practices. In addition, they serve as governance

mechanisms that can constrain opportunism and enhance trust (Ring and Van De Ven, 1992). Conversely, networks also have inertial properties that can constrain change (Kim et al., 2006). From the perspective of an individual firm, network-based collaboration has been shown to reduce risk, speed products to market and decrease the cost of process improvement and product development (for a review, see Fjeldstad et al., 2012).

Several research streams in management and organizational studies have examined inter-organizational networks. For example, the industrial network approach has been developed in industrial marketing to understand business networks (Håkansson and Snehota, 1995; Möller and Halinen, 1999). In this perspective, markets are interconnected webs of dependent exchange relationships that are built on the bonds, activity links, and resource ties between the actors in organically evolving networks or strategic networks (Håkansson and Johanson, 1992; Easton and Håkansson, 1996).

The research on strategic networks, mainly originating in business studies and strategic management, is another perspective for understanding inter-organizational networks in the business world (Jarillo, 1988, Gulati, Nohria, and Zaheer, 2000). According to this stream of research, strategic networks are based on inter-organizational ties that have strategic significance for the companies that are included in them and the relative stability of their nature (Gulati et al., 2000). In addition, these strategic networks include strategic alliances, long-term buyer-supplier partnerships, and joint ventures (Gulati et al., 2000; Gerwin, 2004).

Some central issues regarding networks have garnered considerable attention in both of the aforementioned research streams. One of these is the effect of networks on the behavior of organizations, e.g. what kind of benefits do the networks present to the organizations embedded in them, and how do they constrain action (Provan et al., 2007). Common issues in this research stream are the impacts of network structures on organizational learning or innovation (Ahuja, 2000; Tracey et al., 2014), or on the effectiveness of organizational and inter-organizational activities (Aarikka-Stenroos et al., 2014; Tachizawa and Wong, 2015).

Another key issue is the extent to which organizations can effect networks, which often deals with the question of whether networks can be managed or not (Möller and Halinen, 1999; Provan et al., 2007). Some researchers following the industrial network approach view networks as inherently unmanageable, self-organizing systems in which change is generated through bottom-up interactive processes (Håkansson and Ford, 2002). On the other hand, scholars representing the strategic network approach have advocated the view that networks can be managed or orchestrated, usually by powerful hub-firms occupying central positions in the network (Jarillo, 1995; Zaheer et al., 2000). A midway approach between these acknowledges that networks cannot be completely managed but can contain subnetworks, or "strategic nets" which can be managed in a limited way (Möller and Rajala, 2007; Ritter et al., 2004).

Networks generally include specific governance mechanisms which are used to coordinate their activities. Existing research has generally distinguished two main types of governance mechanisms used in network collaborations. Relational governance mechanisms are informal in nature and based on norms and joint understanding, forming a common macro-culture in the network (Jones et al., 1997). Hierarchical and contractual governance mechanisms are mostly formal in nature. They establish decision rights and acceptable behavior through contractual arrangements (Fjeldstad et al., 2012; Zaheer et al., 2000). However, informal hierarchical structures and processes are also formed in networks (Diefenbach and Sillince, 2011).

Other network governance has identified three generic types of governance models (Provan and Kenis, 2007). At one end, hub-organization led networks have a focal organization, which usually has the most power and the largest responsibility for coordinating a network, while also being a participant (Provan and Kenis, 2007). At the other extreme, networks that have shared governance are self-organizing and their decision-making is distributed among the members (Provan and Kenis, 2007). The last form of governance falls between these two extremes; it generally includes a network administrative organization (NAO), which is in charge of coordinating the network and bridging organizations, while not being directly involved in the network's activities (Klerkx and Aarts, 2013; Kowalski and Jenkins, 2015; Provan and Kenis, 2007). NAOs are commonly public sector organizations (Klerkx and Leeuwis, 2009), but can also be NGOs (Milward et al., 2010).

Polycentric network governance models have been suggested as suitable governance models for encouraging collaboration on global environmental issues (Ostrom, 2014). Such models involve various (public and private) actors coming together at multiple levels to work towards collective goals. The existing studies on polycentric governance systems have focused on various environmental issues, such as climate change (Ostrom, 2014), national electricity and ethanol programs (Sovacool, 2011), global water governance (Gupta and Pahl-Wostl, 2013) and global water and marine life (Galaz et al., 2012). Ostrom (2014) defines a polycentric governance system as existing when multiple public and private organizations come together at multiple scales (levels) to jointly affect collective benefits and costs. Polycentric models commonly include both hierarchical and self-organized governance mechanisms (Giest and Howlett, 2014). In practice, many collaborative networks often have some degree of polycentric governance (Galaz et al. 2012). Strongly polycentric networks often contain a structure with formalized governance mechanisms across a tightly integrated core group of actors and more loosely connected peripheral actors (Galaz et al. 2012). Existing studies on polycentrism have mostly focused on public-sector led networks where governments and transnational initiatives play a large role (e.g. Galaz et al., 2012; Gupta and Pahl-Wostl, 2013; Ostrom, 2014). However, many sustainability collaborations such as green supply chain management initiative and industrial symbioses are undertaken largely through the efforts of the private sector, although the public sector may play an important catalytic role in

these networks. The empirical study on network governance in publication IV will thus focus on networks where the actions of private sector organizations take emphasis.

Sustainability issues are profoundly affected by complex networks of actors that comprise industries, NGOs and governmental agencies. These networks are involved in the collaborating and contesting that occurs when considering the urgency of environmental problems and the role of government and markets in addressing these problems (Wittneben et al., 2012). In addition, specific forms of collaborative networking can contribute to reducing the environmental load of industrial operations. Examples of network collaboration for sustainability include sustainable supply chain management, where firms collaborate inside supply chains to decrease environmental impacts (Gupta et al. 2014); multi-sector initiatives focused around specific environmental issues, such as water contamination (Ritvala & Salmi, 2010); industrial symbiosis networks which focus on waste and by-product reuse for improving material efficiency; as well as collaboration in the creation of sustainable R&D (Baraldi et al. 2010). However, in the extant literature on organizations and the environment, the unit of analysis primarily lies on the level of individual actors instead of a network of actors. It is thus important to gain a better understanding of the role of networks and their governance to understand sustainability collaboration. Publications III and IV will apply network theory in their theoretical background. Publication III will focus on the role of networks in advancing SOI and publication IV will focus on the governance of these networks.

Table 6 summarizes how the different theoretical fields are applied in the individual publications to address the research gaps outlined in this literature review section.

Table 6: Theories used in the publications and research gaps addressed

Publication	**Theories used**	**Gaps addressed (research field)**
Publication I	Industrial marketing	-Technology suppliers' role in sustainable industrial marketing (industrial marketing) -Incorporating sustainability to value propositions (industrial marketing)
Publication II	Institutional theory	-Legitimation strategies under institutional change (institutional theory)
Publication III	Network theory, sustainability-oriented innovation	-Understanding of the role of collaborative networks in sustainability (SOI, industrial marketing)
Publication IV	Network theory, sustainability-oriented innovation	-How polycentric governance can facilitate sustainability collaboration (SOI, network theory)
Publication V	Sustainability-oriented innovation, institutional theory	-Identifying barriers to sustainable business model innovations and methods to overcome them (SOI)

3 RESEARCH METHODOLOGY

3.1 Research approach

When choosing a research approach appropriate for the topic in question, it is important to first identify the philosophical worldview the research relies on. These worldviews often remain hidden in research, but acknowledging them is important as they play a large role in shaping the methodological choices of the research (Creswell, 2009). Alternate philosophical worldviews are commonly accepted in the realm of the social sciences, as the scientific method used in the natural sciences is predominantly positivist in nature (Symon and Cassell, 2012). When comparing philosophical worldviews, it is important to clarify two key concepts: ontology and epistemology. *Ontology* is a branch of philosophy which deals with the nature of existence and reality. In general, ontological assumptions range between realist approaches, where reality is seen to be objective and "real," and subjectivist approaches, where reality is understood as being constructed in the minds of individuals. *Epistemology* refers to how we view knowledge and how we understand truth. Epistemological positions range from objectivist positions, where truth can be found through adequate evidence and facts, to subjectivist positions, which subscribe to the view that absolute truth cannot be determined, but is only the result of human-made constructions (Symon and Cassell, 2012).

Table 7: Key philosophical positions in social science research (Guba and Lincoln, 2005)

	Positivism	**Postpositivism**	**Social Constructionism**
Ontology	Realism – reality is "real" but apprehensible	Critical realism – "real" reality but only imperfectly understood	Relativism: reality is constructed and co-constructed
Epistemology	Objectivist – findings true	Modified objectivist – findings probably true	Subjectivist: findings constructed
Methodology	Experimental, manipulative, verification of hypotheses, quantitative methods	Critical multiplism, the falsification of hypotheses, may include quantitative and qualitative methods	Hermeneutical, interpretivism, qualitative methods

The three primary philosophical position are summarized in Table 7. The traditional philosophical position in research is that of *positivism*, and it also represents the roots of

the scientific method. A positivist epistemology is characterized by a focus on directly observable phenomena and theory testing. This position relies on ontological realism, which states that there are objective facts in the world, which can be measured (Symon and Cassell, 2012). Its epistemological standpoint is that findings can be stated to be true or false if adequate data are collected (Guba and Lincoln, 2005). The methodology for positivists is that of deductive hypothesis testing, gathering data for measuring phenomena and attempting to falsify a hypothesis based on the data (Creswell, 2009). Experiments, numerical data collection, surveys and statistical analyses are common methodological tools for positivists.

Another philosophical tradition often advocated by scholars in the social sciences, especially those conducting qualitative research, is *social constructivism.* This worldview stands in strong contrast to the positivist stance. Social constructionism is built on relativist ontology, meaning that reality is seen as being constructed by the subjective views of individuals (Guba and Lincoln, 2005). Reality is thus constructed from multiple viewpoints, and the goal of the researchers is to understand the complexity of these viewpoints (Creswell, 2009). Social constructivists acknowledge the subjective viewpoints of individuals, and act as interpreters for these viewpoints. They often study phenomena which are focused on the processes of interaction between individuals (Creswell, 2009). As reality is seen to be subjective, constructivist researchers also acknowledge their own subjective stance and do not strive for objectivity.

Falling between these two extremes, *postpositivism* is grounded in the positivist proposition that there is an objective reality to be understood, but that it is shaped by the subjective views of individuals. The main difference of postpositivism to traditional positivism is that it recognizes that we cannot be absolutely certain of truth when studying the behavior of humans (Creswell, 2009). This is the overall philosophical position adopted in this thesis. Postpositivism relies on the ontological position of *critical realism* (Guba and Lincoln, 2005) which assumes that there is a "real" and objective reality out there, but that our understanding of it is limited by human cognition and subjective views (Guba & Lincoln, 2005). Critical realism has been advocated as a useful ontological position for case study research, and it is especially suitable for the analysis of complex entities, such as organizations and networks of organizations (Easton, 2010). Critical realism also has strong proponents in the research spanning natural and social systems, having been proposed as the de facto foundation for ecological economics (Spash, 2012). Some of the key assumptions of critical realism include:

- An objective reality exists independent of humans;
- Humans create social reality;
- Facts about social reality are inseparable from values;
- Biophysical and social realities are distinct but interconnected;
- A hierarchical ontology is accepted in which there is an ordered structure (e.g. biophysical, social, economic) (Spash, 2012)

The critical realism perspective is presented in the individual publications in different ways:

- Customer value propositions: understood as a communicative practice which translate objective, measureable impacts (economic, environmental, social) into customer value, which are, in turn, affected by the subjective value perceptions held by the customer
- (Rhetorical) legitimacy management strategies: understood as the subjective accounts of organizations' substantial and real actions, e.g. a new power plant investment, with the aim of affecting the subjective perceptions of the stakeholders
- Networks: include substantive elements such as organizations and the relationships (formal and informal) between them. However, the perception of a network is affected by subjective views held by both the studied actors as well as the researcher.

This thesis adopts an approach which is also rooted in a *pragmatic* worldview (Creswell, 2009). Pragmatism arises out of actions, situations and consequences rather than the antecedent conditions used in positivist and social constructivist approaches. Rather than focusing on the method, researchers following this worldview emphasize that all approaches available for understanding a problem should be used to understand (Rossman & Wilson, 1985). This view is often advocated by those researchers who use mixed-methods approaches, which are also applied in this thesis. Pragmatism advocates that researchers are free to use the methods which are most suitable for their needs and purposes (Creswell, 2009). As such, researchers who advocate pragmatism might use methods associated with differing philosophical standpoints within the same research project, depending on their research purpose. Following the pragmatic approach, the individual publications in the thesis utilize different research methods which were chosen according to their suitability for each research project. Therefore, while the overall thesis follows the critical realist perspective, the pragmatic perspective is reflected in the plurality of used methods.

3.2 Methodological choices

This section will explain the methodological choices of the empirical part of the thesis. The thesis utilized different methodologies for the individual publications of the thesis. For each individual study, careful consideration was used to choose the most suitable research approach for the goals of the study. The three empirical research methods used in the thesis are case study (publications I and IV), content analysis (publication II) and Delphi study (publication V). In addition, Publication III utilized a systematic literature review of existing research. The four methodologies are outlined in this section. The methodological choices are summarized in Table 8, and will be described in more detail

in this section. Data collection and analysis will be described in more detail in section 3.3.

Table 8: Methodological choices for the individual publications

	Publication I	**Publication II**	**Publication III**	**Publication IV**	**Publication V**
Research objective	To examine how sustainability can be integrated into the value propositions of technology suppliers	To understand how incumbents use rhetoric to legitimize their actions during institutional change	To explore the role of inter-organizational networks in advancing environmental sustainability	To explore the role of polycentric models in the governance of sustainability collaboration	To identify the barriers to a sustainable business model innovation and exploring how the innovation system can overcome them
Research method	Case study	Mixed methods content analysis	Systematic literature review	Case study	Delphi foresight study
Data collection	32 expert interviews with the suppliers and customers of two industrial companies	483 press releases from 34 energy firms	42 journal articles	34 expert interviews and two focus groups from three nested networks	8 expert interviews (pilot), 40 expert participants in the first round and 27 in second round
Data analysis	Qualitative data analysis and quantitative life cycle assessment	Mixed methods content analysis	Qualitative synthesis	Qualitative data analysis	Qualitative data analysis

3.2.1 **Case study**

The research method used in publications I and IV is the case study. Case study is a suitable method for building new theory and examining novel and complex phenomena (Yin, 2013). Case studies are widely used in management research to study various phenomena in their natural settings. Case studies allow the researcher to gain deep insights into the focal phenomenon by studying it in a constrained system (a case). This allows the researcher to gain in-depth knowledge of the contextual factors, characteristics and mechanisms which affect the focal phenomenon. Case studies have often been the preferred method for gaining a deep understanding of complex social phenomena, which

includes organizations and their relationships, such as supplier-customer dyads and business networks (Halinen and Törnroos, 2005).

The objective of case studies is to generalize to an existing theory, rather than to a larger population. The question of analytical generalizability presents a choice to the researcher of how many cases should be studied in a single study. This is generally a choice between a single case study or a multiple case study (Eisenhardt, 1989; Yin, 2013).Single case studies can be highly useful for describing the existence of a phenomenon, motivating and inspiring readers and illustrating a theory (Siggelkow, 2007). However, the one limitation of single case studies is the lack of generalizability, as findings from case studies are usually highly specific to the context of the case. However, multiple case studies allow for comparative insights from cross-case analyses, thus increasing the potential for theory building (Eisenhardt and Graebner, 2007).

The selection of a case study for analysis is a vital consideration for case studies. The most commonly used method for choosing cases is theoretical sampling, where cases are chosen according to their ability to offer new insights into the phenomena being studied (Eisenhardt and Graebner, 2007). In a single case study, a case is commonly chosen because it is unusually revelatory, an extreme example, or offers an opportunity for unusual research access (Eisenhardt and Graebner, 2007). For multiple case studies, cases can be chosen in order to elaborate the theory, for example, by replicating findings from other cases or by seeking contradictory findings (Eisenhardt and Graebner, 2007).

Publications I and IV use a multiple case study as their primary research method. This approach was chosen as both publications involved complex social phenomena, which required the collection of data from multiple organizations. In publication I, for the purpose of exploring the creation of sustainable value proposition, the focal cases are two industrial offerings and their value propositions. Data were gathered through 31 interviews from both the suppliers of these offerings as well as five different customer organizations. Thus, there are multiple viewpoints within the cases for providing a comprehensive understanding of the customer value of the offering. The case studies served three primary purposes in relation to the study. The first one was to understand the elements of the value proposition: i.e. those features of the offerings which provide benefits for the customer as well as the value creation mechanisms of these benefits. The second purpose was to understand how the aforementioned value can be quantified and demonstrated based on measurements, estimations and publicly available data. The third purpose was to develop a normative framework for developing the sustainable value propositions, based on the experiences and insights gained during the two case studies. The cases thus served a twofold role. Firstly, they provided empirical input which was combined with the previous theoretical knowledge to *abductively develop* the framework (Dubois and Gadde, 2002). Secondly, they also *illustrated* the process of developing sustainable value propositions (Siggelkow, 2007). The cases also produced new managerial knowledge in the forms of new value propositions. Therefore the research also demonstrated characteristics of action research, which aims at simultaneously

producing new theoretical knowledge and solving managerial problems (Checkland and Holwell, 1998).

In publication IV, the focal cases consisted of three nested inter-organizational networks focused on sustainability collaboration in order to study how multi-level polycentric governance is manifested in sustainability collaboration. The networks were focused on different forms of sustainability collaboration, which enabled the conducting of a comparative study. Data were gathered from altogether 27 organizations involved in these networks in order to gain a comprehensive understanding of the governance forms used in the networks. The primary method for choosing the cases in publication IV was theoretical sampling (Miles and Huberman, 1994). Three main criteria were behind the choice of the different networks: a network had to involve public-private sector collaboration and multiple actors, it had to include distinct goals for environmental sustainability and network governance had to involve national and local levels. To obtain a comprehensive view of the forms and influencing factors of polycentrism, we chose networks with different operational logics. The data was obtained through 36 semi-structured interviews and a focus group discussion with the managers involved in the sustainability collaborations. The respondents represented 27 different organisations, including corporations, public sector organisations, universities/research centres and industry associations. The data was gathered from both organisations involved in national-level governance and organisations participating in the local networks.

The data was analysed abductively through an interactive process between existing theory and the data gathered (Dubois and Gadde, 2002). Existing theory informed the data analysis in three ways. Firstly, three elements of polycentric governance, public-private collaboration, distributed power and formalized key activities were used as the basis for assessing the polycentric governance models. Secondly, the study followed the view advocated by Galaz et al. (2012) that polycentric governance can exist to different degrees. Thirdly, the networks' structure and operating logic were identified from previous research, including publication III, as elements which affect the degree of polycentrism. The empirical data added two major insights to the research. Firstly, it elucidated three archetypes of polycentric governance in eco-industrial networks. Secondly, through inductive analysis, the specific mechanisms through which the networks' structures and operating logics affect polycentrism were identified. The details of the case studies are listed in Table 9.

Table 9: Characteristics of the case studies

Case	Primary industries	Involved organizations	Data collection	Focal study
Industrial monitoring system	Metal refining	Supplier and two customers	19 interviews	Publication I
Optical Measurement system	Automotive industry	Supplier and three customers	12 interviews	Publication I
Industrial symbiosis network	Bioenergy, Chemical industry, Waste management, Food industry	Six firms, four public sector organizations, two research organizations	15 interviews, 1 focus group	Publication IV
Sustainable supply chain network	Forest industry, Energy production, Electronics industry	11 firms, two public sector organizations	17 interviews, 1 focus group	Publication IV
Sustainable R&D network	Oil refining, Natural gas distribution, Pulp & paper industry	Three firms	Four interviews, 1 focus group	Publication IV

3.2.2 **Content analysis**

Publication II utilizes a content analysis of publicly available corporate media disclosures as the primary research method. The analysis of media content has been used in various studies on legitimacy (e.g. Erkama and Vaara, 2010; Humphreys, 2010; Joutsenvirta and Vaara, 2015). The advantage of such approaches is that they allow a researcher to study public discourse as it occurs in its natural form and without interference from the researcher. The generally associated methods with media analyses are *content analysis* (Krippendorf, 2013) and *discourse analysis* (Symon and Cassell, 2012). The main difference between the two approaches is that discourse analysis focuses on understanding and interpreting meanings on the level of sentences and paragraphs, while content analysis allows a researcher to also analyze meaning on the level of individual words, which allows for quantitative approaches with which to understand meaning from textual data (Krippendorf, 2013; Symon and Cassell, 2012).

Content analysis was chosen as the main method for publication II. The purpose of publication II was to study how incumbent firms use rhetorical strategies to legitimize their new investments during institutional change. Content analysis offers a rich method for studying the legitimation strategies of corporations by analyzing their corporate press releases. It was also chosen for its ability to accommodate the use of both qualitative and quantitative analysis. Content analysis is concerned with analyzing meaning in textual data through various methods. Content analysis has a long history in the analysis of media

and it has gained popularity in the recent years due to the ease of performing large-scale, quantitative content analyses with computer assisted content analysis (CATA). (Krippendorf, 2013)

Corporate press releases were chosen as the main data source in publication II. They are suitable for studying legitimation strategies because, as public disclosures, they are directed to society at large rather than a specific stakeholder group. Press releases generally reach traditional and new media, investors, customers, competitors, and affiliates as well as competitors. Since they are used as a PR tool and companies have a high degree of control over them, the releases portray a company in the light it wishes to be seen. Their content and appearance is created with the intention of enhancing a positive image and the organization's legitimacy, which makes them ideal for examining legitimation strategies. Previously, press releases have been employed in the study of legitimation by, for example, Erkama and Vaara (2010) in their study on rhetorical legitimation concerning a plant closure, Desai (2011) on the legitimacy defenses of the US railroad industry, and Elsbach (1994) on the legitimation activities of the California cattle industry.

3.2.3 **Systematic review**

Publication III utilized a systematic literature review as the main research method. Systematic a structured method to identify and synthesize existing research within a specific field or multiple fields (Denyer and Tranfield, 2006). Traditional literature reviews are often rather subjective in nature as data sources are chosen by the researcher based on the specific research objective of the research at hand. Systematic reviews address this by creating a comprehensive search protocol which aims to capture all the relevant knowledge in a specific field. Systematic reviews commonly include a specified set of keywords and a specified time period and the researchers screen through all the relevant data sources within these boundaries. The screening process may include for example abstract screening and a full-text screening in order to screen out data sources with low relevance to the topic. Further steps often include an analysis of the references of the identified articles as well to find further data sources.

The research objective of publication III was to identify explore the role of inter-organizational networks in regards to sustainability actions, as well as the operational logic and network structure of these networks. Therefore, a set of keywords was chosen according to a brief initial review of key articles. These keywords were then used to search through two databases for academic articles: Scopus and Web of Science. The date range chosen for analysis was 1990-2012, and the selected keywords were as follows:

> *("Industrial" OR "Business" AND "Network" AND "Sustainability" OR "Environmental") OR "eco-industrial network" OR "industrial symbiosis" OR "eco-industrial park" OR "eco-cluster" OR("industrial ecology" AND "network")*

Both databases were searched individually with the chosen keywords. The search covered the title, keywords and abstracts of the articles and found a total of 808 articles. Based on a review of their abstracts, 160 articles were qualified and their full texts scanned. This resulted in 36 articles being chosen for further analysis. An additional three articles were identified through a snowball method of scanning the references of the 36 selected articles, bringing the total number of articles to 39. A further three articles were identified through by scanning the main journals present in the original dataset for additional relevant articles, bringing the total dataset of articles to 42.

3.2.4 **Delphi study**

Publication V utilized a Delphi study as the primary research method in order to explore the barriers to sustainable business model innovation and identify how the innovation system actors can overcome these barriers. Delphi is a qualitative method that is applied to a variety of problems where input from a variety of experts is needed. A Delphi study can be characterized as a method for structuring a group communication process so that the process is effective in allowing the group to deal with a complex problem (Linstone and Turoff, 1975). A Delphi study is typically characterized by anonymous responses, iterative questionnaires and controlled feedback (Landeta, 2006; Rowe and Wright, 1999). Traditionally, Delphi studies aim at achieving consensus among experts, but some variations, such as policy Delphi, have also acknowledged disagreement regarding preferable futures. The method used in publication V is a variation of the policy Delphi. The objectives of the study were to identify how sustainability will be integrated into the business models of firms in the future and the identifying of the potential barriers to the achieving of such a transition.

The study first included a set of semi-structured interviews with eight experts, which were used to form the basis for the Delphi questionnaires. There then followed two rounds of online questionnaires for a set of 42 experts, comprised of managers, consultants, researchers, governmental authorities, NGO representatives as well as students. Forty of the experts participated in the first round and 27 in the second round. The questionnaires included statements which were evaluated on a 7-point Likert scale and open-ended questions where respondents provided written answers to the questions. After both rounds the experts had a chance to comment on each other's answers and clarify their own comments. The responses were anonymous.

3.3 **Data collection and analysis**

Data collection is a vital consideration for empirical studies in the field of management. One of the key decisions for a researcher to make is the choice between naturally occurring data (e.g. observations, archival data) and researcher-provoked data (e.g. interviews). Naturally occurring data has the advantage of not being affected by the researcher, i.e. the researcher can observe and analyze the data in its pure form. The

disadvantage of naturally occurring data is that it can be difficult for the researcher to find interesting data for the phenomenon from the wealth of other data that is not relevant for the research. On the other hand, researcher-provoked data such as interviews and surveys allow the researcher to get directly to the heart of the focal phenomenon but their disadvantage is that the researcher's choice of questions and words can influence the respondents, making the findings more subjective. This thesis utilizes both forms of data collection (Silverman, 2006).

A second important consideration for a researcher in the field of management is between quantitative and qualitative data. Quantitative studies use numerical data, which is generally associated with positivist paradigms, hypothesis testing, and statistical analysis methods. In the management field it is often conducted with surveys or publicly available numerical data from databases. But it is also sometimes utilized in more exploratory forms of research, such as case studies. Qualitative data generally refers to data in textual form, and is primarily associated with social constructionism and interpretivist research methods, such as ethnography, case studies and grounded theory. Mixed methods research employs both forms of data collection in the same research project (Creswell, 2009).

Publications I, IV and V primarily utilize researcher provoked data. Publications I and IV use qualitative semi-structured interviews as their primary data collection method. Respondents to the interviews were initially chosen based on their knowledge and experience with the topic. In addition, a snowball sampling method was utilized in which the initial respondents are asked to name other respondents familiar with the topic. In addition, the data collection in Publication I was complemented by various technical documents, presentations and numerical data for understanding the specific benefits of the offerings made by the organizations. Publication I can thus be considered a mixed-methods study for including both textual and numerical data. Publication IV was complemented by a focus group, which is a group discussion method where the researcher facilitates discussions among a group of experts on the focal topic. Publication V utilized semi-structured interviews for the first phase of the Delphi study. The second and third phases followed up that first phase with qualitative online questionnaires sent to the same group of experts. Publications I and IV included 66 interviews and one focus group discussion, while publication V had 40 respondents involved in the Delphi study. The interviews and focus group discussions, which were used as the primary data, were recorded and fully transcribed, the online Delphi responses were recorded in digital form.

Publication II utilized naturally occurring data in the form of corporate press releases. These were particularly suitable for studying the rhetorical legitimation strategies, which were the focus of the study, since they are used as a tool by firms to manage their public image and portray the firm in the light that it wishes to be seen, regarding the many different stakeholder groups of their audience. The press releases focused on new technology investments made by energy utility firms, making them particularly suited for the study of the legitimacy of sustainable and unsustainable energy technologies.

Altogether 483 press releases were gathered from 34 energy utility firms. The firms were chosen from Platts Top 250 global energy companies (Platts, 2015).

3.3.1 Qualitative data analysis

The primary data were analyzed by following the general guidelines for qualitative data analysis (Miles and Huberman, 1994). The data analysis consisted of the partially overlapping phases of data reduction, data display, and the drawing of conclusions and verification. *Data reduction* refers to the selection of key parts of the raw textual data and simplifying and abstracting meanings from that data (Miles and Huberman, 1994). This was achieved by coding the data for meanings with the help of computer software (Nvivo 10). *Data display* refers to the production of organized and compressed representations of the data that permit the drawing of conclusions and action. Data displays can take many forms, including matrices, graphs, charts and networks. Publication II utilized flowcharts as the main data display method to illustrate the process of forming sustainable value propositions. Publications IV used network pictures and matrices to represent the case networks. Publications V also utilized matrices to structure the barriers to SOI. *The drawing of conclusions and verification* refers to the production of the meanings that can be gleaned from the analysis, which can take forms such as patterns, configurations, explanations, causal flows and theoretical propositions (Miles and Huberman, 1994). Iterating the conclusions also requires researchers perform cross-case comparisons in the case of multiple case studies. In publications I and IV, cross-case comparison tables were used for this purpose.

The analysis approach used in publications I, IV and V could be best described as *abductive* in nature because insights from existing theory are systematically combined with empirical findings to form new theory (Dubois and Gadde, 2002). In essence, the findings from both studies combine specific elements which were identified from previous studies with elements found from the analysis of the empirical data. An abductive approach allows for a rich cross-fertilization between theories and data, and it is thus particularly fruitful for refining and developing theories rather than the generation of new ones. The abductive approach has been suggested as being particularly suitable for case studies (Dubois and Gadde, 2002).

Publication II utilizes the content analysis method (Krippendorf, 2013), but branches out from generally used qualitative content analysis by using a mixed-methods content analysis (Humphreys, 2010). In this data analysis method, a qualitative content analysis was first performed on a sample of the dataset to find emergent themes from the textual data in the press releases (Berg and Lune, 2004). Following the qualitative analysis, keyword dictionaries were formed for each of the emergent themes (Short et al., 2009). These dictionaries included keywords that best represented manifestations of that particular theme. The dictionaries were then input into specific computer software for performing an automated quantitative content analysis, WordStat. In essence, the software counts the number of occurrences of each keyword across the whole dataset,

allowing for various metrics to be calculated. These metrics allowed for comparative analyses of the themes of sustainable and unsustainable energy technologies, as well as an analysis of the co-occurrence of the themes in the text.

3.3.2 Life-cycle assessment

The two case studies in publication I also utilize life-cycle assessment (LCA) methods for analyzing the economic, environmental and social impacts of the industrial offerings. LCA itself is a standardized method for analyzing the environmental impacts of a system over its life-cycle (Rebitzer et al., 2004). It is widely used for the assessment of the environmental sustainability of products, services, production networks or specific changes to a production process (Öberg et al., 2012). Varieties of LCA have also been developed for the assessment of life-cycle costs (Kaenzig and Wüstenhagen, 2009) life-cycle profits (Räsänen et al., 2008) and social impacts (Guinée et al., 2011). Recent developments in LCA have called for an integration of economic, environmental and social impacts into a single assessment framework (Guinée et al., 2011). This is the approach that is also followed in publication I, where the principles of LCA are applied to achieve an integrated assessment of economic, environmental and social impacts.

LCA studies are comprised of three main stages: goal and scope definition, inventory assessment and impact assessment. Goal and scope definition set the targets for the assessment while inventory assessment calculates the impacts involved in the process in physical units, such as emissions to air and water. Impact assessment calculates the final impacts of the physical inventories based on a chosen set of indicators. The indicators can be chosen according to the goal of the study, but guidelines for LCA generally distinguish between midpoint and endpoint approaches. A midpoint approach can be an intermediary indicator such as a carbon footprint, while endpoint indicators focus on the final damage caused to ecosystems, resource use or human health. There is generally less uncertainty associated with midpoint approaches, thus that was the chosen method for publication I.

The collection of data for LCA can be an arduous process, and therefore the goal and scope definition generally limits the assessment to specific focus areas which are of interest to the study. The data collection usually involves a mix of verified test data, publicly available data from sources such as literature and databases, as well as estimations by experts. In publication I, the numerical data on the impacts created by the offerings included estimations from the respondents, verified test data and relevant literature sources.

The combination of life cycle assessment with qualitative data analysis in Publication I was conducted in an iterative manner. The objective of the qualitative data analysis was to first identify the benefits the customers receive from the offering. For those benefits which were possible to quantify, suitable indicators were then chosen together with the informants. The indicators provided the starting point for the life cycle assessments by limiting the scope to assessing changes in the chosen indicators. The informants also

provided input data in the form of performed measurements or estimations in order to perform the life cycle assessments. Data from previous literature and databases were used for those parameters where informant data was unavailable. The critical realism perspective guided this data analysis process, as quantifying value propositions had both a subjective and objective component. The case offerings' features combined with the customer's subjective value perceptions to determine the elements of the value proposition. In order to quantify this value, objective data such as technical measurements and numerical data from the natural sciences were used. The development of the framework was informed by the subjective views of the informants as well as the inherently subjective biases of the researchers. However, the use of the multiple informants and the demonstration of the framework in the case projects enhance the credibility of the results. The quality of the research will be addressed in more detail in the next subsection.

3.4 Quality of the research

Various criteria exist for the evaluation of the quality of academic research. Many scholars have suggested that reliability, validity and generalizability are good indicators for assessing research quality (Miles and Huberman, 1994; Eriksson and Kovalainen, 2008). However, these criteria have been developed especially for a quantitative approach that emphasizes objectivity and generalizability through replication logic. For primarily qualitative methods, another set of criteria, known as trustworthiness criteria, has been developed and this set is comprised of credibility, transferability, dependability and conformability (Lincoln and Guba, 1985).

The *credibility* of the research refers to how well interpretations made from the data accurately represent the views of the informants. In essence, it is concerned with the strength of the logical links between data observations and the conclusions made from them. In this thesis, credibility was strengthened in several ways. First, the research took place in three separate, larger research projects with multiple collaborators. Interaction during the research projects, including the continuous presentation of interim results among project researchers and partner firms, helped to improve the credibility of the findings. The findings were also presented at a total of eight academic conferences, and all of the individual publications have undergone a peer review process. Second, the research used two forms of triangulation. Method triangulation was used in Publications I and II by combining both qualitative and quantitative analysis methods in order to enhance the credibility of the findings. Data triangulation was also employed by using multiple data types, e.g. interviews, focus groups, numerical data, for the individual publications. Third, each empirical publication also used multiple data sources (organizations and informants), which further enhances the credibility of the publications.

Transferability refers to the degree that the research findings are generalizable to other contexts or from a smaller sample to a population. With qualitative research, findings are often generalized to theoretical propositions which extend theory. The case studies in this

research represented different industries and were chosen through the method of theoretical sampling, which increases the transferability of the findings. In addition, in-depth descriptions of the case studies are provided in the individual publications, allowing readers to determine if the findings are applicable to their situations. The sample of press releases used in publication II was systematically chosen from Platts Top 250 in order to accurately represent this specific sector.

Dependability refers to the degree that the researcher provides information on the research process, to allow other researchers to replicate the study. This is generally achieved by giving a detailed description of the research process and providing the data for other researchers to use. Detailed qualitative data, such as interviews, are generally very lengthy and thus hard to append to research reports. However, whenever possible, the interviews were recorded, transcribed and stored for potential future use, otherwise detailed notes were made during the interviews. The quantitative data and analyses in publications I and II were also appended in the respective publications. In addition, detailed descriptions of the research process were given in each publication.

Conformability, which is highly related to dependability, refers to the extent that the data, findings and conclusions are linked in a way that others can understand them. Researchers must, in effect, provide a chain of evidence to readers that logically leads to the stated conclusions. Detailed data excerpts, such as direct quotations, were provided in the publications so as to provide evidence for the reader. Within and cross-case analyses in the case studies provide additional evidence. The findings were also compared with findings from earlier studies in the same field whenever possible. In addition, in each publication the findings were confirmed by the co-authors in order to provide additional conformability.

4 SUMMARY OF THE PUBLICATIONS AND THEIR KEY RESULTS

This section will detail the primary findings of the thesis, by summarizing them and the contributions made by each of the individual publications. The order of the findings proceeds according to the level of analysis in the publications, starting from the smallest scale. The first two publications, focusing on value and legitimacy, focus on the actions of a single organization and its relationship with customers. The last three publications focus on networks, including multiple organizations, as the unit of analysis. A summary of the findings and their relationship with the SOI framework is presented in the last subsection.

4.1 Publication I – Sustainable value propositions: framework and implications for technology suppliers

4.1.1 Objectives

The objective of the first publication was to explore how the three dimensions of sustainability can be incorporated into the value propositions of the industrial technology suppliers. Customer value propositions are a vital method for firms aiming to demonstrate the customer value provided by their offerings (Anderson et al., 2006). For industrial suppliers that provide products and services which increase the sustainability of their customers' processes, an effective value proposition should communicate the *societal value* of the offering (environmental or social benefits) as well as the *customer value*, which includes the direct economic benefits received by the customer as well as the derivative benefits of the societal value. The objective of this research was to develop a framework for forming sustainable value propositions by conducting two case studies on commercial industrial offerings.

4.1.2 Main findings

The findings from the two case studies reveal that developing value propositions for sustainable technologies can be characterized as a process framework for applying principles from life-cycle thinking. The process consists of five stages: 1) identifying the potential economic, environmental and social impacts of the offering; 2) identifying key value creation mechanisms for customers; 3) choosing key indicators for assessing the value of the offerings; 4) conducting life-cycle modeling to quantify the value; and 5) demonstrating the life-cycle value of the offerings. For the last stage of the process, the study revealed three strategies for demonstrating the value that the customer receives from environmental and social benefits. This include monetization strategies for calculating the economic value of the impacts, certification strategies to symbolically

demonstrate increased sustainability as well as risk reduction strategies to demonstrate a decrease in the operational risks faced by customers.

4.1.3 Main contributions

The findings of the study elucidate how technology suppliers can integrate sustainability into the core element of their marketing activities: the value proposition. The business benefits of sustainability have been explored in various other studies but the ability of suppliers to demonstrate the sustainable value of their offerings has been identified as a major barrier to the diffusion of sustainable innovations. This study addresses this gap and provides a framework for assessing how the customer value of sustainable innovations can be demonstrated. The study contributes to the theories of sustainability in industrial marketing by taking the technology supplier's perspective on analyzing and demonstrating their sustainability "handprint" while previous studies in the field have mostly focused on exploring the sustainability "footprint" of industrial firms in their supply chains. The study additionally contributes to the theory on customer value propositions by demonstrating their construction in practice.

4.2 Publication II – Legitimacy under institutional change: How incumbents appropriate clean rhetoric for dirty technologies

4.2.1 Objectives

The objective of the second publication was to study legitimation strategies used by incumbents in situations of institutional change. The chosen context was the energy sector, where new investments in energy utilities have had a large impact on sustainability in this field. The study focused on the rhetorical legitimation strategies that were used by the incumbents in press releases in order to justify their new technology investments in sustainable (renewable energy) and unsustainable (non-renewable energy) technologies. Thus, in comparison with the first study, this study takes the view of a technology adopter and examines how they communicate the value of their actions to their wider stakeholder network rather than customers.

4.2.2 Main findings

The findings from the linguistic analyses of press releases revealed that during a period of institutional change, incumbents will engage in a larger amount of legitimation work so as to justify their unsustainable actions compared to their sustainable ones. They primarily use rationalization and moralization strategies to highlight economic and social benefits to offset the negative environmental benefits of their actions. Additionally, they also appropriate the rhetoric of sustainability to justify their unsustainable actions by emphasizing their relative benefits when compared to even more unsustainable actions. Conversely, sustainable actions are justified by less varied and less pronounced rhetoric

that focus on normalization strategies, which emphasize strategy and future growth potential.

4.2.3 Main contributions

The findings contribute to the understanding of legitimation strategies in regards to sustainable and unsustainable technology investments. The results highlight how multifaceted discourse which uses rational, moral and authority –based arguments can be used to build the legitimacy of emerging sustainable technologies. Wide societal acceptance is needed for new technologies to break through and the energy transition highlights the legitimacy contests between sustainable and unsustainable technologies. On the other hand, the findings also highlight how incumbents borrow from the characteristics of new, sustainable technologies to justify investing into old and unsustainable technologies. In past research, opposite legitimation actions have been observed by providing cognitive legitimacy from old to new technologies. The findings demonstrate the potential dark side of innovation by showing how incumbents can employ innovative activities to justify clinging on to older, unsustainable technologies rather than adopting novel technologies which have higher sustainability potential.

4.3 Publication III – Towards a broader perspective on the role of inter-organizational networks in advancing sustainability

4.3.1 Objectives

The purpose of the third publication was to examine the role of inter-organizational networks for advancing sustainable innovations. Network collaboration has been previously studied in the specific context of sustainability, such as supply chains and industrial symbiosis networks (Bansal and McKnight, 2009), but a comprehensive typology of these networks types and their characteristics is missing from the research field. This study addressed this research gap through a systematic literature review. The specific objective was to identify the different *roles* of networks in advancing sustainability, the *operating logics* of these networks and the *architectures* of these networks.

4.3.2 Main findings

The systematic literature review uncovered four forms of eco-industrial networks, which aim at simultaneously advancing economic and environmental outcomes: 1) industrial symbiosis networks, 2) sustainable supply networks, 3) environmental solution networks, and 4) environmental issue networks. While all of these networks have the ultimate aim of achieving an increase in environmental sustainability whilst creating economic benefits, they differ from each other on the basis of their operational logic and network architecture. Industrial symbiosis networks aim at the reuse of wastes and byproducts in

dense regional networks, which have distributed power and sustainable supply chains, in order to decrease the life-cycle impacts of products in hierarchically coordinated supply chains. Environmental solution networks aim at the co-production of eco-innovations in R&D projects comprising firms with complementary resources, while environmental issue networks aim at environmental protection initiatives which bring together a variety of actors such as firms, NGOs and the public sector.

4.3.3 Main contributions

The findings of the study open an avenue of research that takes a wider view of inter-organizational network collaboration in the context of sustainable innovations, which have so far been studied in separate literature streams. These contribute to the conceptualization of *eco-industrial networks* as novel forms of inter-organizational sustainability collaboration, opening up new avenues for research. In addition, there is a large body of research concerning networks in the management literature but its application in the sustainability management literature has been relatively low. This study demonstrates the usefulness of analyzing network structures in order to better understand phenomena at the point of interface between sustainability and organizations. Business managers can use the typology to understand and coordinate their portfolio of network collaborations, while public-sector decision makers can make use of the typology when designing new platforms and programs that aim to increase sustainable innovations.

4.4 Publication IV – Governance of cross-sectoral sustainability collaboration: a polycentric perspective

4.4.1 Objectives

This study follows on from publication III's research by analyzing the governance forms of different eco-industrial networks. Specifically, it looks at the polycentric governance models, which bring together both private- and public-sectors actors on multiple scales of governance, e.g. local and national (Ostrom, 2014). The objective is to explore the types of polycentric governance models in eco-industrial networks and identify those factors which influence the choice of governance models.

4.4.2 Main findings

The study first characterizes polycentrism as a characteristic that can exist to different degrees, depending on the network's depth of public-private collaboration, the formalization of core activities and the distribution of power. Second, through a multiple case study of three nested networks, it identifies three archetypes of polycentric governance models: a loosely-coupled coalition, polycentric coordination, and a polycentric governance system. These archetypes correspond to low, medium and high cases of polycentric governance. Lastly, the study identifies four influencing factors

which affect the choice of a network's governance model. Two of these, the alignment of goals and external resource need, arise from the operational logic of a network. The two others, structural holes and the centralization of local networks, are characteristic of a network's structure.

4.4.3 Main contributions

This study contributes to the understanding of polycentric governance by examining how it manifests in eco-industrial networks which have a high degree of private sector involvement, while previous studies on polycentric governance have focused on large, global-scale issues in which the public sector plays the largest role. Second, the study takes a step towards a more integrative theory of governing environmental collaboration, where the actions of multiple types of actors on different scales can be coordinated with a suitable governance model, depending on the characteristics of a network's operating logic and structure. Polycentric governance models can be one solution to solving one of the important tensions in sustainability – the tension between efficiency and resilience – by encouraging a diversity of activities at the system-level, while allowing smaller scale governance units to focus on efficiency in coordination. The study also further contributes to the wider view of eco-industrial networks by providing empirical proof of their key characteristics, which were identified in publication III.

4.5 Publication V – Analyzing barriers to sustainable business model innovations: innovation systems approach

4.5.1 Objectives

The last study examines how societal transition towards sustainable business models (SBMs) can be achieved. Specifically, its aim is to identify the potential barriers to sustainable business model innovation by means of a qualitative Delphi study, and analyze how the different functions of an innovation system can help to overcome these barriers.

4.5.2 Main findings

A Delphi study with 40 experts identified a total of 19 unique barriers to sustainable business model innovations. These can be classified into three categories: 1) regulatory barriers, 2) market and financial barriers, 3) behavioral and social barriers. These barriers can be overcome by the seven different functions of an innovation system. Entrepreneurial activities can overcome incumbent technologies, existing firms can cooperate together to create standards and indicators for improved sustainability, governments can create better functioning regulations and provide support and incentives for innovation, research and educational organizations can provide the knowledge base for sustainable business model innovations, and various parties can undertake action to

strengthen the legitimacy of sustainable business model innovation. Lastly, collaboration with consumers is needed to develop consumer behavior so that it supports an increase in sustainability.

4.5.3 Main contributions

Similarly to publication IV, this study advances the understanding of actors from different sectors (public and private) collaborating to advance sustainable innovations. It highlights the importance of a well-functioning, consistent regulatory framework that focuses on a long-term perspective and provides support for different types of innovations that can enhance the resilience of an innovation system. Second, it emphasizes the roles of visionary entrepreneurs as well as the voluntary activities of incumbent firms in creating and diffusing new sustainable innovations. Both managers and policymakers can use the findings to identify potential barriers to sustainable innovation as well as some solutions to overcoming those barriers.

4.6 Summary of the findings

This section will discuss the relationship of the findings to the advancement of SOI. It will first elaborate the contribution of each publication to the overall purpose of the study, and present a framework for advancing SOI based on the findings. Secondly, key implications of this framework are discussed in the second section

4.6.1 A framework for advancing sustainability-oriented innovation

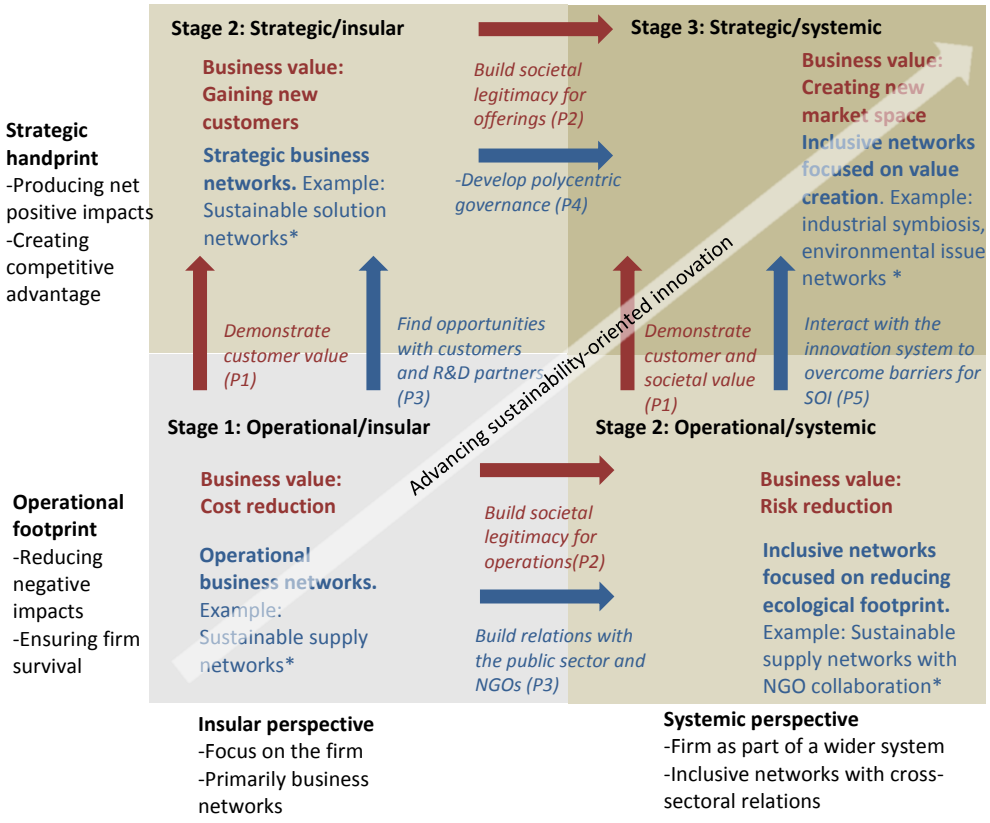
Table 10 summarizes the findings of each individual publication. It also details each publication's contribution to the overall purpose of this thesis, which is concerned with the shift from developing SOI with an operational and insular focus to SOI with a strategic and systemic focus.

Table 10: Summary of the findings and contribution of the individual studies

Publication	Main findings	Contribution to advancing SOI
Publication I: **Sustainable value propositions: framework and implications for technology suppliers.** Published in *Industrial Marketing Management*	A framework for developing sustainable value propositions, comprised of 1) value potential identification, 2) value creation mechanism identification, 3) choosing key indicators, 4) life-cycle modeling as well as 5) life-cycle value demonstration.	Shifting the focus to sustainable value propositions will highlight the potential for strategic handprint of sustainability: i.e. the net benefits that SOI can provide to customers and the wider society
Publication II: **Legitimacy under institutional change: How incumbents appropriate clean rhetoric for dirty technologies**. Published in the *Proceedings of the Academy of Management annual meeting 2016*	Incumbents legitimate sustainable and unsustainable investments differently: they appropriate sustainability rhetoric to legitimate their unsustainable investments, while primarily using the rhetoric of strategy to legitimate sustainable investments.	Building legitimacy is vital to the wider societal acceptance of a firm's offerings and operations. This will promote a systemic and inclusive perspective of SOI.

Publication III: **Towards a broader perspective on eco-industrial networks.** Published in *Journal of Cleaner Production*	Identified four forms of eco-industrial network that can advance SOI: 1) industrial symbiosis networks, 2) sustainable supply networks, 3) environmental solution networks, and 4) environmental issue networks. The networks differ from each other on the basis of their operational logic and network architecture.	Characterizes the types of networks typical for different stages of SOI. Networks at the first stage are characterized by relations in the supply chain. Shifting to strategic view requires building networks with customers and R&D partners while systemic perspective requires networks with the public sector and societal actors (e.g. NGOs).
Publication IV: **Governance of cross-sectoral sustainability collaboration: a polycentric perspective.** Published in the *Proceedings of the GRONEN 2016 conference*	Identifies three archetypes of polycentric governance models: loosely-coupled coalition, polycentric coordination, and polycentric governance system. Also identifies four influencing factors which affect the choice of a network's governance model.	Polycentric governance emphasizes a more systemic view of SOI by emphasizing inclusive decision-making in governance and building nested, multi-level governance systems
Publication V: **Analyzing barriers to sustainable business model innovations: innovation systems approach**. Published in *International Journal of Innovation Management*	Identified 19 unique barriers to sustainable business model innovations, representing: 1) regulatory barriers, 2) market and financial barriers 3) behavioral and social barriers. These barriers can be overcome by the different functions of an innovation system.	Promotes a strategic view of SOI by identifying the barriers which can hinder the diffusion of new sustainable offerings. Systemic view is required to work with other actors in the innovation system to overcome the barriers.

As described in the literature review on SOI in section 2.1, existing studies have identified that while there are many types of SOI, more advanced SOI typically are *strategic* rather than *operational* in nature, for example by focusing on creating sustainable products and services which capture new market share. Secondly, more advanced SOI are also typically *systemic* rather than *insular*, meaning that they consider the needs of various business and non-business stakeholders and aim to achieve wider societal change. Combining the systemic dimensions, advancing SOI can be characterized as a three stage process moving from stage 1 (operational/insular) to stage 2 (strategic/insular or operational/systemic) and eventually to stage 3 (strategic/systemic) innovations. A framework for advancing SOI, based on the findings of this thesis, is presented in Figure 6. The framework presents the contributions of the individual publications as *activities and processes which can advance an organization's SOI in the strategic and systemic dimensions*. These are characterized according to the two elements that are the subthemes of the thesis: value/legitimacy (represented by the color red) and networks (represented by blue).



*Network forms elaborated in publication III

Figure 6: A framework for advancing sustainability-oriented innovation

The framework for developing sustainable value propositions presented in Publication I is primarily focused on how suppliers can integrate sustainability into the value propositions of their offerings. Integrating sustainability assessment into value propositions is important for progressing from the operational view of sustainability towards a strategic view, as it shifts the perspective from reducing harm to producing net positive value to customers and the wider society. This requires that suppliers can demonstrate the customer value of sustainability (shift from the lower left to upper left quadrant) as well as the benefits to the wider society (shift from the lower right to upper right quadrant).

The legitimation strategies identified in Publication II shift the perspective from an insular to a more systemic SOI, as they are concerned with the acceptance of the firm's activies by the wider society. Progressing towards a more systemic view of sustainability requires that firms are able to manage the societal legitimacy of their operations (lower left to lower right quadrant) and the societal legitimacy of their products and services (upper left to upper right quadrant). However, as novel SOI gain societal legitimacy, incumbent firms whose technologies are under threat of being replaced by the SOI will likely engage in defensive legitimizing work in order maintain their legitimacy as evidenced by the findings. In this situation, innovators should build relations with societal actors (e.g. public sector and NGOs) who can provide more objective accounts to build the legitimacy of SOI and potentially deter defensive greenwashing activities of unsustainable offerings.

Publication III focuses on the role of collaborative networks in advancing SOI. It compares the different operating logics through which the network can advance SOI. These network forms are examples of the collaboration that is typical of each quadrant (marked by an asterisk). Networks in the first stage of SOI are typically limited inside the supply chain, exemplified by the sustainable supply chain –type of networks identified in the study. Based on the findings of the study, suppliers should collaborate with customers and R&D partners in order to develop and commercialize innovations with a higher strategic focus. One example of strategic/insular network would be the sustainable solution networks where firms collaborate with customers, R&D partners and firms with complementary offerings in order to create sustainable solutions such as product-service systems (PSS). Firms should also engage in cross-sectoral collaboration with the public sector and NGOs to promote a more systemic perspective for SOI. Sustainable supply chains with a high degree of collaboration with NGOs or public sector actors are examples of networks in the operational/systemic quadrant. Lastly, for advance SOI which are both strategic and systemic require both strategic network partners to create new offerings and societal network partners for a systemic perspective. For example, the industrial symbiosis networks identified in the study are examples of networks in the strategic/systemic quadrant.

Publication IV follows up the topic of network collaboration with an empirical study which explores polycentric governance models for sustainability collaborations. These models promote a more systemic perspective of SOI. The identified governance models were characterized by inclusive decision-making from actors from different sectors such as the public and private sector. Engaging and collaborating with actors outside of the traditional business networks is a key characteristic of more systemic SOI in order to facilitate change on a wider level (Adams et al, 2015). Polycentric governance models are also commonly organized across nested networks spanning multiple levels, such as national and local levels. Multi-level networks with a diversity of involved actors have the capability to facilitate change on a wider scale as innovative practices can diffuse through the network (Aarikka-Stenroos et al., 2014).

Publication V identifies various barriers to the advancement of SOI in the regulatory, market and financial as well as behavioral and social dimensions. These barriers primarily hinder the development and commercialization of sustainable products, services and new business models. Overcoming these barriers will promote a more strategic view of SOI as it unlocks new market potential for sustainable products and services. The findings of the publication also identified that collaboration among the various actors of the innovation system such as universities, public sector and consumers, is required to overcome the barriers. Therefore, overcoming these barriers also requires the presence of a systemic view for SOI in order to form collaborative partnerships.

The empirical examples of SOI examined in the individual publications include different types of SOI, in regards to the locus of the innovation outlined in section 2.1.1. The cases in publication I and the technology investments examined in publication II are primarily examples of technological innovation. The networks studied in publication III and IV in turn focus primarily on organizational innovation by exploring novel forms of inter-organizational collaboration. However, the eco-industrial network forms commonly also included technological innovation. Lastly, publication V explores all three of the SOI types: technological, organizational and social/institutional innovation. The findings suggest that institutional/social –level innovation in the innovation system should be a key focus in order to overcome the barriers to SOI.

4.6.2 Implications of the framework

Two keys issues of the framework presented in Figure 7 warrant additional discussion. The first one concerns the link between values and legitimacy to inter-organizational networks. The second one is related to the two alternate paths that a firm could take in order to progress from the first stage of SOI to the third stage.

The two key elements of the framework which formed the subthemes of this thesis were *value and legitimacy* and *inter-organizational networks*. These were presented in the framework as separate dimensions. However, the process of moving towards more advanced SOI is likely to have and interactive relationship between these elements.

Firstly, as firms start to form network relationships with actors outside of business networks, new value drivers are likely to start to take importance in the firm's activities. Stakeholder theory suggests that firms need to also consider the expectations of their non-business stakeholders and create value for them (Frow and Payne, 2011). On the other hand, network relationships can also provide value by themselves. The industrial marketing literature considers relationship value as a key element of value propositions (Skålén et al., 2014). Networks can thus act as both conduits of new value drivers as well as sources of value.

Similar interactions can exist in regards to legitimacy and networks. Firms need some degree of societal legitimacy in order to retain their societal license to operate, and many non-business actors such as NGOs are unlikely to collaborate with firms that they consider to be illegitimate. Legitimacy is thus a prerequisite for forming new collaborative networks. At the same time, as new network collaboration are formed and persist over time, they can also increase the legitimacy of participating firms. For instance, large firms often enter into collaborative relationships with NGOs in order to increase the legitimacy of their actions (Dahan et al., 2010). The interrelations between value, legitimacy and networks suggest that the process of advancing SOI will likely include repeated interactions between these elements.

The overall framework for advancing SOI presented in Figure 7 also suggests two potential paths that enable firms to progress from stage 1 to stage 3 of a SOI, depending on whether strategic or systemic aspects are emphasized first. The first one involves making sustainability a strategic concern, and then progressing towards more systemic SOI. This could be the case, for instance, in a technology-intensive firm which identifies the market potential for sustainable products or services and starts, fostering a more strategic mindset towards sustainability. The view can consequently lead to the increased consideration of the views of stakeholders and opportunities for broader stakeholder networks. Evidence of this path could be found in some of the organizations participating in the industrial symbiosis networks studied in publications III and IV. The catalyst for these SOI was often market demand for a particular material or a suitable technology for reprocessing a technology. These early opportunities eventually fostered a systemic mindset within the local network, leading to increased involvement between traditionally unrelated or separate industries as well as different sectors.

The second path begins by focusing on the promotion of a systemic perspective first, while still keeping an operational focus. This can result in a strong focus on stakeholder concerns and maintaining legitimacy within the organization. This can eventually become an organization-wide mindset which also starts to affect the development of new products, services and business models. Large consumer-facing MNEs, such as the energy utilities studied in publication II, typically demonstrated this type of process. Societal concerns shifted the requirement for energy firms to improve the sustainability of their energy generation processes while slowly promoting the use of technologies with a stronger potential for sustainability, such as renewable energy.

5 CONCLUSIONS

This thesis is focused on the advancement of sustainability-oriented innovations. These innovations are highly important for decreasing the environmental impacts of industries and improving societal well-being, while also providing economic value for industrial firms. However, the marketing and advancement of SOI, especially in B2B markets, is still underdeveloped. SOI have certain specific characteristics which set them apart from other types of innovations, such as multidimensional value creation; the diversity of the actors involved; and the institutional frameworks, which often favor incumbent technologies. *The purpose of this thesis was thus to explore two central issues in the advancement sustainability-oriented innovations: their value and legitimacy and the role of collaborative networks in their advancement.* The following research question were addressed in the thesis:

1) How can firms develop sustainable value propositions to demonstrate the economic, environmental and social value of their sustainability-oriented innovations to customers?

2) What kind of rhetorical legitimacy strategies do incumbents firms use to justify investments into (un)sustainable technologies under conditions of institutional change?

3) What forms of inter-organizational networks with the potential to advance environmental sustainability can be identified in the literature and what are the principal operational logics and architecture of these network forms?

4) How can polycentric governance facilitate sustainability collaboration and what are the archetypes of different polycentric governance models?

5) What are the key structural and cultural barriers to sustainable business model innovation and how can societal change towards sustainable business models be promoted?

These research questions were answered through the findings of the individual publications listed in part II of the thesis. This thesis began with an introductory section which detailed the research gap, objectives and conceptual background of the study. The second chapter covered the theoretical background of the study and presented insights from the SOI literature on industrial marketing as well as institutional and network theories. The research design and the methodology of the thesis were explained in section 3. The findings of the individual publications were summarized in chapter 4.

This fifth chapter discusses the contributions of the study and will begin by stating the specific theoretical implications of the findings for the different streams of SOI literature. Second, implications for business managers as well as policy-makers will be discussed.

Third, this section will finish with a discussion of potential SOI research directions that could be pursued based on the findings of the thesis.

5.1 Theoretical implications

This section will discuss the theoretical implications of the thesis. The major implications contribute to the fields of *sustainability-oriented innovation* and *sustainability in industrial marketing*, which formed the main theoretical background for the thesis. The thesis also applied ideas from organizational theories in the individual publications, and consequently the findings also offer minor implications to the research in those fields.

5.1.1 Contributions to the sustainability-oriented innovations literature

This thesis presented and elaborated on the activities through which a firm can advance SOI from operational and insular innovations toward the creation of strategic and systemic innovations. Several key contributions to the literature on sustainability-oriented innovations are discussed in this section. The first two concern the two elements which make up the key processes in the framework of advancing SOI (presented in Figure 6). Previous research has acknowledged that advancing SOI is a multi-stage process and that more advanced innovations are characterized by a more strategic and systemic nature, this thesis highlights *customer value and legitimacy* and *inter-organizational networks* as two key factors which influence this process.

First, much of the literature on corporate sustainability, and even SOI, has focused on how firms can innovate within and throughout their own operations and become more sustainable. Less attention has been paid on how companies can innovate through their customer's processes and create new business opportunities and shared value (Porter and Kramer, 2011). Following the SOI process model proposed by Adams et al. (2015), the importance of realizing new market opportunities and creating shared value is shown to progress through a firm towards the second (strategic/insular or operational/systemic) and third (strategic/systemic) stages of SOI. This thesis thus contributes to the emerging literature on commercializing sustainable innovations (Bocken et al., 2013, 2014; Boons and Lüdeke-Freund, 2013) by highlighting the importance of the understanding and demonstration of customer value as a prerequisite for the promotion of SOI. The existing research has shown that a failure to effectively demonstrate customer value can be one of the major obstacles to the commercialization of SOI (Ramirez et al., 2014), and the first publication of this thesis presents guidelines on how effective value demonstration can be achieved.

Second, this thesis highlights the role of inter-organizational networks as a locus for the *generation and diffusion* of SOI. Previous research in the fields of industrial ecology, industrial symbiosis and green supply chain management have utilized the network perspective (Ashton, 2008; Zhu and Cote, 2004), but lacked a holistic perspective on the role of networks. Thus *eco-industrial networks* as a new research field, acknowledging

the many roles which networks can have in advancing SOI, is proposed. Based on the findings, collaborative eco-industrial networks have the ability to 1) rationalize and improve resource utilization through industrial symbiosis and sustainable supply networks; 2) accelerate the diffusion of more sustainable practices and foster environmental awareness and collective action through environmental issue networks; and 3) generate novel technologies and solutions for reducing environmental impacts through environmental solution networks. The thesis also highlights the network architecture of eco-industrial networks as an important factor influencing how a network is governed and how its goals are achieved. As firms progress to the third stage (strategic/systemic) of SOI, the ability to take a systemic view and co-innovate with network partners becomes a vital capability for a firm (Adams et al., 2015). System-level collaboration is also vital for overcoming barriers to the adoption of SOI, which were identified in publication V. Incumbent firms, visionary entrepreneurs, public-sector organizations, regulators as well as consumers all contribute to the functioning of an innovation system that can support SOI.

Third, this thesis also demonstrates the potential negative side of innovative activities in relation to SOI. Incumbent firms, such as the large-scale utilities studied in publication II, can engage in innovative activities and still cling to unsustainable technologies rather than adopt sustainable ones. Some studies in the field of SOI have also studied sustainability transitions from an institutional, multi-level perspective (Geels, 2011, 2005), and have demonstrated that existing institutional frameworks in a technological field often favor incumbent firms to a degree that makes it difficult for novel sustainable technologies to break into the market. Niche SOI innovators are generally seen as a force for change and incumbents as restraining innovation or resisting it. This thesis studied how the innovative use of rhetoric in regards to unsustainable investments by incumbents can be used to shape perceptions in the innovation system so that it favors unsustainable technologies.

On the other hand, the findings in publication II also demonstrated that incumbents can act as a force for change in the adoption of sustainable technologies, while simultaneously remaining supportive of conventional technologies. Specifically, they make new investments in old technology, while simultaneously making strategic investments in novel sustainable technologies. This can be seen as a form of diversification and risk hedging, as incumbents invest in capabilities that they think might give them a competitive advantage in the future (Henderson, 2015). The findings suggest that future studies on sustainability transformations using the multilevel perspective (Geels, 2011) could take a more in-depth perspective with which to explore the potentially multifaceted role of incumbents in advancing or hindering SOI.

5.1.2 Contributions to the industrial marketing literature

The findings of this thesis also make several important contributions to the industrial marketing literature. The *first* one concerns the proactive role of suppliers in increasing

sustainability. Thus far, much of the literature on sustainability in industrial marketing has focused on sustainable supply chain management and its relationship to the green marketing activities made to end-consumers (Chan et al., 2012; Gupta et al., 2014). This view advocates the perspectives of large consumer-facing MNEs, who have to manage the sustainability of the supply chain in order to achieve certifications and acquire other marketing tools in order to attract and capture the market share containing sustainability-oriented consumers. Less attention has been paid to suppliers of clean technologies and other SOI, who must proactively market these innovations to their industrial customers (Doganova and Karnøe, 2015). The findings in publication I demonstrate that technology suppliers can be proactive and craft effective customer value propositions that are able to improve a customer's sustainability. The ability to do that is a critical skill. In fact, the inadequate demonstration of customer value is one the key barriers to the adoption of sustainable innovations (Ramirez et al., 2014). As technology suppliers are increasingly the experts on industrial processes, their customers are also willing to transfer some of the responsibility to them for also managing the functioning of their customers' processes. This suggests that if suppliers can also proactively manage the sustainability of their customer's customers' processes, they have increased potential to gain key supplier status with the customer.

Second, the findings of this thesis contribute to the existing literature on customer value and customer value propositions by increasing the understanding of value as a multidimensional concept. The previous literature has recognized that customer value may include at least functional, emotional and social value elements (Prior, 2013). Publication I uses the concept of a sustainable value proposition to refer to the demonstration of the economic, environmental and social value of an offering. More specifically, it highlights the sustainable value elements of *customer value,* e.g. functional, emotional and social, and the elements of *societal value,* e.g. decreased environmental impacts and the improved well-being of stakeholders. The key function of a sustainable value proposition is to bridge these two categories and demonstrate to customers the benefits they will receive from added societal value. More research is needed on value propositions and how they bridge the gap between the functional features of an offering and the perceived value that a customer sees.

This thesis also demonstrates how customer value propositions are formed in practice, and characterizes this as an interactive process between a supplier and a customer in which value is uncovered through an iterative process of collecting data on potential benefits; measuring and quantifying these benefits through the use of life-cycle tools; and calculating the bottom line of a life-cycle value. The findings in publication I suggest that life-cycle thinking may be a key paradigm for effectively demonstrating customer value. Similar methods, such as the total cost of ownership (TCO) (Wouters et al., 2005), have been applied in the past from the customer side of sourcing decisions. But their application on the supplier side has received less attention, potentially because of the difficulty of collecting comprehensive data in order to conduct an assessment. However, recent research has characterized value propositions as inter-organizational management

accounting practices (Wouters and Kirchberger, 2015), and the framework in publication I supports this view as an interactive process between a supplier and a customer. Life-cycle thinking also has the added potential to capture other elements of value, such as environmental and social impacts and their derivative customer value. This added value can make it worthwhile for suppliers to engage with a customer regarding the activities required for conducting comprehensive life-cycle analyses.

Third, the findings of this thesis contribute to the understanding of inter-organizational networks in industrial marketing research. The main contributions are made through the improved understanding of the role of networks in advancing the sustainability of industrial processes. Network research has strong traditions in the industrial marketing literature, but aside from a few studies (Baraldi et al., 2011; Lacoste, 2016; Ritvala and Salmi, 2010), this perspective has been neglected in the B2B sustainability research. The findings from publication III elucidate four roles for industrial networks in advancing sustainability. Out of these four, sustainable supply chain management has received the most attention in the industrial marketing literature. Two other forms, environmental issue networks (Ritvala and Salmi, 2010) and environmental solution networks (Baraldi et al., 2011), have received very limited attention. The fourth form, industrial symbiosis networks, has thus far been completely neglected in the industrial marketing literature. The findings suggest that more research should be conducted on the three other network forms aside from sustainable supply chains, especially industrial symbiosis. It is suggested that industrial symbiosis networks could also present other fruitful avenues for research in industrial marketing aside from sustainability. They have a focus on collaborative, cross-industrial relationships as well as products which often fall outside of the core business of industrial firms. These special characteristics could provide an unconventional setting for exploring some of the limits of the current mainstream theories on industrial marketing.

The findings in publication IV also contribute to the literature on network governance. Some scholars have explored the degree to which business networks can be managed by firms (Järvensivu and Möller, 2009; Ritter et al., 2004). The main contribution of this thesis is that explores the role of *polycentric governance* in the management of networks. Polycentric governance combines a high degree of public-private sector collaboration with distributed power, responsibilities and decision-making across multiple levels of governance. More attention could be paid to these characteristics in the network management literature. For example, the role of public sector collaborators could be given more attention in the industrial marketing literature. Firms undertaking innovation are often embedded in networks which include the public sector (Aarikka-Stenroos et al., 2014), especially when it comes to societally relevant issues such as sustainability (Hermes and Mainela, 2014; Ritvala and Salmi, 2010). Managing the potentially different interests of heterogeneous actors can thus become a key issue in network management. Second, the degree to which a network can be managed may depend on the areas of influence of the different network members. For instance, global supply chains may often exceed the jurisdiction of the public sector actors collaborating within the network. The

question of how network management can be managed may then become a question of scale.

Lastly, this thesis also makes a contribution to the relationship of legitimacy to sustainability in B2B marketing. Existing research has characterized legitimacy as operating alongside reputation as a resource for firms engaging in SOI (Czinkota et al., 2014). Legitimacy is also a key concept in the topic of green branding (Kumar and Christodoulopoulou, 2014; Sheth and Sinha, 2015). Furthermore, previous research has acknowledged the *behavioral* and *visual* aspects of corporate branding and its relationship to legitimacy. Publication II also highlights the role of *rhetorical strategies* for legitimacy management in regard to SOI. These findings suggest that the types of rhetorical strategies used can be considerable when firms are looking to legitimize their sustainable investments rather than their unsustainable investments. Firms can also shape the societal perceptions of sustainability through the use of rhetoric in their stakeholder communication. This suggests that the studying the use of rhetorical strategies in their different forms, e.g. rationalization, normalization, moralization and authorization, may have interesting implications for future research in the field of green branding and legitimacy management.

5.1.3 Contributions to organizational research

The findings of the thesis also offer minor implications to organizational research. The findings of the overall thesis offer some novel implications for the emerging research field of organizations and the natural environment. In addition, although the main theoretical grounding of the thesis is in the fields of sustainability-oriented innovations and industrial marketing, some insights from institutional theory and network theory were also used and the findings of the individual publication contribute to the research in these fields. This subsection will briefly discuss these contributions.

This research offers three key contributions to the emerging literature on *organizations and the natural environment*, a field that focuses on the interface of organizational research and environmental sustainability. *First*, the thesis increases our understanding of value creation as a complex phenomenon that spans organizations and natural ecosystems. Value is created in the processes of organizations and is perceived in the minds of individuals, but the complex mechanisms that lead to value creation may also involve the natural environment. For instance, a firm's actions may impact on the functioning of ecosystems, which might decrease the quality of the ecosystem services provided to firms (Winn and Pogutz, 2013). The complex pathways through which different types of societal and customer value are created is an area that could benefit from more research.

Second, the results from publications III and IV highlight SOI as a locus of inter-organizational collaboration. Eco-industrial networks represent inter-organizational activities where the natural environment can be considered a key stakeholder. This

contributes to the emerging field of hybrid organizations which combine business and sustainability logics (Haigh and Hoffman, 2014). However, rather than hybridity being a characteristic of a single organization, eco-industrial networks demonstrate that hybridity can also occur in network-level goals and activities.

Third, the findings in this thesis also highlight the usefulness of combining tools and concepts from the environmental management and business domains and this has been proposed as an important pathway for sustainability research (Hoffman, 2003; Whiteman et al., 2013). The findings from publication I suggest that combining specific sense-making tools from environmental and business domains, such as life-cycle thinking and value propositions, can be used to generate new insights about sustainable value creation, as well as the broader relationship between organizations and the natural environment. Business and management scholars would can benefit from increased collaboration with the fields of environmental science to further develop the body of knowledge on organizations and the natural environment.

For *institutional theory*, the findings of publication II offer new insights into the legitimacy management of firms. Several previous studies have studied the use of rhetorical strategies on contested legitimacy issues such as CSR and organizational mergers (Joutsenvirta and Vaara, 2015; Vaara and Monin, 2008). Publication II explores how rhetorical strategies are used under conditions of wide, field-level institutional change (the energy transition). This shows that incumbent firms use more pronounced rhetoric in combination with a broader and more diverse usage of different rhetorical strategies in order to defend the legitimacy of prevailing technologies. Incumbents also appropriate characteristics of novel technologies in order to re-legitimate old technologies, while opposite actions have observed in past studies (Hargadon and Douglas, 2001). The findings suggest that studying legitimation strategies under conditions of institutional change can provide new insights into how actors contribute to institutional change. The findings of publication II also shed light on the role of incumbents in contributing to institutional change. Incumbents have traditionally been seen as a constraint on institutional development while institutional entrepreneurs (often smaller organzations) are regarded as the agents of change (Russo, 2001). The findings in publication II suggest that some incumbents actively embrace change even when their current capabilities are more suited towards prevailing institutional conditions. Studying incumbents as agents of change and exploring the conditions under which they do so, could be a potentially fruitful avenue for future research.

For *network theory*, the primary contribution of this thesis comes through findings made on polycentric governance models in publication IV. Network governance has been a popular topic for business scholars (Jones et al., 1997) and public-sector scholars (Provan and Kenis, 2007) alike. Polycentric governance models, which bring together both public and private sector actors on multiple levels, have been of interest in the governance of global scale environmental issues, such as climate change (Ostrom, 2014) and water management (Galaz et al., 2012). These issues are generally in the primary interest of the

public sector, although private sector actors are involved to some degree. This thesis explores polycentric governance models for eco-industrial networks, which lie primarily in the domain of the private sector, although the activities also create positive externalities that are of interest to the public sector. Thus they often involve collaborative governance between the public and private sectors. This thesis takes a step towards a more integrative theory of the governance of public-private sustainability collaboration by suggesting three generic archetypes for polycentric governance models. Furthermore, four influencing factors were uncovered, which affect the choice and suitability of the governance model that is most appropriate for the network.

5.2 Implications for practice

The findings of this thesis also offer several guidelines for business managers engaging in the development and commercialization of sustainability-oriented innovation as well as policy-makers and public sector managers who are aiming to advance SOI. These are detailed in the following subsections, in the form of key recommendations.

5.2.1 Implications for business managers

Understanding that the advancement of sustainability-oriented innovation is a multi-stage process that requires organizational changes

First, business managers should view advancing sustainability-oriented innovations as a process that occurs in stages defined by shifting a worldview toward the strategic and systemic nature of the innovations. Managers should first view SOI from a *strategic* perspective which focuses on the sustainability handprint rather than footprint. This can ensure firm survival and create competitive advantage through decreased risks, improved cost effectiveness, the capturing of new market share and the creation of new competencies for the future. Managers should also take a more *systemic perspective* and create shared value for their customers as well as wider society through SOI. The growth of the cleantech field, hybrid organizations as well as bottom-of-the-pyramid strategies, are examples of the successful creation of shared value. Price and quality leadership are generally acknowledged as two methods for differentiating products from their competitors in the marketplace. As the boundaries of our planet become more evident, it is time for sustainability leadership to be recognized as another method.

Advancing SOI may also require considerable organizational change to make sustainability a strategic issue and to foster a a systemic perspective. Creating sustainable value propositions may require new types of functional teams inside an organization, so that the competencies of sales and marketing personnel along with experts in operational sustainability assessment, such as LCA, can be combined. At the same time, in order to foster a systemic mindset, sales and marketing personnel also need to become more receptive to societal and public sectors actors in addition to listening to their customers.

Utilize networks in the development and commercialization of new sustainability-oriented innovations

Sustainability-oriented innovations are seldom created in isolation. They require interaction with customers to identify latent needs; alliances with knowledge and R&D partners in order to generate new technologies; interaction with various third parties, consultants, NGOs, etc. for complementary resources; as well as interaction with the public sector to realize the societal goals of the innovation. Therefore, managers need to acknowledge the importance of networks in developing and commercializing new SOI. Collaborative networks can help to find new business opportunities and customers for innovations and also new partners with complementary resources for developing new SOI. In addition, collaborative networks are useful for the discovery of new opportunities for greening the supply chain and obtaining valuable knowledge partners from outside the business sector, such as public sector organizations and NGOs. While networks are important for many forms of innovation, their role in the creation of SOI is especially vital due to the high variety of involved actors in sustainability issues. Finding new business opportunities may require going outside the traditional supply chain to other industries, and the input for new innovations may come from the public sector that governs the regulatory environment for SOI or NGOs representing stakeholder interests.

Inter-organizational collaboration requires new skills for managing through networks, as well as managing in networks. The former means that networked innovation is considered as a real alternative to internal innovation, and network resources can be a viable alternative to developing or acquiring the same resources in-house. This requires trust in network partners, which directs attention to the skill of managing in networks. The governance of networks must be designed effectively to best support the network's goals and activities. While different forms of governance may be suitable for different networks, the findings of this thesis suggest that many sustainability collaborations can be effectively governed by models that feature a low hierarchy and distributed decision-making amongst different parties. However, clear protocols and guidelines for action are still needed, even in contexts of high trust and distributed power (Fjeldstad et al., 2012).

Craft effective customer value propositions in order to demonstrate sustainable value

The third managerial guideline concerns the importance of demonstrating customer value. The inability to credibly demonstrate customer value has been recognized as one of the key barriers to the adoption of SOI (Ramirez et al., 2014). Therefore, suppliers of SOI need to be able to craft effective customer value propositions, which demonstrate the economic, environmental and social benefits of their offerings. The findings in this thesis provide a managerial framework for how this can be accomplished. Sustainable value propositions can be developed by: 1) identifying the value potential of the offering; 2) assessing the value creation mechanisms available to the customer with regard to the offering; 3) choosing key indicators; 4) conducting life-cycle modeling; and 5) assessing life-cycle value. Environmental and social benefits can also translate into customer value

in addition to societal value. Suppliers can demonstrate this by placing a monetary value on the environmental and social impacts, calculating the customer's potential risk reduction or by seeking certifications or standards which symbolically demonstrate improved sustainability.

In the case of SOI, developing value propositions may require new capabilities, such as the ability to conduct comprehensive LCA studies. LCA requires the systematic data collection of the inventories of physical materials which are the inputs and outputs of industrial processes. This data collection, in turn, requires deeper collaboration between the supplier and customer to collect and analyze the needed data. While this may require more resources from both parties, the pay-off may be worth considerable sums, and gains in business capabilities and knowledge. For instance, suppliers will gain a better understanding of the impacts of their offering and the customer value they provide. These data can be a powerful marketing resource for further improving a specific customer's processes as well as gaining new customers. Customers, meanwhile, gain a more comprehensive perception of the value that they receive from an offering.

Manage the broader legitimacy of the organization and the innovation

Lastly, the marketing of sustainability-oriented innovations requires careful legitimacy building and management. Customer value is one important form of legitimacy, but legitimacy also needs to be communicated to other stakeholders, including shareholders, employees, government, the local communities affected by a firm as well as wider society. Several institutional mechanisms may work against SOI during their infancy. Institutional isomorphism promotes stability and generally favors incumbent firms and technologies in the field. The conflicts between energy utilities and emerging renewable energy technologies demonstrate this. This means that new innovations which do not fit into existing institutional frameworks may require a high amount of legitimation work in order to be able to be diffused throughout a market. Legitimacy may be promoted by concrete actions as well as symbolic and rhetorical strategies aimed at changing the perceptions of stakeholders. Legitimation strategies may also take the form of demonstrating utilitarian value to stakeholders, appealing to wider societal norms and morals as well as appealing to authorities such as the government.

5.2.2 Implications for policy-makers and public sector managers

Understand that the private sector can be an important ally in advancing the goals of sustainability

The governance of environmental and social issues is generally seen as the responsibility of the government, which is nested in hierarchical areas of governance. However, many scholars studying the governance of sustainability issues, such as climate change, have advocated polycentric approaches that feature distributed power among different actors and on different levels as well as strong collaboration between the public and private

sectors (Ostrom, 2014; Sovacool, 2011). Businesses can be a great force in improving environmental and social sustainability, provided that there is an incentive for them to do so. Collaboration can be especially fruitful in areas where there is a clear mutual benefit for both parties. The public sector can provide businesses with political support, financing for new innovations and aid in brokering new relationships. The private sector can provide the public sector with proactive governance on sustainability issues that are difficult for the public sector to affect in direct ways, such as those that directly concern the environmental impacts of industry.

At the same time, the public sector should not become too involved with the direct development of SOI. Some examples in the field of industrial symbiosis have shown that solutions which are designed in a top-down approach by the public sector are usually inferior to those which grow organically through business relationships (Gibbs and Deutz, 2005). Instead, some studies have suggested that a midway approach, combining planned and emergent activities (Baas, 2011), in which the government acts as a facilitator (Paquin and Howard-Grenville, 2012), might be the best approach.

Create platforms for collaboration and design effective governance models for them

In order to advance SOI in its different forms, new platforms should be designed which consider the diversity of methods available for supporting innovation. Policymakers can build systems that take into account the differences and similarities in alternative collaboration forms, and which enable actors to connect with each other and access relevant resources in a meaningful and purposeful manner. For example, the advancement of symbiosis could be promoted through the use of the comprehensive databases of industrial inputs and outputs within a specific region, whereas the advancement of sustainable R&D projects would require information on ongoing and planned development projects and platforms that pair firms with synergistic R&D opportunities. Arranging networking events to discuss specific environmental issues may also create opportunities for firms that share an environmental concern and enable them to take collective action. New opportunities may also be realized by combining traditionally separate platforms for SOI development. The polycentric governance models explored in publication IV can be an important way to govern the aforementioned platforms. The findings from highlight three forms of polycentric governance which can advance SOIThese represent different degrees of polycentric governance, and the suitability of the governance model can depend on the specific contextual and structural characteristics of the network

Build a supportive regulatory framework for encouraging sustainability-oriented innovations

Lastly, one of the key focus areas of this thesis is the development of a proactive orientation for sustainable innovation by companies instead of sustainable innovation for the sake of regulatory compliance. However, that does not mean that the importance of effective regulation should be forgotten. The results of this thesis, particularly the findings

in publication V, highlight the fact that regulation still plays a key role in overcoming the barriers to SOI. Effective regulation can guide industrial activities towards sustainability-oriented innovation by creating limits and costs for environmental and social impacts as well as incentives for improvement. However, one of the key problems with regulations governing sustainability has been that they change too fast to provide businesses with the stability required for making new investment. A good example is the energy field, where the regulatory mechanisms of many countries serve to promote renewable energy, yet many of these mechanisms have been criticized for being ineffective. In some cases, such as industrial symbiosis, regulations can even hinder innovation, for example waste reprocessing regulations can be too strict and make the reuse of wastes and byproducts unfeasible (Salmi et al., 2012). Regulations should be made with a consistent, long-term outlook that can give firms the confidence to make new investments. They should also support different options for solving sustainability issues because multiple viable solutions can exist. For example, in the automotive sector SOI includes many types of technologies, such as electric vehicles, hybrid vehicles, fuels cells and biofuels.

5.3 Suggestions for future research

The findings of the studies conducted in this thesis offer several fruitful avenues for future research. *First*, more research is needed on value creation and value propositions in relation to SOI, especially in the marketing field. Based on two product-focused case studies, this thesis has proposed a process model for developing sustainable value propositions for commercial industrial offerings. Further research could study the applicability of this framework in various other contexts, such as consumer offerings as well service-oriented offerings. Future studies should also be conducted to identify other potential value creation mechanisms that can turn societal value into customer value, and find strategies for demonstrating how these mechanisms can be made salient. This study did not address individual level value perceptions, which may shape the perception of value for the whole of a customer organization to a considerable extent. As industrial purchasing processes involve multiple individuals in different roles, such as buyers, users and decision-makers, future studies should examine how these individual value perceptions differ and how they come together to create organizational level value; research approaches involving experiments could provide useful insights in that regard.

Second, sustainability and marketing scholars alike should pay more attention to the role of networks in advancing sustainable innovation. They are not only conduits for knowledge sharing and the diffusion of innovation, but also a potential source for novel innovations. New forms of organizations and innovations often emerge at the nexus of different networks and domains (Padgett and Powell, 2012). This study identified four forms of networks where new SOI can emerge, but other potential forms exist and should be explored in future research. Second, these networks are not likely to exist in isolation, but are interlinked with other types of networks. Future research could therefore explore the links, synergies and potential conflicts at the intersection of different network types, such as industrial symbiosis and sustainable supply chains. The evolution of these

networks over time is another key issue that has not been researched in this thesis. For example, the governance models of these networks may change considerably over time. Network dynamics has been observed to be an important in e.g. industrial symbiosis networks (Chertow and Ehrenfeld, 2012), and while the research in publication IV included a retrospective analysis of the networks' governance, real-time longitudinal data collection is often required to accurately study change (Halinen et al., 2012).

Third, marketing and organizational scholars should pay more attention to legitimacy in relation to SOI. The marketing field has recognized the importance of legitimacy for green branding and institutional scholars have studied legitimacy struggles in relation to sustainability transitions. However, as institutional change is an inherent aspect of the path towards a more sustainable future and existing institutions often favor unsustainable activities, these research areas warrant more attention. New innovations need active business entrepreneurs as well as institutional entrepreneurs in order to beat the technological and institutional inertia which exist in industries (Doblinger and Soppe, 2013; Olsen and Boxenbaum, 2009). Legitimacy management, in its various forms, should also warrant more research attention. For example, researchers could explore how stakeholders respond to legitimacy management tools, such as the corporate press releases studied in publication II. Marketing scholars should also study the effectiveness of various rhetorical legitimation strategies in marketing communication, as legitimacy has been identified to be vital in regards to building a sustainable brand, but the detailed studies on legitimation strategies in marketing have been scarce (Humphreys, 2010).

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PART 2: INDIVIDUAL PUBLICATIONS

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Sustainable value propositions: Framework and implications for technology suppliers

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ABSTRACT

Advances in sustainable purchasing put pressure on firms to evaluate and demonstrate the sustainability of their products and services. In this paper, we coin the term *sustainable value proposition*, develop a process framework for building sustainable value propositions, and illustrate its application with two technology-intensive offerings. By integrating the literature on sustainable marketing and customer value propositions with life cycle assessment methodologies, we build a process framework that can be applied to demonstrate and evaluate the economic, environmental and social benefits of industrial products and services. The framework comprises 1) identification of potential impacts, 2) identification of key value creation mechanisms, 3) choosing key indicators, 4) life cycle modeling, and 5) life cycle value demonstration. Through two case studies, we examine the development of sustainable value propositions in two industry sectors: metallurgical and automotive. The results highlight the value provided to customers through the combination of direct economic benefits and derivative benefits of reduced environmental and social impacts. Our paper contributes to the growing field of sustainable marketing by offering guidelines on how to integrate sustainability with the marketing and purchasing of technology-intensive offerings. In addition, we offer guidelines for how to construct sustainable value propositions that resonate with customers.

1. Introduction

Growing demand for sustainable products and services is one of the major macro-trends shaping competition (Kotler, 2011; Porter & Kramer, 2011). Social, environmental and economic problem solving is considered a new strategic imperative and a potential source of competitive advantage (Porter & Reinhardt, 2007; Berns et al., 2009). As "sustainability initiatives are transforming markets" (Brindley & Oxborrow, 2014, p. 45), we need more understanding on how firms can incorporate the sustainability approach into marketing and purchasing (Sharma, Iyer, Mehrotra & Krishnan, 2010; Chan, He & Wang, 2012).

The United Nations Sustainable Development Goals (SDGs) set ambitious priorities for governments and businesses to drive the implementation of sustainable development up to 2030. However, ambitious goals alone will not generate change. Specific processes for action and decision-making need to be created at global, national and individual levels (Norström, 2013). For example, buyers and sellers need systematic approaches to assess the economic, environmental and social impacts of products and services. The science of sustainability measurement has progressed and advances in life cycle assessment (LCA) and product "footprinting" enable marketers and purchasers to collect data, assess impacts and turn data into decision-support tools (O'Rourke, 2014).

Analysts have estimated that the current levels of global production and consumption are expending 50% more natural resources than ecosystems regenerate and the environmental costs externalized each year from global production systems amount to approximately USD 4.7 trillion (O'Shea, Golden & Olander, 2013; Trucost, 2013). As a result, there is an urgent need to develop processes and tools to better integrate sustainability into the functions of global value chains, including industrial marketing and purchasing.

In this paper, we explore how firms can develop *sustainable value propositions* that will respond to and resonate with customers' environmental and economic concerns. We define sustainable value propositions as a *promise on the economic, environmental and social benefits that a firm's offering delivers to customers and society at large, considering both short-term profits and long-term sustainability* (c.f., Anderson, Narus & Van Rossum, 2006; Ballantyne et al., 2011; Parguel, Benoit-Moreau, & Larceneux, 2011). This is in accordance with the triple bottom line approach, which emphasizes the economic, environmental and social benefits that result from sustainability (Elkington, 1998; Savitz & Weber, 2007). Further, we explore how firms can verify sustainable value propositions by calculating the realized economic, environmental

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and social effects through life-cycle based approaches. The life cycle approach offers a comprehensive framework to analyze the full range of environmental, social and economic impacts of product life cycles and supply chains. We propose that integrating life-cycle based assessments with marketing and purchasing is an important step towards implementing sustainability efforts within global supply chains.

In the following sections, we integrate the literature and contemporary research on sustainability and marketing to discuss the need for sustainable value propositions in more detail. This is followed by a field study, which draws insights from two dyadic case studies involving two technology offerings that aim to improve the efficiency of industrial production processes. Based on our findings, we develop a framework that firms can apply to evaluate and quantify the economic, environmental and social benefits of their products and services. Overall, our paper contributes to the literature on sustainability (e.g., Sharma et al., 2010; Connelly, Ketchen & Slater, 2011) and industrial marketing (e.g., Ballantyne et al., 2011) by providing a framework to evaluate the customer value of sustainable industrial offerings. Sellers can use the framework to build and verify sustainable value propositions, while buyers and third parties (such as consultants and engineering offices) can apply the framework to evaluate the sustainability of alternative offerings. Our theoretical contribution lies in integrating marketing and environmental management literatures to develop new processes that advance sustainable development at the firm level. We propose that sustainability-driven competitive advantage requires new processes and tools that fundamentally shape core business functions such as marketing and purchasing.

2. Literature review

2.1. Sustainability in the marketing literature

Regulatory, competitive and stakeholder pressures are driving the motivation to integrate sustainability into academic literature and managerial practice (e.g., Porter, 2007; Kotler, 2011; O'Shea et al., 2013). In addition, increased awareness of the limits of planetary boundaries (Rockström et al., 2009) and the related risks of potential supply chain disruptions amplify these drivers. Consequently, a great deal of scholarly research has been devoted to exploring the link between sustainability and marketing. Due to the multidisciplinary nature of sustainability, scholars have addressed sustainable marketing in a variety of research streams, including *green marketing* (Ottman, 1993; Kalafatis, Pollard, East & Tsogas, 1999), *environmental marketing* (Peattie, 1995), *ecological marketing* (Fisk, 1974; Henion & Kinnear, 1976) and *enviropreunial marketing* (Menon & Menon, 1997). Given that sustainability is concerned with meeting customers' economic, environmental and social needs (Brundtland & Khalid, 1987), this research has largely focused on how to create value for the customer and society while reducing environmental impacts (Brezet & Hemel, 1997), and how to incorporate environmental and social criteria into marketing activities (Chamorro, Rubio & Miranda, 2009; Leonidou & Leonidou, 2011).

Customers and other stakeholders are paying increased attention to environmental, ecological and social purchasing criteria (Drumwright, 1994; Porter, 2007; Kotler, 2011). However, in practice, customers do not purchase products or services based on environmental attributes alone; instead, they evaluate the trade-offs between the economic and environmental attributes of an offering (Rokka & Uusitalo, 2008; Olson, 2013; Papista & Krystallis, 2013). Prior research in consumer markets indicates that although customers may prefer environmentally friendly offerings in general, they are often reluctant to make the appropriate purchasing decision, since they are uncertain about the potential benefits that such an offering will deliver (Ginsberg & Bloom, 2004; Gupta & Odgen, 2009; Olson, 2013). In industrial markets, this uncertainty is likely to be higher, since sustainable offerings may involve novel and expensive technologies, high information asymmetry between supplier and buyer, and intangible benefits that are difficult to evaluate (Schweitzer & Aurich, 2010). For example, in investigating customer perceived barriers to adopting environmentally sustainable offerings in industrial markets, Ramirez et al. (2014) found that suppliers' inability to communicate the economic and environmental benefits to the customer's business was a major factor hampering customers' willingness to buy.

In the sustainability literature, the value delivered by firms is usually considered in terms of economic, environmental and social benefits, also referred to as the triple bottom line approach (Elkington, 1998). This approach aims to take into account all the relevant tangible and intangible benefits that firms deliver to customers, wider stakeholder networks, and society (e.g., Cronin, Smith, Gleim, Ramirez & Martinez, 2011; Porter & Kramer, 2011; Fearne, Garcia Martinez & Dent, 2012). As firms are increasingly held accountable for their environmental and social impacts, this stream of literature emphasizes that besides economic benefits, firms need to communicate also the environmental and social benefits their offerings deliver.

In the consumer marketing literature, research on sustainability has addressed green marketing (Peattie, 1992), green branding (Chen, 2010), or green advertising (Schuhwerk & Lefkoff-Hagius, 1995) as potential strategies to communicate how suppliers can reduce environmental impact and ecological footprint. However, these approaches tend to emphasize environmentally friendly product attributes and socially responsible supplier behavior as the basis of the firm's marketing messages, while focusing less on the actual value added, or potential benefits that a prospective customer may receive (c.f., Polonsky, 2011). In the industrial marketing literature, research on sustainability has thus far focused largely on "greening" the primary supply chain, or more specifically, how to reduce the environmental impacts of operations and signal to external stakeholders a commitment to environmental values (Fraj, Martínez & Matute, 2013; Sharma et al., 2010; Gupta et al., 2014). However, what still remains relatively less well understood is the role of technology suppliers in sustainable marketing (Chan et al., 2012).

Green supply chain management activities generally cover primary production chains from sourcing raw materials to consumer product consumption (driven by consumer buying preferences) and reverse supply chains for waste management. Technology suppliers thus often fall outside the core activities related to greening the supply chain, and their role has been under-researched (Chan et al., 2012). Their role can however be vital, since many manufacturers invest in green technologies to reduce the environmental footprint of their products (Chan et al., 2012). But the current frameworks in green marketing related to greening the supply chain and green communications do not sufficiently address the technology supplier's activities in demonstrating sustainable value, which requires developing targeted *customer value propositions* that also address environmental and social concerns.

2.2. Value propositions in the industrial marketing literature

In the industrial marketing literature, *customer value propositions* are considered to be marketing messages that communicate the value a supplier's offering delivers to customers (Ballantyne et al., 2011). Essentially, value proposition reflects the firm's core strategy (Kaplan & Norton 2001; Lehmann & Winer, 1991), and a promise on how it will serve its customers. Conventionally, customer value propositions have been defined as statements of the benefits of a particular product or service (Rintamäki, Kuusela & Mitronen, 2007). For example, Anderson et al. (2006) suggest that suppliers can develop customer value propositions in three ways, identifying: 1) all benefits, 2) benefits that exceed the next best alternative or 3) the value of the selected key benefits their offerings deliver to customers.

The extant research usually considers value propositions in terms of economic benefits, or monetary value, that the supplier's offering delivers to its customers (e.g., Anderson et al., 2006; Wouters & Kirchberger, 2015). This view has largely ignored the environmental

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and social benefits that customers may also receive. One reason for this might be the difficulty of quantifying the environmental and social benefits that suppliers are able to deliver (Öberg et al., 2012). For example, environmentally friendly offerings are usually technologically complex, and deliver benefits that are relatively intangible in nature, such as improved end product quality, production process safety, and public image, or reduced environmental footprint, waste material, or energy usage (Roy, 2000; Schweitzer & Aurich, 2010). Since customers increasingly pay attention to environmental and social buying criteria (Drumwright, 1994; Meehan & Bryde, 2011), and expect concrete evidence of their impact on business performance (Ramirez et al., 2014), suppliers need to quantify and communicate the economic, environmental and social benefits their offerings deliver to customers.

Given that value propositions are considered one of firms' most important organizing principles (Webster, 2002; Payne & Frow, 2014), and the development of improved value propositions has been highlighted as a key research priority (Marketing Science Institute, 2010), industrial firms need more understanding on how to integrate environmental and social elements into value propositions (c.f., Bolton, Gustafsson, McColl-Kennedy, Sirianni & Tse, 2014; Frow et al., 2014). Next, we discuss life cycle tools that can facilitate the evaluation and quantification of environmental and social impacts.

2.3. life cycle approach in the sustainability literature

In the sustainability literature, various environmental management tools have been developed to assess the environmental impacts produced by products, systems, and an organization's activities along its value chain. These include, for example, Environmental Risk Assessment, Eco−/Green Marketing, Eco-design, Environmental Accounting (Burritt, Hahn & Schaltegger, 2002), Environmental Impact Assessment, Life Cycle Assessment, and Environmental Management Systems (Schaltegger et al., 2003). Similar methods exist for the assessment of social impacts, such as Social Impact Assessment and Human Rights Impacts Assessment (Benoit & Vickery-Niederman, 2011).

Many of the aforementioned tools focus on the impacts at the organizational level, while LCA, and tools that utilize LCA information, such as eco-design and eco-labels, consider the impacts of product chains from raw material acquisition to final disposal. More specifically, LCA is one of the most standardized methods published under the ISO 14000 family, which is used as a framework for many Environmental Management Systems (EMS) and environmental labels and declarations. Societal LCA tools have not yet been standardized, although guidelines for assessing social impacts can be found under the ISO 26 000 framework for social responsibility (Benoit & Vickery-Niederman, 2011). Certified eco-labels and declarations can be used to signal sustainability, and have been used effectively in consumer markets, as demonstrated for example by the MSC certification for seafood products, or the EU eco-label that can be used on various consumer products (Thrane, Ziegler & Sonesson, 2009). Regarding social sustainability, eco-labels commonly convey the impression that fair working conditions have been enforced throughout a supply chain or that the employees and producers in the developing countries a raw material, component or product comes from were paid fair prices. In order to show the worth of this market, it is worth noting that the Fair Trade label has an annual market size of approximately €5.5 billion worldwide (Fairtrade International, 2014).

While several environmental management tools have been applied in marketing studies (e.g. Cronin et al., 2011; Chen, 2010; Pujari, Peattie & Wright, 2004), we focus specifically on life cycle assessment and its applications in this study for two primary reasons. First, life-cycle based approaches are the common methods used to assess the impacts of an offering throughout its life cycle from inception to post-usage (e.g., Rebitzer et al., 2004). Second, life-cycle based methods can also provide the basis for many of the other methods. They can be used in green marketing activities to communicate sustainability to customers, can provide information for eco-design product decisions, and can also be used to calculate the impacts of environmental damages. They can further provide the background information for many eco-labels (EEA, 1997).

The commonly used applications of life cycle tools are LCA to assess environmental impacts and life cycle costing (LCC) to assess economic impacts (e.g., Lee, Geum, Lee & Park, 2012; Rebitzer et al., 2004; Öberg et al., 2012). LCA is a systematic method that examines material flows relating to a system, and considers a wide scope of effects that relate to the natural environment, human health, and resource usage, and aims to determine the environmental impacts and life cycle phases most relevant to them (Rebitzer et al., 2004; Soukka, 2007). LCA tools are typically employed to identify the potential to improve environmental performance at various points over the life cycle of an offering. For example, services such as training, repair, maintenance or the upgrading of physical equipment components, result in a longer equipment life cycle (Aurich, Fuchs, & DeVries, 2004). Offerings that do not include the transfer of ownership can lead to reduced equipment and material disposal. Thus, the effects of included services can be beneficial to the environment, but they might also have negative rebound effects (Bartolomeo et al., 2003). This indicates a need to analyze the potential for improved environmental performance of each offering individually.

While LCA standards are developed to assess environmental impacts, recent studies have focused on integrating *economic, environmental and social impacts* into a single, multidisciplinary sustainability assessment framework (e.g., Guinee et al., 2011; Lee et al., 2012). Moreover, prior research indicates that overly focusing on environmental impacts can hinder the promotion of ecologically beneficial offerings (Sharma et al., 2010), and emphasizing the economic benefits of the offering might facilitate their more widespread business acceptance

Table 1
Typical impact categories for economic, environmental and social impacts (Jorgensen, Bocq, Nazarkina & Hauschild, 2008; Soukka, 2007; VROM, 2000; Fuller & Petersen, 1995).

Economic impact categories	Environmental impact categories (endpoint and midpoint)	Social impact categories
Benefits • Availability of production • Performance of production • Quality of production • Residual value Costs • Investment costs • Input costs (material, energy, water) • Maintenance costs • Man-hour costs • Material costs • Costs of externalities (environmental and social costs)	• Damage to resources (e.g. availability of minerals and fossil fuels) • Damage to ecosystems (e.g. biodiversity, land use) • Damage to human health (e.g. radiation, respiratory effects, ozone layer depletion, climate change effects)	• Human rights (e.g. child labor, forced labor, non-discrimination) • Labor practices and decent working conditions (e.g. wages, benefits, safety at work, job satisfaction) • Society (e.g. corruption, job creation, support of local suppliers • Product responsibility (e.g. product safety concerns, labeling, ethical marketing communications)

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Table 2
Case descriptions.

	Case A	Case B
Company description	Global supplier of technology solutions for minerals and metals processing, with a key emphasis on the sustainable use of resources in these sectors.	Supplier of measurement systems for quality control in automotive manufacturing.
Focus of the value proposition	Monitoring system designed to enhance process efficiency in the electrolytic refining process for copper, nickel and zinc.	Optical measurement system to improve the process output of welded assemblies in the manufacture of automotive parts.
Personnel involved in value proposition development	19 experts from the supplier and two customer firms.	12 experts from four organizations: measurement system supplier, line builder, parts manufacturer, and an OEM
Role of the researcher(s)	One researcher involved as a direct observer	Two researchers involved: direct observer and business owner

(Tukker & Tischer, 2006). Consequently, other life cycle applications such as life cycle profits (LCP) (Räsänen, Soukka, Kokki & Hiltunen, 2008), life cycle costing (LCC) and societal LCA (Guinee et al., 2011) have been developed to interpret and take into account economic and social impacts as well. Table 1 provides a summary of the typical indicators for economic, environmental and social impacts employed in the sustainability literature. The environmental indicators can be chosen through a midpoint or endpoint approach. A midpoint indicator uses an environmental theme such as climate change. Endpoint refers to impacts on a final area of human concern, such as impacts on human health. The most important social considerations that industrial firms typically take into account are the need to ensure decent working conditions, the need to reduce negative health impacts on employees and addressing safety concerns—both in the workplace and the final product.

3. Methodology

Given the explorative nature of our study, we adopted a case study research method, which is suitable for building new theory and examining a novel or complex phenomenon (Eisenhardt, 1989; Johnston, Leach, & Liu, 1999). Case studies are generally employed in marketing research to examine a specific phenomenon in different contexts and it allows us to explore how sustainable value propositions are developed for two different offerings in two different industries (Eisenhardt & Graebner, 2007). The empirical data were collected during two separate projects, completed in 2010 and 2012, which focused on developing value propositions for two industrial offerings. Three of the authors were personally involved in these projects, either as direct observers or business owners.

Our cases represent two different industry sectors, metallurgical and automotive manufacturing, and we collected a mix of qualitative and quantitative data from both the suppliers and customers of industrial offerings. The selected industry contexts were especially suitable for examination as sustainable solutions have the potential to improve ecological performance, particularly in energy intensive and natural resource intensive industries such as power generation, mining and metals refining, and the automotive industry (Energetics, 2004). These mature industries consume scarce resources, and are under considerable pressure to restructure their operations by developing and adopting environmental solutions. This trend is reflected in the growth of the "clean tech" industry (Johnson & Suskewicz, 2009), which offers environmentally beneficial technologies that consume less resources compared with alternatives.

3.1. Case descriptions

The case offerings were both technological solutions that provided environmental and/or social benefits, as well as economic value to their customers. Both can be classified as input oriented solutions (Ulaga & Reinarzt, 2011), in which the supplier's product formed the core of the offering, with complementary services that included maintenance, updates, and remote support. Both offerings were designed to improve the efficiency of an industrial customer's production process (providing economic value), while optimizing materials usage (providing environmental value) and improving safety at work (providing social value). However, neither of the firms providing these solutions had previously promoted the offerings as sustainable, but had focused on emphasizing the economic benefits of the value propositions. The details of the two cases are listed in Table 2.

Case company A is a global supplier of technology solutions to the mining and metallurgical industries, with a key emphasis on the sustainable use of resources in these sectors. The company is ranked among the top ten in the Global 100 list of the world's most sustainable companies (Forbes, 2014). The offering examined in this study is a monitoring system designed to enhance process efficiency in an electrolytic copper refining process, with applications also for nickel and zinc refining. This particular offering was selected because it provides economic value by enhancing process efficiency, environmental value by optimizing resource usage, and social value by improving the working conditions for the personnel operating the system.

Case company B is a supplier of advanced measurement systems for quality control in the automotive industry. The offering examined in this study is an optical measurement system designed to enhance process efficiency in measuring welded assemblies on the production line of an automotive parts manufacturer. This particular offering was selected because it provides economic value by enhancing process efficiency through faster and more comprehensive measurements, environmental value by performing all the visual inspections on the production line and eliminating the need for several types of inspection system, and social value by improving the traceability of faulty parts should there be quality defects that require recall campaigns.

3.2. Data collection

The empirical data include a total of 31 interviews, with representatives from both the supplier's and customer's organization in both cases. This is consistent with sample sizes recommended for exploratory research (McCracken, 1988, p. 17). For Case A, we conducted interviews with 19 representatives: 12 from the monitoring system supplier, and seven from two of its customers. The representatives included senior managers, salespeople and technical experts from the supplier, and buyers, process experts and plant operators from the customers. All the representatives were chosen on the basis of their familiarity with the system. The interviews were recorded and fully transcribed for qualitative content analysis.

For Case B, we conducted interviews with 12 representatives: three from the optical measurement system supplier, three from the original equipment manufacturer (OEM) that assembles the end product cars, four from the manufacturer that produces parts for the OEM, and two from the line builder that delivers the production line to the parts manufacturer. The representatives included directors, production managers, salespeople and technical experts, to ensure a broad view of the economic, environmental and social benefits provided by the system. These interviews were not recorded, because of confidentiality issues, but detailed notes were taken from each interview. In addition to the interview data, we obtained internal data from both supplier companies, including documents on prior benefit assessments, technical

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performance analyses and sales presentations, related to the studied monitoring and measurement systems.

3.3. Data analysis

Instead of employing strictly inductive logic, we used a systematic combining approach to search for emerging themes in the empirical data (Dubois & Gadde, 2002). In practice, we build on the existing literature on sustainability, value propositions, and life cycle tools, to generate an understanding of the key requirements to develop sustainable value propositions. At the same time, our empirical data provided insights on how industrial firms evaluate the economic, environmental and social benefits of their offerings, and how these were used as marketing arguments. The result was an iterative process where the emerging framework and the actual customer value propositions were developed concurrently.

We employed a loosely thematic, semi-structured interview guide, focused on exploring the key economic, environmental and social benefits of each offering, and the related drivers, mechanisms and performance indicators for each benefit. We conducted the interviews first with suppliers in both cases, and then used customer interviews to complement and validate the preliminary findings.

The data analysis involved several stages. In the first stage, the interviews from both the suppliers and customers were analyzed to identify the key benefits and their related value creation mechanisms. In the second stage, we identified suitable performance indicators for each benefit. In the third stage, we gathered additional data, including actual measurements and estimates from the suppliers, customers, and the literature, to quantify the value that each benefit delivered. After obtaining the data, we employed Excel and GaBi life cycle assessment software[1] to quantify the impact of each benefit based on the selected performance indicators. In the final stage, we validated the quantified benefits with both suppliers and customers, and integrated the benefits into sustainable value proposition. The economic impacts were calculated through a combination of life cycle costing and life cycle profit analysis, which calculates the overall performance of a process, based on three factors: availability (time efficiency of production), performance (ratio of production volume to maximum capacity), and quality (rate of parts of acceptable quality). The environmental and social impacts of the offerings were assessed by applying the principles of life cycle assessment (LCA). A detailed description of the input data and calculations used to quantify the benefits is presented in the Appendix, and the key results are illustrated in the next section.

4. Results

This section will demonstrate how a customer value proposition that is environmentally, socially and economically sustainable is developed. The process, based on a synthesis of the existing literature and our empirical findings, is depicted in Fig. 1. The stages of the value proposition development process are detailed and examples from the two case studies are provided for each stage. At the end of the section, we present flowcharts which exemplify the value proposition development process for each case.

4.1. Identify potential impacts of the offering

Identification of potential impacts refers to defining the current and future key benefits of a specific offering that represent expected value-in-use for a customer and relevant stakeholders, following the logic of Anderson et al. (2006). This involves recognizing all of the features of an offering which can potentially provide value by creating gains or decreasing losses in the economic, environmental and social dimensions. While many features can provide a similar value as competing offerings, they can still form a vital part of the value provided for the customer and thus they should be included in further assessments despite their lack of competitive advantage. This stage is used as a basis to determine which benefits of an offering which provide the most value for the customer.

In case A, the monitoring system provides real-time data from the electrolytic refining process, and thus allows the operators to improve the start-up time of the process after mandatory process halts to harvest the refined metal, and to detect and remove efficiency-decreasing short circuits more quickly. This can improve the economic potential of the production process and decrease environmental impacts through smaller energy use. The system also provides the operators, through an LED indicator, with improved feedback on the removal of short circuits, which previously required the manual inspection of each cell separately to detect short circuits. This can provide social value for the customers' employees. Finally, the wireless nature of the system requires less maintenance than traditional wired systems.

The optical measurement system in case B is designed to enhance the efficiency of an automotive production line. Compared to traditional quality control methods, the optical measurement system a decreases maintenance time that halts production, achieves 100% inspection of every part and improves overall inspection quality. These features can improve the customers' profitability by higher overall production rate and decrease environmental impacts through smaller energy and material usage. The system also enables the traceability of faulty parts since every part is measured and the information is stored, providing social value to the end customers of automobiles.

4.2. Identify key value creation mechanisms

The identification of potential beneficial impacts is not enough to develop a sustainable value proposition. Suppliers must also try to ascertain the type of impacts a customer values and thus customize the value proposition to the customer's needs. This requires determining the unique value drivers of the target customer to uncover the elements of the *key value creation mechanisms* of the customer's processes, where the supplier's offering can create value, or prevent losses where problems exist.

An assessment of competing offerings should be conducted to determine the favorable points of difference. While many features in competing offerings can provide a similar value to the customer, some can be pivotal to the value provided.

For the monitoring system in case A, the core functionality of short circuit indicators had for several years been provided by conventional wired systems. However, the wireless nature of the new system was a novel feature that made the functionality considerably more attractive to customers. This made the system considerably easier to use and maintain, since refineries generally have hundreds of individual electrolysis cells with each one requiring a separate short circuit indicator.

The monitoring system improves the customer's process availability through *decreased downtime*, due to the provision of accurate information from the monitoring system on the process parameters. The process performance rate is improved through the faster removal of short circuits, leading to a higher total production volume. Short circuits are further a principal cause of quality defects, so the monitoring system also improves the *overall quality rate*.

While short circuit removal was the core feature of the offering for all customers, it was found to have a different impact in two different customer segments. In copper refineries, the system allowed the faster detection and subsequent removal of short circuits. In nickel refineries, the system was capable of predicting and thus completely preventing short circuits. Thus, the above examples indicate that a value proposition should be always tailored to the specific drivers of customer value.

[1] Two of the authors, who had primary responsibility in conducting the life cycle analyses, had prior training on the application of these tools to ensure their correct usage in the case projects.

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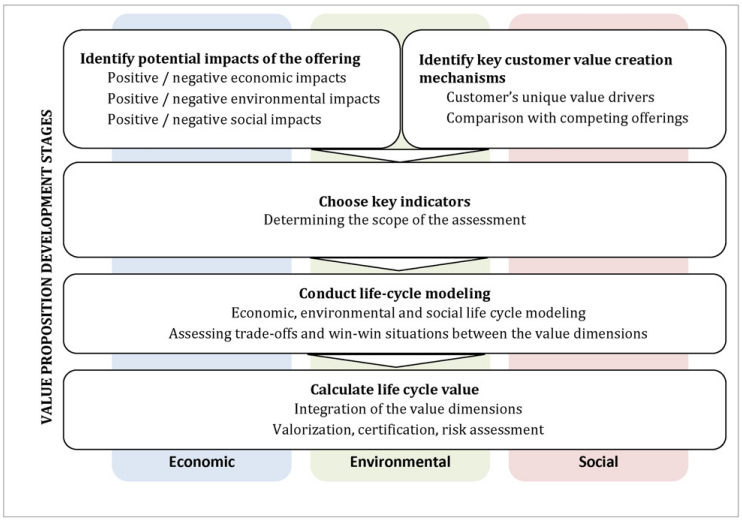

Fig. 1. Proposed framework for sustainable value proposition development.

The efficient short circuit removal process also decreases the volume of copper scrap that needs to be reprocessed, leading to lower environmental impacts and improve customer's public image. Respondents from both the supplier and customers stressed that sustainability is a key consideration, due to high material intensity and the visibility of environmental hazards in the mining and metallurgical industries. The following quote from the technology supplier's sales manager illustrates this:

> *If our customers want to keep sustainability in their image, then they also want to give the impression that they are doing everything they can to improve sustainability. Then this offering can be one of the ways to accomplish that. Since it improves the production efficiency of the customer and saves the amount of used energy and heat, we can say it has an effect on their environmental impacts*, sales manager, supplier, case A.

Social value can mean, for example, a firm improving the working conditions of its employees, thereby improving employee motivation and performance. For instance, the system was also found, due to the effects of optimized short circuit removal, to decrease wasted effort on the part of the operators. The traditional method of removing short circuits involves considerable wasted effort, and this is eliminated by the monitoring system through the provision of instant feedback on removed short circuits. This was recognized as having a positive impact on the operators' work satisfaction, and in another customer segment it was found to decrease negative health impacts because the employees spent less time in hazardous conditions.

The optical measurement system in case B was found to improve the efficiency of the customer's process through four main mechanisms. First, an optical measurement system requires considerably less corrective and preventive maintenance compared with a mechanical system. This *increases overall production uptime*, which translates into higher revenues. Second, the system *eliminates the need for sampling inspection*, in which a percentage of the parts (typically 0.3%) is taken for manual inspection. That incurs man-hour and equipment costs which are entirely eliminated with the optical measurement system, which inspects each part. Third, the most important benefit of the system is the improved overall *quality of inspection.* Since the optical measurement system is able to inspect every feature of every part, there is considerably less chance of faulty parts being forwarded to further processes. This reduces the risks involved in the customer's processes, as the reclamation costs of faulty parts can be very high in downstream assembly processes. The higher inspection quality also allows the customer to exploit the full tolerance range of their process, decreasing scrap material, which translates into savings in energy and material use. This reduces the environmental footprint of the process and improves profitability. Last, the fact that each part produced is fully inspected increases *traceability* in the event of safety issues. If an unpredicted major safety defect is found in a car, the stored data concerning the comprehensive inspection will enable the problem to be traced to specific vehicles and thus help in eliminating accidents or worldwide recall campaigns.

4.3. Choose key indicators

Choosing key indicators involves determining the relevant indicators that can quantify the value provided by the offering, and measuring their baseline. This determines the scope of the life cycle modeling which is a vital part of the LCA process. The most common indicators for economic, environmental and social impacts are listed in Table 1. It is important to note that some indicators, e.g. environmental and social ones, do not necessarily quantify the value provided to the customer, but do indicate the benefits for wider society and the environment. However, the last stage of the value proposition framework specifically focuses on demonstrating the value received by the customer.

The economic indicators chosen by which to measure the value of the monitoring system in case A were improved *performance* and *quality* rates due to the faster removal of short circuits, and improved *availability* rate through the real-time process data provided by the system. For the reduced environmental impacts resulting from lower energy use, *carbon footprint* was employed as the main indicator. For the added social value resulting from improved working conditions for plant operators, improved *job satisfaction* was employed as the main indicator. However, this was assessed qualitatively by interviewing the operators, and thus was not quantified.

The key quantitative indicators chosen for the optical measurement system in case B included increased *availability* rate resulting from decreased downtime (due to faster maintenance and adaptation to

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new product models), and improved *quality* rate resulting from decreased scrap, similarly to the first case. Decreased cost elements included *elimination of sampling inspection costs* and decreased *reclaim costs*. For the environmental impacts, *energy and material savings* were chosen as the main indicator. Each scrapped part equates to energy wasted during the process. There were two benefits that were difficult to quantify, and thus qualitative indicators were chosen for them. Improved inspection quality resulted in a *reduced risk of losing reputation* as a result of recall campaigns. Last, the system provided a societal benefit in the form of *improved safety* for cars. Since every measured part is traceable to its origin, it is easier for manufacturers to identify faulty units should a recall campaign be required.

4.4. Conduct life cycle modeling

Life cycle modeling is employed to quantify the indicators in the economic, environmental and social dimensions (Guinee et al., 2011), which involves establishing a baseline for the key indicators and analyzing the resulting impacts over the life cycle of the offering (Rebitzer et al., 2004). In our analysis, we also found that the life cycle modeling phase should include the recognition of potential *trade-offs* between the different dimensions of sustainable value. The cases we examined were focused on improving customers' operational efficiency, and consequently provided mostly win-win situations in the different value dimensions. But that is not always the case. Sometimes, increased value in one dimension can cause decreased value in another. One example of this was related to operators' improved work processes. Some of the supplier and customer representatives noted that if the system provides considerable streamlining of the operators' work, it can also potentially lead to downsizing the operator workforce, which reduces costs for the customer firm but at the same time decreases social value through lost jobs. The life cycle value assessment can uncover such trade-offs, and the supplier can work with the customer to find the best mitigating solution.

The main value elements for the monitoring system in case A included in the life cycle modeling phase were the increased revenue resulting from improved availability (0.2%), performance (1.6%) and quality (1%), as well as the reduced carbon footprint in production. The reduced carbon footprint was calculated at −780 t CO_2 p.a. For the optical measurement system in case B, the improved profitability potential resulting from a decreased need for maintenance was calculated as an increased availability of 3.1%, or a decrease of 250 h of downtime. The overall chance of a reclamation was estimated to decrease by 0.4%. For the decreased scrap resulting from improved inspection quality, the scrap rate was estimated to decrease from 1.0% to 0.1%, equating to a 0.9% increase in quality rate. This reduces raw material usage by 0.9%, while also improving the energy efficiency of production, resulting in an annual decrease of 30 MWh in wasted energy.

4.5. Demonstrate life cycle value

Demonstrating life cycle value refers to determining the total value-in-use that results from the improved key performance indicators over the life cycle of the offering (i.e. the total value realized for the customer). In the context of customer value propositions, this can be accomplished by integrating the direct economic benefits, and derivative economic benefits of reduced environmental and social impacts, as well as the benefits provided to the wider society.

In assessing the life cycle value of the studied offerings, we found three different options by which to demonstrate the customer value provided by reduced environmental and social impacts. The first, *monetization*, refers to assessing these benefits in direct economic terms. Various studies have been conducted to place a monetary value on such impacts. A monetary value can be allocated for example through the mechanism of the European carbon trading system, which derives a specific cost per tonne of CO_2 produced. In addition, carbon impacts can be internalized by calculating the costs of climate change over a longer time period. However, such calculations involve considerable uncertainty due to the long time frames and global-scale mechanism involved in climate change.

The economic benefits for improved availability, performance and quality provided by the monitoring system in case A were calculated at €57 000 p.a., €760 000 p.a. and €204 000 p.a. respectively. While the public image delivered by the reduced carbon footprint is difficult to quantify in economic terms, the value of the carbon footprint can be monetized through carbon emission prices. For these, a mean value of €25/kg CO_2 was suggested by a study by Maibach et al. (2008), based on both the costs of climate change and the carbon trading prices. This delivers a €20 000 annual cost decrease for the case refinery. In addition, when compared with competitors, the system's *ease of use* delivers more value by decreasing maintenance costs and improving adaptability. For the optical measurement system in case B, the increase availability equates to a 67 500 € increase in profits. The elimination of inspection costs was estimated to result in 60 900€ annual cost decrease. The increase in quality rate and amounts to an annual profitability increase of 54 000€.

A second option by which to demonstrate the customer value of sustainability is to employ environmental or social *certifications*. Both our cases demonstrate the impacts of sustainable value on the public image of the customer firm. As firms are increasingly required to communicate their value to a broader set of stakeholders, including environmentally and socially conscious customers, employees, governmental organizations and industry standard committees (e.g., Ballantyne et al., 2011), environmental and social elements of value can play a large role. But allocating a direct economic value to improved public image is challenging. Instead, various signaling mechanisms such as environmental certifications and eco-labels can be utilized to demonstrate the value of sustainability to the customer, who can in turn use the certification in communication with its own stakeholders. Eco-labels are often employed to convey sustainable value in consumer products (Thrane et al., 2009) but their use in industrial markets is less common. For example, the supplier firm in case A had a key focus on sustainability in its own public image, and the interviewed representatives in the firm mentioned that they often use certifications such as the Best Available Technology not Entailing Excessive Costs (BATNEEC) (Pierce & Brisson, 1993), as evidenced by the following quote. The supplier has successfully gained this certification for their integrated technology solution for entire refining process, of which the focal offering is a part of.

> *We have communicated these values with this offering. It is environmental value, we talk about Best Available Technologies. It means the offering has the smallest environmental impacts in its class. And we argue that our offering is one of these technologies*, product manager, supplier, case A.

A third option by which to demonstrate the customer value of environmental and social impacts is to conduct a *risk assessment* for the customer. For example, in case B, we assessed the risks of reclaims for automotive parts by estimating the probability and cost of typical reclaim cases. Production part quality also has a high impact on the end users, i.e. the consumers who drive the cars. Any kind of safety issues caused by faulty parts can pose a dramatic risk for the OEM.

> *These short circuits, they might heat the electrolyte to too high temperatures which can damage the production equipment, causing the electrolyte to leak out. Our system can recognize these risks ahead of time and prevent them.* Director, supplier, case A.

For the decreased reclamation costs of the optical measurement system in case B, quantifying the monetary value required the assessment of the reduced risk of reclamations. This required the estimation of probabilities for each kind of recall case, varying on where the faulty

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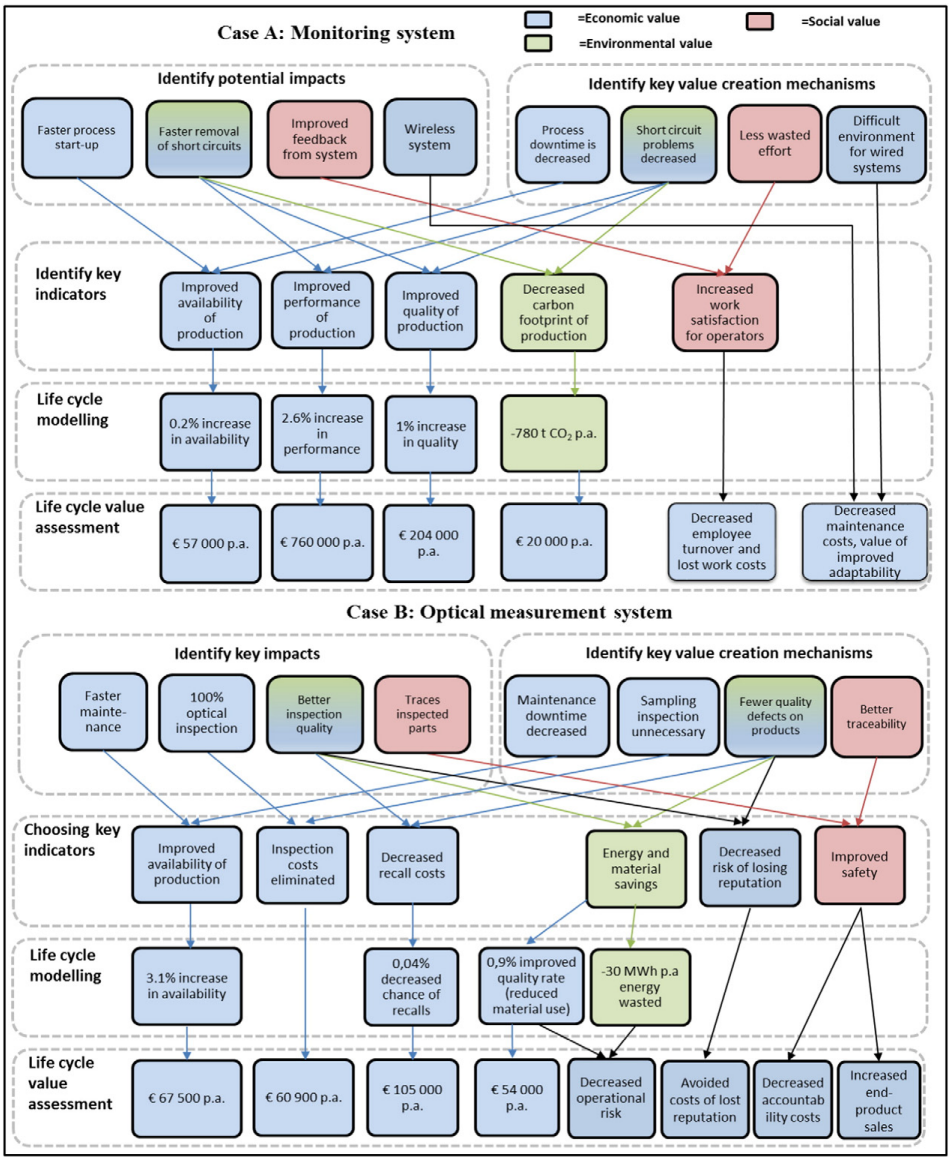

Fig. 2. Value proposition development processes for the case offerings.

part is found. The monetary values of reclamations varied depending on the extent of the fault. The overall chance of a reclamation was estimated to decrease by 0.4%, translating to annual savings of 105 000€. In case A, the social value as a result of increased job satisfaction translates into reduced risks for the customer, by reducing the costs of employee turnover and absences.

The *life cycle value* provided to the *customer* arises from a combination of increased profitability, gained through improved production, and reduced costs as well as the improvement of its public image through a reduction in environmental impacts, improvements in safety and the reduction of risk to the company's reputation. Furthermore, wider *society* also benefits from a reduction in negative environmental and social impacts. Fig. 2 illustrates the process of building sustainable value propositions for the two case offerings from the potential impacts and value creation mechanisms to the final quantified estimates of their impact.

5. Discussion

In this section, we will focus on two particular aspects of the customer value proposition development process—for which our empirical

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findings provided new insights. The first concerns the possible trade-offs between the different dimensions of sustainable value, i.e. their economic, environmental and social benefits. The second concerns the three strategies that have been identified as demonstrating the benefit of sustainability as a customer value, i.e. monetization, certification and risk assessment.

Our analysis focused on two offerings that increased production efficiency, thereby creating both increased profitability and sustainable value through improved material efficiency. They provided social benefits due to the improvement in the safety of the end product and the working conditions of employees. Both offerings clearly resulted in win-win situations and we recognized two instances of trade-offs, between the economic-environmental and economic-social dimensions. Improving employee working processes can lead to better work satisfaction and thus social value, too much streamlining can lead to downsizing the operator force. An economic-environmental trade-off was possible in both cases due to the rebound effect. The rebound effect is a commonly used concept to describe a situation in which improved efficiency leads to a larger quantity of production and therefore an increase in absolute resource use. However, in our case studies, the rebound effect was not mentioned as a reason for concern by the respondents. Instead, the improvements in relative material efficiency were seen as clearly beneficial for the environment. It was also noted that finding optimal solutions to problems can be facilitated by engaging stakeholders in the value proposition development process. With regard to social impacts, it can involve engaging employees and with respect to environmental impacts, engaging external stakeholders, such as local community representatives or regulators may be necessary.

Previous research has suggested three main strategies for firms wishing to manage sustainability trade-offs (Hahn et al., 2015). The simplest method is to accept the trade-off situation and focus on the most favorable outcome. The second method, separation, involves separating the two opposing value dimensions either spatially or temporally. The third method, synthesis, involves working to find a solution that eliminates the trade-off. Using the rebound effect as an example, the acceptance strategy would involve accepting increased resource use and simultaneously highlighting the overall life cycle value. However, that would not resolve the trade-off situation. A spatial separation strategy could involve the supplier and customer working together to determine geographical areas, such as developing countries, where the potential for relative environmental value gain would be large enough to offset potential rebound effects. A temporal separation strategy could mean accepting the trade-off initially, but using immediate increases in economic profits to make further investments to decrease future environmental impacts. Finally, a synthesis strategy could involve the supplier and customer working more cooperatively to find ways to enhance a solution so that it resolves the trade-off or achieves a larger decoupling of economic growth from environmental or social impacts. For example, if a customer's plant has ample renewable energy production available, an increase in energy use would not result in additional environmental impacts.

The second major insight of the empirical analysis was three different strategies for demonstrating the customer value of environmental and social impacts. In essence, this stage involves translating *societal value* (environmental and social benefits) into *customer value* through the identified customer value creation mechanisms (stage 2). These three strategies are closely linked to three recognized benefits that sustainability can bring to firms: the improvement of operational efficiency, the capturing of customer markets that are sensitive to environmental concerns and the reduction of operational risks (Henderson et al., 2015). Our insights contribute by elaborating on strategies that demonstrate how the features of specific products can translate into such benefits.

The first strategy, *monetization*, is closely linked to instrumental value, following the logic of quantifying and monetizing customer value as far as possible (Anderson et al., 2006; Wouters & Kirchberger, 2015). Improved resource efficiency can be a significant potential of profitability, for example, between the years 1990 and 2013 IBM has saved $513 million through its annual energy conservation actions (Henderson et al., 2015). The monetization strategy demonstrates the value of operational efficiency by translating the indicators of physical resources or process performance into monetary units. Resource costs and emission costs are the primary market mechanisms through which this can be achieved. In our case studies, we used carbon pricing as an example for a mechanisms to use in a monetization strategy.

The second strategy, *certification*, is aimed at symbolic demonstration of sustainability. They see value propositions as communicative practices to customers or a wider stakeholder network (Ballantyne et al., 2011; Frow & Payne, 2011). Certifications and standards can also target the specific niche of sustainability-oriented customers, which can be a large market for some firms. For example, the value of the certified organic food market in the US is approximately $39 billion. These products are targeted at sustainability- and health-oriented customer niches. While these customer groups are especially relevant for B2C companies, the rise of the cleantech market has demonstrated that there is also demand for sustainable solutions in the B2B sector. The sustainability orientation of an industrial firm can originate, for example, from corporate culture or downstream consumer demands (Henderson et al., 2015).

Sustainability is also a legitimacy issue, especially for industrial firms in resource-intensive industries such as mining and manufacturing (Czinkota, Kaufmann & Basile, et al., 2014; Prno & Slocombe, 2012). Firms can face considerable difficulties if relevant stakeholder issues, such as community demands, employee concerns or regulation, are not considered adequately. In these industries, addressing sustainability issues can be a "license to operate" for the customer (Prno & Slocombe, 2012). For example, the supplier in case A emphasized that for their customers in the mining and metallurgical sectors, having sustainable technologies can be vital for securing the support of key stakeholders such as government, local communities and employees since the industry. A sustainability certification can therefore be a necessary part of the core value of a firm's product range. Consequently, products and services lacking adequate sustainability certification may be ignored when a firm with sustainability certifications considers new investment, resulting in advantages for suppliers that do have the necessary certification requirements.

The third strategy, *risk assessment*, is focused on managing the uncertainties related to environmental and social risk. At worst, the mismanagement of sustainability issues can lead to environmental or social disasters—as demonstrated by the BP oil spill in 2010, and Nike's issues with the unsustainable working conditions of the employees of its suppliers in the 1990s. Climate change also poses the risk of added costs for firms (Henderson et al., 2015). Failure to comply with emission regulations can result in significant legal or reputational costs, such as those faced by Volkswagen in 2015 that could result in up to $18 billion in litigation costs and the recall of more than one million vehicles (BBC, 2015) The role of risks and how they are perceived is a critical factor in a firm's investment decisions (Wustenhagen & Menichetti, 2012) and the focus of a risk assessment strategy is to make such risks salient and demonstrate how a focal offering can forestall them. The risk value can be quantified by estimating the probabilities of critical events happening and their resulting costs.

A diverse use of these strategies can also play a role in resolving sustainability trade-offs. For example, if we consider a trade-off situation where environmental benefits cause economic losses from a purely monetization perspective, the net value can be negative. However, additional consideration of reduced risks can make the net value positive for the customer. Drawing on immaterial forms of customer perceived value (such as legitimacy and risks) can thus be another form of a resolution strategy for addressing trade-offs. The framework that we have developed in this research aims to elucidate more of the complexity involved in sustainable value creation. The use of life cycle assessment can demonstrate value in the

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economic, environmental and social dimensions while the three value demonstration strategies can capture a wider array of customer perceived value compared to a purely monetary analysis.

6. Conclusions

6.1. Theoretical and managerial implications

A range of tools has been developed to incorporate sustainability concerns and trade-offs into product and sourcing decisions (Dangelico & Pujari, 2010). The adoption of sustainable sourcing has driven demand for transparent and credible sustainable value propositions. This paper offers guidelines for integrating sustainability when marketing and selling products that require the intensive use of technology. We have proposed a framework for building sustainable value propositions and have applied a sustainable life cycle assessment model in order to evaluate the sustainability performance of two technology intensive offerings.

The theoretical implications of our research are threefold. First, we contribute to the research on sustainability in industrial marketing by adopting the perspective of technology suppliers in proactively advancing sustainability. There is a growing research interest in responsible and green supply chain management and its relationship to marketing activities (Gupta, Rudd & Lee, 2014), although such research often concentrates on the perspective of an industrial firm and its initiatives in cooperation with downstream suppliers in sustainable supply chain management. As technology suppliers are increasingly becoming industrial process experts, they may also be best equipped for improving the sustainability of such processes. This would thus suggest that suppliers who are able to leverage such knowledge, while simultaneously adopting a proactive stance on improving their customers' sustainability, will be better placed to achieve key supplier status. This will require that the supplier is able to convincingly demonstrate how their product or process will improve the sustainability of a customer's processes because a supplier's inability to demonstrate customer value will be a key barrier to the adoption of sustainable innovations (e.g., Ramirez et al., 2014). Our case studies illustrate how this can be achieved through the use of life cycle assessment tools. We encourage further research on the proactive role of technology suppliers in the formation of sustainable supply chain management.

Second, our research adds to the existing knowledge on value propositions in industrial markets by offering guidelines on how they can be developed in practice. One view of customer value propositions characterizes them as inter-organizational management accounting practices with monetized benefits and costs regarding the impacts on their customers' processes (e.g., Anderson et al., 2006; Wouters & Kirchberger, 2015). Our study contributes to this view by presenting two empirical examples of how such value propositions can be developed and evaluated through life cycle assessment tools. We propose that life cycle thinking is a key paradigm for demonstrating customer value in the long-term. We also expand on the ideas of Wouters & Kirchberger (2015) regarding the difference between quantifying and monetizing customer value. In the context of sustainability, it is important that environmental and social benefits are quantified using their appropriate indicators to demonstrate value to wider society. At the same time, these benefits should be monetized, whenever possible, to demonstrate the indirect value of these impacts to a customer firm. We also contribute to this view by highlighting customer risk reduction as another dimension of the instrumental and quantifiable form of customer value. In comparison to direct monetary impacts, risk assessment involves the estimation of uncertainties and the resulting monetary impacts of a particular risk. Sustainability risks can incur extensive costs, e.g. legal, reputational, for industrial firms if they are realized. Thus, reducing these risks is a key motive for driving investment in sustainable technologies (Hockerts, 2015). We therefore suggest that further studies could specifically focus on the reduction of sustainability risks and that it be presented as a form of customer value creation.

Third, we contribute to the view of value propositions as communicative practices that appeal to a wider stakeholder network (Ballantyne et al., 2011; Frow & Payne, 2011). As demonstrated by our research and recent studies (e.g., Skålén et al., 2015), customer value propositions often include elements for which direct monetary value is difficult to calculate. These immaterial elements are even more prevalent in service-oriented offerings and solutions. In our research, we suggest certification as an alternative method for demonstrating the immaterial value provided by sustainability. Certifications, standards and audits are able to convey the symbolic value that can be translated into public image benefits for the customer. Third parties, such as certification agencies, engineering offices and consultants, can adopt a holistic view by applying the proposed framework in order to evaluate alternative offerings. A best available technology (BAT) evaluation should consider the sustainability of alternative offerings in a comprehensive manner by taking social, environmental and economic effects into account. Hence, certifications and eco-labels are important communication tools that industrial firms can use to convey the legitimacy of their products to wider society and thus retain their license to operate.

The managerial contribution of our research is a framework that industrial technology suppliers, purchasers and third parties can apply when developing and evaluating value propositions from the perspective of sustainability. Marketers will face the questions of how to build sustainable value propositions, while purchasers face the question of how to evaluate competing value propositions. By integrating the literature on customer value propositions and life cycle approaches, this paper proposes a process framework with which to develop sustainable value propositions for industrial offerings. The framework consists of 1) the identification of potential impacts, 2) the identification of customer value creation mechanisms, 3) the choosing of key indicators, 4) life cycle value modeling, and 5) the demonstration of life cycle value. We elucidated the framework through empirical research on two illustrative cases from the metallurgical and automotive industries. The resulting value propositions demonstrate how the environmental and social benefits of an industrial product can complement economic benefits in order to create value for the customer, for example, by improving the public image of a firm and improving safety at work. The cost and time required to perform life cycle calculations makes it unfeasible to develop sustainable value propositions for every product or service. Thus, companies must choose the trailblazing products they wish to experiment with.

Sustainability issues cannot be resolved in isolation within firms, they require cooperation along supply chains. In our research process, close interaction was required between technology suppliers and their respective customers in order to determine the environmental, economic and social impacts of the supplier's product. Identifying the customer's key values, choosing suitable indicators to represent those values, assessing the baseline values of the indicators, and estimating the value of a product during its life cycle cannot be achieved in isolation from supplier firms, instead close cooperation is required. Suppliers can turn this collaboration into competitive advantage and take the initiative in helping customers manage issues of sustainability.

6.2. Limitations and suggestions for future research

While our research focused on a framework to develop sustainable value propositions for industrial offerings, we did not assess the effectiveness of such propositions in the sales process. Further research should be conducted to determine whether sustainable

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value propositions are more effective in conveying the value provided to the customer, in comparison with value propositions that focus purely on the functional benefits and economic value they provide. Both the studied cases also focused on input-based industrial solutions. Thus, we do not suggest that the framework is directly applicable beyond that scope, such as in consumer markets. Future studies could elaborate the framework with consumer products and service-oriented offerings that focus on functionality.

The two cases that we studied also demonstrate the limits of the life cycle assessment tools for quantifying customer value. Regarding case A, we found most of the potential value that was identified could be quantified. In contrast, additional elements that provide value, such as lower employee turnover and reduced work costs were difficult to quantify and found to be relatively minor. In relation to case B, the value elements that were most difficult to estimate or quantify were those that represented potentially very large monetary impacts; as the risk of losing a reputation due to an environmental disaster or safety issue can have disastrous consequences for an industrial firm, as demonstrated by the Volkswagen' emissions scandal in 2015. For organizational decision-makers, the peace of mind that reduced risk can bring to organizational decision-makers is hard to assess quantitatively, but may nonetheless be a vital buying condition.

Researchers need to critically assess how the emerging sustainability processes, LCA results, footprints and indexes are implemented and used by corporates. Firms may be reluctant to "internalize the externalities" and tempted to draw system boundaries selectively. Very few firms are ready to translate the totality of the negative environmental and social impacts of their operations into monetary terms. Some companies (such as Puma and Disney) have attempted to do so by calculating the costs of the degrading ecosystems and creating internal pricing for carbon emissions that is then applied in costing and sourcing decisions (Chouinard, Ellison & Ridgeway, 2011). Researchers need to critically evaluate these and other emerging practices to determine the progress of integrating sustainability into the academic literature and managerial practice.

Appendix A

Case A

Benefits	Input data	Calculation
Availability	• A = Added production time 17 h added production per year • Previous production 8497 h/year • V = Production value 0.165€/kg C = Capacity 170 000 t/year	Increased availability = 17/8497 = **0.2%** Value = 0.2% * C * V = **57 000€/year**
Performance	• CE = Current efficiency improvement **1%** • V = Production value 0.165€/kg • C = Capacity 170 000 t/year • Current density improvement CD = 5 A/m^2 • Previous current density 300 A/m^2	Increased production = CE*C = 1771 t/year Value = 1771 * 1000 * V = 292 000€/year Improved performance = 5/300 = **1.64%** Increased production CD * C = 2833 t/year Value 2833 * 1000 * V = 465 000€/year Total = 292 000€ + 465 000€ = **757 000€/year**
Quality	• Q = Quality increase in A-grade production = 1% • C = Capacity 170 000 t/year • VP = Value premium for A-grade production = 0.12€/kg	Increased production (grade A) = Q * C = 1700 t/year Value = 0.12€/kg * 1000 * 1700 t/year = **204 000€/year**
Carbon footprint	• CE = Current efficiency improvement **1%** • C = Capacity 170 000 t/year Transportation carbon footprint: • Truck capacity = 7.5 t • Number of truck transportations per year = 236 • Distance to smelting = 40 km • CO_2 emissions for a 7.5 t truck = 375 g CO_2/km Reprocessing carbon footprint: • Carbon footprint of copper refining process = 3542 kg CO_2/t Cu (Grimes et al., 2008) • CC = Costs of carbon emissions = 25€/kg (Maibach et al., 2008)	Scrap decrease CE * C = 1700 t/year Transportation kilometers per year = 1700 t/year/7.5 t * 40 km = 9444 km Transportation carbon footprint decrease = 3542 kg CO_2/year Reprocessing carbon footprint decrease 2 213 542 kg CO_2/year TD = Total emissions decrease = **2 217 083 kg CO_2/year** Carbon costs = CC*TD = **55 000€/year**

Case B

Benefits	Input data	Calculation
Availability	• Labor cost LC = 120€/h • Operating cost OC = 270€/h • Downtime decrease 300 h (old)–50 h (new) = 250 h/year	Downtime cost DC = LC + OC = 270€/h Value = 250 h/year * 270 €/h = **67 500 = €/year**
Inspection costs	• V = Production volume 300 000/year • Sampling rate (old) = 0.3% • Sampling rate (new) ~ 0% • Sampling cost 70 €/part	Sampling amount reduction = R = 900 parts/year (old)–30 parts/year (new) = 870 parts/year Value = 870 parts/year * 70 €/part = **60 900€/year**
Reclaim costs	• V = Production volume 300 000/year (typical size) • P1 = Probability of an internally solvable defect 0.04% • C1 = Cost of an internally solvable defect =200€ • P2 = Probability of a minor defect found at assembly line = 0.001% • C2 = Cost of a minor defect found at assembly line = 15 000€ • P3 = Probability of a major defect found at assembly line = 0.0003% • C3 = Cost of a major defect found at assembly line = 40 000€	Value = V * ((P1 * C1) + (P2 * C2) + (P3 + C3)) = **105 000€/year**
Quality	• V = Production volume 300 000/year (typical size) • Scrap rate (old) = 1% • Scrap rate (new) = 0.1% • Part value = PV = 20€/part	Quality improvement = 1–0.1% = 0.9% Increased production = IP = 0.9%*V = 2700 parts/year Value = PV*IP = **54 000€/year**
Energy efficiency	• V = Production volume 300 000/year (typical size) • Scrap rate (old) = 1% • Scrap rate (new) = 0.1% • Energy usage E = 10 kWh/part	Decreased scrap = S = 0.9%*V = 2700 parts/year Decreased energy use = S*E = **30 MWh**

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Publication II

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Legitimacy under institutional change:
How incumbents borrow clean rhetoric for dirty technologies

ABSTRACT

How organizations legitimate their actions under conditions of institutional change is a central yet little understood question. To address this gap, this paper investigates how incumbent firms legitimate investments into both established and novel technologies during transitional periods between the disruption of an established technological regime and the prospect of a new one. The on-going contestation over renewable and non-renewable energy technologies offers a fruitful context to study this question. We examine the rhetorical strategies that energy incumbents use to gain legitimacy for their investments into non-renewable (legitimacy-losing/established) and renewable (legitimacy-gaining/novel) technologies. Employing a mixed-method content analysis of 483 press releases on strategic energy investments made by the world's largest energy firms during the time period 2010-2015, we find that instead of a purely technocratic language, incumbents appropriate the rhetoric of sustainable and clean technology typically associated with new and renewable technologies to justify investments into established and polluting technologies. We also observe that the rhetoric that incumbents use to justify non-renewable investments is substantially more pronounced and blended than the one for renewables. Our study contributes to research on rhetorical institutionalism and legitimization under institutional change by showing how incumbents, in their effort to continuously hold on to established technology, engage in innovative behavior by blending rhetorical frames and recombining institutional templates in novel ways.

INTRODUCTION

"We are demonstrating that we can generate electricity using coal in a more environmentally sustainable way. Some would like to turn away from coal completely. That's not realistic given that it powers most of Indiana's -- and half of our nation's -- energy needs. Indiana has more than 110 years of recoverable coal reserves. We simply cannot turn our back on this abundant, relatively low-cost fuel resource." (Duke Energy, 2010)

The above quote of Duke Energy's public announcement to invest into a coal plant characterizes the dilemma that energy incumbents are facing: there are significant pressures to invest into renewable energy, but the industry is still locked into conventional technologies that are rapidly losing their legitimacy.

The tendency of incumbents to maximize the returns from existing technologies rather than devote resources to new technologies with an uncertain payoff is well established in the literature (Henderson and Clark, 1990; Christensen, 1997; Tushman and Anderson, 1986). It is also well documented that investments into new technologies require higher levels of justification and more legitimizing work as novel technologies typically suffer from a legitimacy deficit (Deephouse and Suchman 2008; Galaskiewicz 1985; Hargadon and Douglas, 2001). Yet, under conditions of institutional change, the dynamics may differ from the existing literature. For example, we know relatively little about how incumbents legitimate their actions during transitional periods, that is, in situations when the established technology is rapidly losing its legitimacy while novel technologies are gaining legitimacy.

Research on rhetorical institutionalism suggests that rhetorical strategies play a critical role in shaping the legitimacy process (Bitektine and Haack, 2015; Cornelissen, Durand, Fiss, Lammers, &Vaara, 2015; Green & Li, 2011; Hoefer and Green, 2016; Phillips, Lawrence, & Hardy, 2004; Suddaby & Greenwood, 2005). Similar to organizations, technologies depend on mechanisms by which alternatives, often in spite of their technical superiority, are perceived as less "desirable, proper or appropriate" (Suchman, 1995, 574; Hargadon and Douglas, 2001). Beliefs and legitimacy judgments, in turn, are shaped by rhetoric and argumentation (Hoefer and Green, 2016). Prior studies have focused on how technologies gain or lose legitimacy (Rao 2002; Hardagon and Douglas 2001¸ Markard et al. 2016). However, we know little about how technology adopters, particularly incumbents, use rhetoric to ride the wave of increasing legitimacy or fight the wave of declining legitimacy.

In this study, we explore this topic by addressing the following research question: What kind of rhetorical legitimacy strategies do energy incumbents use to justify investments into established (legitimacy-losing) and novel (legitimacy-gaining) technologies under conditions of institutional change? Answering this question is critical for our knowledge of legitimacy work and rhetorical strategies by incumbents, as well as for understanding the processes of new technology adoption. In addition, while several studies have focused on the contestation between incumbents and new entrants seeking to introduce new technologies (Gurses and Ozcan, 2015; Dewald and Bowen, 2009; Madsen and Walker, 2007), we analyze a situation in which the incumbents are part of the change and legitimizing work for both established and novel technologies.

Our context is the energy sector. This sector represents an ideal setting to analyze the rhetorical strategies that incumbent firms employ to justify their investments into established and novel technologies during transitional periods, that is, periods during which old technologies are losing legitimacy and novel technologies are gaining legitimacy. On the one hand, established fossil fuel technologies dominate the energy sector which accounts for nearly 70% of all greenhouse gas emissions, and since 2010, coal-fired generation has grown more than all non-fossil sources combined (IEA, 2014). On the other hand, the legitimacy of renewable technologies is rapidly growing. Public opinion and institutions such as the media and governments are important sources of validity cues that influence legitimacy judgements (Bitektine and Haack, 2015). Civil campaigns and movements towards divesting from fossil fuels fostered by renowned foundations such as the Rockefeller Brothers Fund, the Norwegian Oil Fund, and reputable universities are profoundly challenging the legitimacy of fossil fuel-based technologies and altering the institutional landscape. Eventually, the institutionalization of a negative legitimacy judgment may become an important liability for energy incumbents as has occurred with tobacco, fast food, or arms companies (Vergne, 2012). The changing legitimacy judgments of both established and new energy technologies thus represents an especially salient context to study the use of rhetoric under the conditions of profound institutional transition.

Our empirical approach employs a mixed-method content analysis of 483 press releases on strategic energy investments made by the world's largest energy firms during the time period 2010-2015. We observe, firstly, that incumbents use higher levels of justification for investments in established technologies, and secondly, that they strongly appropriate from the dominant rhetorical frame of new technologies, that is, they employ the clean and sustainability rhetoric that is so

diffused among the domain of renewable technologies. This is a surprising finding in the context of the existing literature. For example, Hargadon and Douglas (2001) have shown the contrary: in order to gain acceptance for a novel, competing technology, Edison would borrow what is cognitively legitimate from the established technology. Our findings thus provide novel insights into situations in which actors may borrow elements from novel technologies in order to justify their continued investment into established technologies.

Our paper is structured as follows. First, we develop the theoretical background of our study and research question by combining insights from the literatures on incumbent lock-in, technology legitimacy, and rhetorical strategies of legitimacy. We then describe our methodological approach, which combines qualitative and quantitative analysis of 483 press releases regarding the investment decisions of large energy firms. Our mixed methods analysis provides deep insights into the justifications used for the investments as well as the underlying rhetorical strategies. We conclude with a discussion of the implications of our work for incumbent organizational analysis and legitimacy strategies under conditions of institutional change.

THEORETICAL BACKGROUND

Incumbents and technological change

Much of the literature on incumbent firms and technologies emphasizes the inertia inherent to established organizations and their technological choice. Organizational and institutional theorists have demonstrated that incumbents pursue little change, are strongly committed to existing technologies, and thus seek to hold on to their established practices. Embedded in an institutional field, incumbents as the dominant and central actors typically appear unlikely to come up with novel ideas or champion innovations. Deeply embedded in the existing institutional arrangements,

they have their interests aligned with current practices, often benefit from the status quo, confirm to coercive, cognitive, and normative templates, and are thus little motivated to substitute existing technologies and pursue change (Greenwood and Suddaby 2006; DiMaggio and Powell, 1983). Moreover, resource-rich incumbents have been shown to actively hinder change and novelty, portraying new technologies and new entrants as potentially destabilizing for their field position. For example, Russo (2001) has investigated the US electric power industry and has shown that utility incumbents rely on established field authorities such as courts and regulators to protect their interests and defend against market entrants by creating a hostile entry setting through certain laws and regulations.

Similarly, evolutionary economists and institutional economists that have studied incumbent behavior in the light of technological change have emphasized path-dependencies and institutional lock-in. With time, technologies achieve lock-in through institutional accretion, governance systems and historical events that lend irreversibility to already existing and adopted technologies. While a new, competing technology may be "technologically superior", transitioning away from an established and known technology and adopting a new one rarely happens (Arthur 1989; David 1985). Technology lock-in may hinder the diffusion of novel and potentially superior technologies. For example, Unruh (2000) argues that lock-in and path-dependencies explain the strong dependency on fossil fuels and hinder the diffusion of environmentally friendly energy technologies despite their many economic and environmental advantages.

Innovation scholars have also shown that incumbents strongly hold on to the status-quo and are seemingly unable to change. For example, in his theory on disruptive innovations, Christensen

(1997) emphasizes how much incumbents resist to let go of their established technologies to turn towards new ones – even if they contributed to their invention. Their value system, resources, and current income streams are heavily aligned with established technologies and customer groups so that incumbents rather fail than breaking out from the existing status quo and turning towards novel directions. Similarly, Tushman and Anderson (1986) have noted that new, radical technologies are often initiated and introduced by new firms, while established firms prefer to engage in incremental changes of their existing technologies. Even if facing a changing institutional environment, such as the transition from analog to digital imaging, innovation scholars have demonstrated that incumbent firms such as Polaroid are often unable to react accordingly, are deeply committed to the existing technologies, and have difficulties in adopting to change (Tripsas and Gavetti 2000). This work follows the tradition of Schumpeter's early work (1934), who, in his theory of creative destruction, has famously demonstrated that it is not the establishment, but newcomers that bring about change. Incumbents – unable to change – are being replaced by change-seeking entrants that eventually outperform the established firms. While these various streams of research have added to our understanding that incumbents are likely to hold on to their established technologies and practices, only little work has shed light on the legitimacy strategies that incumbents use to justify their continued investment into the old technology during periods of transition towards a potentially new technological paradigm.

Gaining legitimacy for novel technologies

Interested in technological change and the introduction of new technologies, institutional scholars have shown how actors borrow from established, familiar settings to legitimate new technologies. For instance, the existing stream of institutional and entrepreneurship studies that focus on new technology legitimacy collectively highlight that new entrants typically emphasize similarity and

congruence with established concepts and actors in order to legitimate their novel attempts. Hargadon and Douglas (2001) have shown that in order to gain acceptance for a novel, competing technology, Edison, the inventor of the electrical light, would borrow from what was cognitively accepted from the established gas lightning industry: He designed a familiar cover for his novel technology that was associated with and cognitively familiar to the established technology. Similarly, in their study on institutionalizing emergent practice of sustainability reporting, Etzion and Ferraro (2010) observe that institutional entrepreneurs first stress similarity to the existing practice of financial reporting in order gain legitimacy for the novel practice of sustainability reporting.

Another line of research has focused on affiliations with established actors as sources of legitimacy. As such, a new technology or idea "becomes legitimate when it is connected to legitimate others" (Deephouse and Suchman 2008, p. 56, Galaskiewicz 1985). For instance, in their recent study of introducing pay-TV in the U.S., Gurses and Ozcan (2015) demonstrate how new entrants, in order to gain legitimacy for their new technology, first address established interest groups to align the new product with incumbents and their interests before starting to emphasize differences by introducing a new linguistic frame. In a study a of high-technology industry, Stuart (1998) showed how the established incumbent IBM acted as an important and prestigious reference customer for the newcomer AMD, which through status-transfer effects gained positive outcomes from signaling its relationship with the more established player. According to Stuart, this demonstrates the certification advantages that alliance relationships with prestigious enterprises bring to new technology firms. Thus, garnering support and endorsement by fostering connections to government, industry leaders, authorities, or engaging in interorganizational affiliations with

established, prominent partners can provide legitimacy boosts to less powerful, new organizations and their new technologies (Pfeffer and Salancik 1978; Galaskiewicz 1985; Zimmerman and Zeitz 2002; Navis and Glynn 2010). Also, prestigious contests and reputable events can be legitimacy-enhancing. For instance, Rao (2002) described the way in which automobile entrepreneurs used highly publicized reliability contests to legitimate the new mode of transportation.

Collectively, these various streams of literature reveal "the power and rigidity of the establishment". In particular, in our literature review on incumbents, we find that much of the work stresses how much they resist technological change and prefer to maintain the status-quo. As such, incumbents seem to rather exploit than to explore current practices and technologies (March 1991). Second, in order to introduce new technologies and practices, actors typically stress similarities to already established processes and familiar technologies in order to gain legitimacy for new ones. An alternative strategy is to garner support of already established and well-positioned players who can lend needed credibility to new attempts. In aggregate, these streams of literature increase our understanding of the inertia of established firms, and the power of already established constructs and practices in seeking legitimacy for new avenues. However, the extant research on legitimacy gaining processes primarily examines situations in which newcomers or 'institutional entrepreneurs' seek to establish their novel concepts and technologies. We therefore know surprisingly little about incumbents' legitimacy-seeking strategies. Specifically, only little research has shed light on the legitimacy strategies that incumbents employ in order to justify their continued investment into old technologies under conditions of institutional and technological change. Thus, this provides an ample opportunity to develop a more complete and theoretically rich understanding about the processes of legitimacy – a central concept in studies of organizations

and institutions (Deephouse and Suchman 2008). Our study attempts to extend current theory and create new insights by studying rhetorical legitimacy strategies of incumbent electric utilities that justify their investment into both novel (renewable) and established (fossil fuel) energy technologies under conditions of institutional change.

Rhetorical legitimacy strategies

Literature on rhetorical institutionalism proposes that rhetoric plays an essential role in gaining legitimacy (e.g., Hoefer and Green 2016). Suchman (1995, p. 574) defines legitimacy as "an assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs, and definitions". Legitimacy is usually pleaded from the key stakeholders of an organization before expanding it to the larger, macro-level audiences (Johnson et al., 2006).

Organizations may seek to respond to the expectations of the social environment and legitimate themselves either substantially or symbolically (Suchman, 1995; Pfeffer, 1981; Ashforth & Gibbs, 1990; Grunig, 2006). While substantive management (also known as behavioral management) involves real, material changes in an organization and its processes and practices, symbolic management involves portraying socially accepted norms and values and transforming the meaning of acts primarily through corporate narratives. Symbolic management is often preferred as it leaves managers with greater freedom and flexibility (Ashforth & Gibbs, 1990). Previous studies have identified various strategies to influence the corporate audiences through both the form and content of narrative messages. (Bitektine & Haack, 2015; Elsbach, 1994). Rhetorical strategies concern the latter one and are particularly focused on the ways in which texts can be used to persuade an evaluator (Suddaby & Greenwood, 2005).

Various rhetorical legitimation strategies have been presented in literature. A common strategy is legitimation through references to authority (Elsbach, 1994; Van Leeuwen & Wodak, 1999). The authority may be authority of tradition, custom, law or person in whom institutional authority of some kind is vested (Bitektine & Haack, 2015). Normalization strategies in turn include references to normal or natural functioning that often relate to retrospective references to similar actions done in the past or similar actions done by others (Vaara et al., 2006).

Moralization strategies in turn refer to the norms of society regarding what is right to do within the institutional context and are thus linked to moral legitimacy. Moralization may consist for example of references to socially accepted values such as nationalism, nature and happiness (Vaara et al., 2006; Van Leeuwen & Wodak, 1999).

Finally, rational evaluations are one of the most common rhetorical strategies. Rational or technocratic strategies are strongly tied with pragmatic legitimacy and thus generally refer to the "utility or function of a specific action or practice" (Vaara et al., 2006, p. 800). Rational arguments often involve measurable technical aspects and performance evaluations such as financial or economic accounts and appeal especially to business audiences (Joutsenvirta & Vaara, 2015; Green, 2004). Table 1 summarizes the rhetorical legitimation strategies discussed above.

Rhetorical legitimation strategies are employed differently during distinct stages of legitimation process (Bitektine & Haack, 2015; Green, 2004). In the beginning, when legitimation rests on individual judgments rather than institutionalized norms, rational and emotional strategies are often used. On the other hand, when legitimacy has already been granted by the key stakeholders

and it is to be expanded, normalization and authorization strategies are commonly used (Bitektine & Haack, 2015; Green, 2004). Justifications are also used more in the beginning of the legitimation process than when the norms regarding an organization or its action have already been institutionalized (Ashforth & Gibbs, 1990). Given the importance of the various rhetorical legitimacy strategies for organizations, the goal of this study is to uncover how incumbents use these tools to justify their investments into novel technologies as well as their continued investment into old technologies under conditions of institutional change.

METHODOLOGY

Empirical context

The empirical context of our study is strategic-scale investments in the energy sector. The energy sector is characterized by on-going contestation over renewable and non-renewable energy technologies; it is in a passage between the disruption of the established fossil-fuel based technological regime and the prospect of a new, renewable-based one. In order to respond to pressures put forward by societal stakeholder groups, some energy incumbents are changing their product technologies and spending resources on new renewable technologies. The growing illegitimacy concerns of established energy technologies has been powerfully illustrated by the statement of the European coal industry representative to the Paris COP 21 agreement: "we will be hated and vilified, in the same way that slave traders were once hated and vilified" (Clark, 2015). Yet, at the same time, many of them are locked into and investing in old fossil-fuel based technologies that are increasingly losing legitimacy due to growing pressures to mitigate climate change.

Strategic energy investments are characterized by one-off, new, ambiguous and complex decision contexts. They require substantial resource commitment and are not easily reversible (Wüstenhagen and Menichetti, 2012). For energy utilities, strategic investments typically take the form of new, large-scale infrastructure for energy production, such as a wind farm or a combustion power plant. As such, they represent long-term commitments to specific technological trajectories, since power plants are typically planned operate for 30+ years. The energy sectors is an especially interesting technological field for the purpose of this study, as it is undergoing a profound shift away from centralized, fossil-fuel based energy production to distributed energy systems based on renewable technologies such as wind and solar.

Press release data

In this study, we examine the rhetoric strategies through which electric utility companies justify strategic energy investments in their press releases. We depart from common practice of using discourse analysis in analyzing rhetoric legitimation strategies and instead use a mixed-method content analysis. A similar method was adopted by Humpreys (2010). This enables broadening the results of the qualitative study to larger amounts of data and also facilitates quantitative comparisons between groups of press releases.

To examine the legitimation and justifications of strategic energy investments, we used purposive sampling to ensure that the sample represents the world's largest energy utility companies. We chose the sample group from the Platts 2014 Top 250 Global Energy Company Rankings list which is an annual survey of the financial performance of large energy companies (Platts McGraw Hill Finance Group, 2014). To achieve a degree of uniformity among the companies, we limited the

analysis to the electric utility sector which consists of 63 companies. Based on the availability of press releases in English, we chose 34 companies for the final analysis.

Total five researchers took part in data collection. We manually collected the press release sample among 9 300 releases from the companies' web pages from years 2010 to 2015. We defined four specific selection criteria for the press releases based on the research questions and purpose of the study. First, we collected only press releases concerning investments on new power generation capacity. This ruled out investments on, for example, grid infrastructure, storing of electricity and research and development. Second, we included acquisitions only when they concerned a specific production site but excluded when they concerned a whole company. Third, we included construction projects only if they were conducted by the company itself. Finally, after consulting an expert in strategic energy investments, we decided that energy investments that accounted for clearly less than € 10 million were excluded from the sample. Other investments were perceived as strategic based on their size in terms of power generation capacity and the fact that there was a press release about them. This selection criteria enabled us to form a dataset that specifically focuses on public disclosures of strategic power generation investments in the energy sector.

483 press releases fulfilled the selection criteria and were selected for the analysis. In addition to the press releases, we collected basic data about each press release on a separate table. This included the company, type, name and country of the investment, the name of the investment, the start and finish year of the project, the date of the press release, the technology used and the size of the investment both in terms of currency and capacity.

Our data covers 402 different projects and the number of press releases per company varies between 1 and 64. A total of 80 percent of the releases discuss renewable energy investments but, when capacity is considered, the share is only 44 percent as non-renewable investments are usually considerably larger in size. Wind power is the most dominant source of energy both in capacity (27%) and share of releases (43 %) while nuclear is the smallest in share of releases (2%) and solar the smallest in terms of capacity (4%).

Mixed-method analysis of press releases

We utilized a mixed-method approach to analyze the justifications for the investments through disclosure in press releases. First, we conducted a qualitative coding of the themes for 150 press releases. We followed an interpretative and meaning-oriented method that intends to inductively identify the latent themes of the texts to determine the occurrence of content categories. Krippendorff (2013) describes this as text-driven content analysis method and Altheide (1987) as ethnographic content analysis. Based on these themes we derived, we identified the legitimation strategies used in the press releases, as done in Humpreys (2010).

The qualitative analysis process consisted of two phases: selecting a sample to be coded qualitatively and the coding it through the method of analytical induction. The sample for qualitative analysis was chosen by using a stratified sampling method as initial reviewing of the data suggested that the themes varied depending on technology that was used. We ensured that we coded at least ten press releases from each of the most common energy sources of the press releases – wind, hydro, solar, coal and gas. The exception was nuclear that only had nine press releases available. Each minor energy source such as fuel cells, biomass, geothermal energy, wave power and waste was also presented in the sample.

Qualitative coding was conducted individually by three researchers in order to achieve optimal reliability. The actual coding included two rounds after which the coders compared the themes and combined them together. At this stage, we grouped the themes also into latent themes that can be defined as the "deep structure" or implicit categories of meaning (Berg, Lune & Lune, 2004). We used QDAMiner software in the coding process.

Secondly, we utilized quantitative computer-aided analysis to measure differences in the occurrence of themes with respect to variables. Classical content analysis uses numerical proxies to measure different dimensions of disclosure behavior and the aim is to produce indices of the manifest content of a text meaning the actual concrete references (Merkl-Davies et al., 2011). We conducted the data analysis for the sample by using the method of computer aided content analysis utilizing WordStat software. To perform the analysis, we built dictionaries representing the qualitatively derived themes.

The main variable that we used in our analysis was the technology used in the investment. We placed each investment into two technological categories: renewables and non-renewables. In terms of their legitimacy, nearly all non-renewable technologies are facing the same issues of high contribution local pollution and climate change as well as the usage of non-renewable resources. The one exception to this is nuclear energy, which does not produce GHG emissions and is thus often mentioned as an alternative form of GHG-free energy production by energy utilities. However, nuclear energy faces legitimacy issues of its own, related to handling of nuclear waste and the potential for nuclear accidents. It is also an established technology and centralized form of production similar to fossil-fuel based energy. In terms of its societal legitimacy, it's thus similar

situation as fossil-fuel based energy production. We also used the general CSR performance of the firms as a control variable. We did this by gathering data from CSRhub on the energy firms in question. CSRHub aggregates data on sustainability performance from various data sources, and gives an overall score (0-100) for each firm on the dimensions of community, environment, employees and governance as well as an overall score (CSRHub, 2015). We compared the overall score for each firm (in 2014) against the industry average and placed each firm in either low or high CSR performance categories.

During the process of creating the dictionaries we followed mainly the five-step-process introduced by Short et al. (2010). First, we extracted a list of commonly used words in a category. In this phase, we used WordNet tool for finding lexically related words for identifying synonyms for the words placed in each category to increase the reliability of the constructed dictionaries as suggested by Pollach (2012). Second, we created working definitions for categories of interest. Thirdly, each coder independently placed words into the categories after which we compared the content of the categories by calculating inter-coder agreement. After building the dictionaries, we refined categories iteratively between the coders, as each coder reviewed the dictionaries created by others to increase the reliability and validity of dictionaries, as suggested by Short et al. (2010). After the inter-judge of the coders, each dictionary category was once more checked with the keyword in context function of WordStat to ensure that each word appeared accurately in the context that it was supposed to appear. The dictionaries are presented in Table 2. After finalized with the dictionaries, we conducted computer-aided content analysis with WordStat.

Insert Table 2 about here

RESULTS

Results of the qualitative content analysis

In this section we will present the results of the qualitative content analysis. A sample of 150 press releases was coded individually by three of the authors, using an inductive coding approach. The emergent themes were aggregated under nine main themes that categorize the justifications that were used. The results are presented in Table 2.

Insert Table 3 about here

Rationalization justifications. Rationalization justifications focused on the instrumental value of the investment. They relied mainly on economic and technical rationale to justify the investment. Arguments related to *financial profitability* were commonly used to argue highlight the economic rationale of the investment. This category included justifications related to the return and long-term value of the investment as well cost-effectiveness or low costs of the investment. Value to *customers* was also a commonly used justification, focusing mainly on the benefits and gains they gain from the investment. These included general references to customers as a stakeholder group, affordability of energy in the long run, ability to supply energy to customers as well as the investments' impacts to short-term customer prices (which can increase temporarily). Companies generally estimated the price effects of an investment to remain small or took actions to make them do so by different funding schemes. This category was differentiated from energy supply as a societal benefits through the use of different words. When referring to customer benefits, the words used included "customers" and "businesses", whereas in relation to societal benefits, the focus was on access to electricity and words used were commonly "households" or "homes".

At times companies justified their investment decisions on experience or expertise of a particular technology or know-how that they already had or that they could attain through an investment. The *knowledge development* category included references to previous know-how or experience, references to the development of know-how in the future by an investment project as well as piloting activities. There were also a considerable number of justifications relating to the superior technical features of the investments that were labeled under the *technical performance* category. This included references to efficiency, reliability and flexibility of the technology. Common examples of performance justifications were highlighting the efficiency of a new power plant, reliability of production or the use of advanced tracking systems for solar panels. Closely related to performance, *technological novelty* included justifications addressed the specialty of technology used in an investment. Highlighting the value of an investment by emphasizing how advanced and state-of-the-art technology it employed was a common argument for many different kind of investments.

Normalization justifications. Normalization justifications used in the press releases were primarily related to *strategy*. Individual investments were often presented as being part of strategic plans of a higher level that also increased their importance. Strategic themes were also often tightly linked to other categories, such as environment and customers. One of the most common references of strategy was portfolio building, referring to how well the investments fits to the firm's existing production fleet. In addition to portfolio building, the diversification of a portfolio was a strategic element recurrently linked to the individual investments. Closely linked to portfolio building, growth, gaining new market share and expansion to new markets were commonly used

justifications for the investment. Renewable energy or sustainability were often mentioned alongside strategy

***Moralization justifications*.** Moralizations identified in the press releases were focused on environmental and societal justifications. The *environmental* theme consisted of large set of references to the environmental impacts and natural surroundings of an investment. The environmental impacts of the investments were generally treated with positive tone – even if a power plant produced emissions, it was communicated through how much less it produced emissions than other similar power plants or power plants in the past. This category included reduced amount of pollution in terms of numerical measures, impacts to land use or surrounding environment (around the power plant), diminished use of water as well as waste generated by the plant and recycling activities. Some justifications related to environment were also more focused on general environmental values and responsibility rather than specific results of the investment. For example, most references to clean energy did not specify in what way the energy was seen as "clean" or "green". The theme of climate change was also used similarly to bridge the action to the prevention of greater environmental challenge and therefore create positive associations. In some cases firms also conducted as a separate environmental preservation project simultaneously with the investment to compensate for the impacts of the new power plant.

The second type of moralization strategies were related to *society*. These consisted of justifications related to the impacts to the local community or wider society as a result of the investment. Employment and regional economic development, related to the wider benefits to local economic life, were among the most common societal benefits mentioned in the press releases. Some press releases also mentioned the direct benefits to local communities in the form of increased tax

income or decreased subsidy expenses. In addition to local economic benefits, safety was at times mentioned as a benefit to the surrounding community. Education and research possibilities were also referred to as societal impacts of an investment, referring to knowledge byproducts provided by the investment to schools and universities. Another, closely related subtheme was community participation that referred to for example possibilities of the local community to track the productivity of a solar plant or participate an event at the production site.

Authorization justifications. Authorization strategies were related to the regulatory aspects of the investments. Various references to regulations, policies and officials were classified into four key subthemes: regulatory approval, compliance with regulations, support schemes as well as price and market regulation. Regulatory approval and compliance were among the most commonly used justifications in the regulation category. These justifications referred to situations where companies made it evident that the investment is compliant with key regulations and permitting processes that effect it. Another key aspect of regulation concerned specific support schemes related to the investment. These included for example different forms of support for renewable energy, such as feed-in-tariffs or renewable energy credits (REC) as well as political support granted for investments in general. The last subtheme in the regulation category included price and market regulation. This consisted of references to the mechanisms used to regulate the customer price on the market or the market in general for example through the distribution of capacity rights.

QUANTITATIVE CONTENT ANALYSIS

This section will detail the findings from our content analysis. Based on the qualitative analysis, we formed dictionaries for each of the categories as described in the methodology section. After the formation of the dictionaries, we used the WordStat software to quantify the occurrences of

words in each category. The first objective of the quantitative analysis was to compare the occurrences of the justifications in each theme (i.e. rank them from most to least common). The second objective was to compare the justifications used in press releases concerning investments into renewable energy (e.g. solar, wind and hydro) with press releases related to non-renewable energy sources (e.g. coal, natural gas and nuclear).

Occurrence of themes

The case occurrence, meaning the number of press releases in which the each theme was present, was used as the main indicator of the prevalence of the justifications. The results of this analysis are presented in Figure 1 below. The most commonly used justifications overall (occurring in 40-54% of cases) were related to environment (emissions reduction and environmental values) and strategy (alignment with strategy, growth, portfolio), technological novelty and societal benefits (community, employment, electrication). Most of the rationalization and authorization justifications fell around the median (22,8%) of the set, ranging from 10-36%. The most occurring themes were expected as they are all closely related to gaining general social acceptance and thus legitimacy. Of particular note, profitability was the least commonly used justification out of the main categories. While it is traditionally seen as the most important factor determining the investment decision, it can be a taken-for-granted attribute and therefore not discussed in length in public briefings.

Insert Figure 1 about here

Justifications of non-renewable and renewable investments

In the second stage of the quantitative analysis, we compared the prevalence of the justification themes between renewable and non-renewable technologies. We did this by comparing the case occurrences of themes between the two categories. The results are listed in Table 4. The comparison is based on Dunning's log likelihood test, also known as the G^2-test, which measures the significance of statistical differences against expected values similar to the χ^2-test..

Insert Table 4 about here

Table 4 shows that there are statistically significant differences between the technological groups in approximately half of the subcategories of justifications. The majority of the themes occurred more in press releases concerning non-renewable energy investments. As could be expected, most of the rationalization justifications (profitability, reliability, efficiency, customers, supply) were more commonly used in regard to non-renewables compared to renewables. These differences can be considered quite understandable due to the generation process of renewable energy: fossil fuel -powered plants have inputs, outputs and production hours that can be measured more easily than those of renewable energy production sites for the sake of performance indicators. What was more surprising is that many of the environmental (emissions reduction, waste management and environmental values) and societal (safety, economic boost, affordable energy) justifications were also used more often with non-renewable investments. This suggests that the energy firms are appropriating some of the discourse generally associated with more renewable technologies in order to defend the legitimacy their non-renewable investments.

The justifications that were used more often with renewables were mainly related to strategic (alignment with strategy, portfolio) justifications. The one exception was electrication category, which included keywords related to providing energy for the society (such as family, households). The results indicate that overall, non-renewable investments need more justifications of all types. As electrication referred to same action as the customer supply -subcategory, it is interesting that analyzing their occurrence in the justifications provided opposing results. This can be explained in part by the size of the investments, as the non-renewable investments were considerable larger in size on average. We also compared the occurrence of themes based on the control variable, CSR performance. Regarding this, we found no significant differences between high- and low-performing firms in terms of the occurrence of the justifications.

Co-occurrence analysis

To obtain a more comprehensive view of the justifications used for the investments, we also performed a co-occurrence analysis of the subcategories. We quantified the co-occurrence of the subthemes on the paragraph level, using the Sorensen-Dice coefficient for measuring similarity, which is available in the WordStat software package. The results are presented in Figure 2 and Table 4.

Insert Figure 2 about here

The co-occurrence analysis revealed interesting differences between the technological categories, in regards to the co-occurrence of *different rhetorical strategies*. When we calculated the average similarity coefficients for each of the rhetorical strategies, moralization and authorization strategies had higher similarity coefficients for renewables while rationalization and normalization strategies had higher similarity coefficients for non-renewables. However, after we removed co-

occurrences within the same category (e.g. co-occurrence of profitability and customer justifications), non-renewable investments had a higher similarity coefficient for all rhetorical strategies. This shows that there are more co-occurences involving multiple rhetorical strategies (rationalization, normalization, moralization and authorization) for non-renewable investments.

Insert Table 5 about here

Figure 2 shows association networks for the two technological categories on the justification subcategory level. It sheds more light on which type of justifications occur more often together. For both technology types, the node with the highest centrality was environmental values, and its similarity coefficient for was higher for non-renewables. For renewable investments, moralization and normalization arguments are used together relatively often, but there are less co-occurrence with the other rhetorical strategies. For non-renewable investment, there is a high prevalence and strength of connections between many moralization, rationalization and normalization strategies, within the same paragraph. We also analyzed the co-occurrence of justifications within a sentence, and the results were similar to the paragraph –level analysis. The quote below exemplifies the use of multiple rhetorical strategies:

> *This important investment will benefit our CUSTOMERS for decades to come with SIGNIFICANT improvements in EFFICIENCY, ENVIRONMENTAL PERFORMANCE and RELIABILITY," said FPL President and CEO Armando J. (Next Era Energy, 19.6.2011)*

The intermixing of rationalization and moralization justifications for non-renewables suggests the utilities use language that frames their actions in a "hybridized" light. They adopt both

environmental and societal arguments normally associated with renewable investments and combine them with rationalization arguments to show that their actions provide value in multiple dimensions of sustainability. This can be seen as a defensive strategy to address the declining legitimacy of non-renewable energy sources. In comparison, for renewable investments the justifications are clustered around the main rhetorical strategies and there is considerably less overlap between them.

DISCUSSION AND CONCLUSION

Our study provides insights into rhetorical legitimacy-seeking behavior of incumbents investing into both novel and established technologies during transitional periods between the disruption of an established technological regime and the prospect of a new one. Comparison of how energy incumbents justify investments into renewable and non-renewable technologies reveals that incumbents appropriate the rhetoric of sustainable and clean technology typically associated with new and renewable technologies to justify investments into established and polluting technologies. Our analysis also uncovers that the rhetoric that incumbents use to justify non-renewable investments is substantially more pronounced and blended than the one for renewables. Thus, in order to legitimate investments into old technology during periods of transition towards a potentially new technological paradigm, incumbents tend to not only engage in higher levels of legitimacy-seeking behavior, but they also engage a hybrid rhetorical frame in which they blend both environmental and societal arguments with rational and efficiency-based rhetoric. Our study highlights rhetorical strategies as an important vehicle for legitimating novel as well as established technologies, and provides interesting insights into situations in which actors may borrow elements from novel technologies in order to justify their continued investment into established technologies. We discuss this and other contributions to the literature below.

Legitimating technologies and institutional theory

Our findings emphasize that incumbents employ the social referencing and clean, sustainability rhetoric that is so diffused among the domain of renewable technologies to justify investments into established and polluting practices. This is a surprising finding in the context of the existing literature on institutions and technology legitimacy. For example, in their account of how Edison introduced the electrical light as a novel technology, Hargadon and Douglas (2001) have shown that in order to gain acceptance for a novel, competing technology, Edison would borrow what is cognitively legitimate from the established technology. Similarly, other scholars have demonstrated that actors typically stress similarities to already established processes and familiar technologies in order to gain legitimacy for new ones. In contrast, in our study, we observe a situation in which actors borrow rhetorical facets from the novel in order to legitimate an established practice. As we have specifically analyzed incumbents' legitimacy-seeking behavior under institutional change, based on our findings, we suggest that in transitional periods during which legitimacy trajectories of novel and established technologies change, incumbents borrow from the novel, legitimacy-gaining technology in order to justify continued investment into the old technology. As such, our study provides novel insights into situations in which actors may borrow elements from novel technologies in order to justify their continued investment into established technologies.

Other lines of research on technology legitimacy within institutional theory have discussed the important role of social values in seeking legitimacy for technologies. Highlighting dominant societal values has been shown to be an effective strategy to enhance the legitimacy of technologies. In their study of nuclear energy associations, Garud et al. (2010) showed how prevailing societal values related to climate change were used re-legitimize nuclear energy by

framing it as a sustainable, emission-free and climate-friendly technology. More generally, Raffaelli and Glynn (2015) note how the valuation today placed on being "green" and on promoting environmental sustainability is increasingly becoming a mainstream business issue that is rippling through organizational fields and shaping institutional innovations. The norms and values that are becoming dominant also shape the rhetorical strategies and arguments that organizations use to justify their actions. As such, the growing dominance of the clean technology and sustainability rhetoric can be viewed as an empirical manifestation of how institutionalization is a process of instilling value (Selznick 1957). The normative order and templates of what are the appropriate justifications for legitimating a given technology change as values, norms, and beliefs shift over time. Our study contributes to this line of research by studying rhetoric and the use of societal rhetorical frames under conditions of institutional change. Our findings suggest that in transitional periods during which legitimacy preferences change and values shift, incumbents align their rhetorical frame to the rhetoric and social values associated with the legitimacy-gaining technology.

Rhetorical institutionalism

Our study also contributes to research on rhetorical institutionalism in several ways. First, we provide insights into how incumbents use rhetoric to justify the adoption of technologies that are on divergent trajectories of legitimacy. While previous work on rhetorical institutionalism suggests that rhetorical legitimation strategies are used differently according to the stability of institutional norms of a practice (Bitektine & Haack, 2015; Green, 2004; Suddaby & Greenwood, 2005), only few empirical studies on the topic have been conducted. In this paper, we have compared rhetorical legitimacy strategies between legitimacy-losing technologies and legitimacy-gaining technologies and found significant differences in the employed strategies. In order to justify investments into

established energy technologies that are experiencing legitimacy threats, incumbents innovatively blend and comprehensively utilize distinct rhetorical strategies. These findings support the view of Ashforth & Gibbs (1990) and Green (2004) who suggest that justifications are used more in case of legitimacy-losing technologies. Moreover, we find that adopters of established energy technologies, while experiencing legitimacy threats and changing institutional demands, engage in rhetorical hybridity by innovatively blending distinct rhetorical strategies. One explanation may be that the difficulty to find persuasive arguments given the changing institutional expectations drive incumbents to extensively borrow clean and sustainability rhetoric from novel technologies. As to novel technologies, we find that incumbents blend fewer strategies and focus more on moralization and normalization arguments. Those strategies are typically associated with later stages of legitimation processes. These findings suggest that rhetorical legitimation strategies and their sequence may be different under conditions of institutional change. More research on the topic is needed to confirm our results.

Second, we show how incumbents attempt to reaffirm the importance, efficiency, and effectiveness of the established technological archetype that is losing legitimacy by appropriating the rhetoric of the novel technological archetype that is gaining legitimacy. Building on our findings and setting them in context to recent work on rhetorical institutionalism (Hoefer and Green, 2016), we propose that, as the strength of presumption of illegitimacy of a given technology increases, incumbents find it harder to produce persuasive arguments in favor of that technology. Accordingly, they borrow or appropriate from the dominant rhetoric and arguments associated with the technology that is gaining legitimacy. One consequence is that in order to build persuasive arguments, proponents of the legitimacy losing technology are forced to bask in the reflected glory

(Cialdini et al., 1976) of the legitimacy-winning technology while, at the same time, have to face the danger of stakeholder skepticism.

Third, much of the existing work on rhetorical institutionalism has focused on explaining how rhetoric affects legitimacy judgements (Hoefer and Green, 2016; Suddaby, 2010). Our study contributes to this work by turning attention to the reflexive interplay between rhetoric and legitimation processes and by showing how the changing institutional landscape and legitimacy judgements shape rhetorical strategies. The current research on rhetorical institutionalism with its focus on the means of persuasion in the formation of legitimacy arguments has largely overemphasized the "free will" of actors in producing persuasive arguments. Our paper is among the first to examine how legitimacy judgements shape rhetoric under radical institutional transition. We show how fighting the wave of declining legitimacy requires resorting to the rhetoric of the legitimacy-gaining technology. Sustainability rhetoric works as a toolkit that is appropriated in the service of established technologies. As such, the rhetorical hybridity and blending that we find seems to offer incumbents a solution to conform symbolically to the broad societal trend of environmental sustainability while holding on to established and legitimacy-losing technologies.

Incumbents and innovation

Much of the literature on incumbent firms and technologies has studied the inertia inherent to established organizations. On the other hand, the literature on newcomers and entrepreneurship is typically concerned with innovation and innovative behavior. Our study seeks to overcome this classical divide in the literature by shedding light on situations in which incumbents may engage in innovative behavior. We observe that incumbents, in order to hold on to what they have established, may actually engage in innovative behavior by bringing in novel elements from new

technologies and develop a new rhetorical frame. In the context of our study, we find that electric utility incumbents engage in innovative legitimacy-seeking rhetoric by blending rational technocratic arguments with moralization, including social and environmental attributes traditionally associated with renewable technology. In doing so, they recombine existing institutional templates in novel ways. In other words, in their efforts to legitimize investments into established and legitimacy-losing technologies, incumbents engage in innovative rhetorical behavior by blending multiple arguments. These insights suggest that not only entrepreneurs can recombine existing elements in novel ways (Schumpeter 1934), incumbents may likewise engage in recombinational and innovative activities. As such, our study adds to yet small body of literature that has studied elites and incumbents and their innovative organizational behavior (e.g., Greenwood and Suddaby, 2006).

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APPENDIX

Table 1. Rhetorical legitimation strategies

Strategy	*Explanations*
Authorization	Legitimation by references to authority such as a rule, directive or expert
Normalization	Legitimation by references to past or normal actions
Moralization	Legitimation by references to moral values or norms
Rationalization (technocratic characteristics)	Legitimation by references to utility, benefits, functions or outcomes of a practice

Table 2. Dictionaries for quantitative analysis

Dictionary	**Examples of content**	**Number of words**	**Alpha**
Performance	Efficient, effective, flexible, reliable, production/7/increased	31	78%
Strategy	Footprint/not after/carbon, committed, goal, portfolio, modernization	48	84%
Customers	Customer, client, affordable, power/7/supply, electricity/7/provider	20	81%
Knowledge development	Experience, expertness, know-how, pilot, learning	12	100%
Environment	Ecological, green, land use, waste, pollutant	45	80%
Society	Labor, jobs, households, boost, educational	44	85%
Technological novelty	Demonstrative, benchmark, remarkable, state-of-the-art, innovative	27	93%
Regulation	Legislation, regulated, incentive, tariff, public/5/tender	43	97%
Profitability	Earnings, profitability, return on investment, cost effective, capital costs	12	95%

Table 3. Emergent themes in the qualitative analysis

Main theme	**Definition for main theme**	**Subthemes**	**Examplary quote**
Rationalization justifications	Profitability and monetary benefits of the investment.		*"TEPCO's decision to invest in STP 3&4 is based on the stable long-term*

Financial profitability			*earnings expected from the project"* (Tepco 10.5.2010)
Customers	Impacts that the investment will have on its current and potential customers via energy supply and affordability of energy.	Customers, Affordable energy, Energy supply	*"The framework keeps long-term costs down for customers through a pay-as-you-go process"* (NextEraEnergy 18.4.2013)
Knowledge development	Impacts that the investment will have on the level of the intellectual capital of the company, its partners and/or the local community.		*"This demonstration project is an ingenious European industrial match combining the best of Finnish and French expertise in renewable energy"* (Fortum 19.9.2013)
Technical performance	Efficiency and technological abilities of the investment.	Efficiency, Reliability, Flexibility	*"The panels use a tracking system to follow the sun's movement during the day, which increases sunlight capture"* (Duke 11.11.2010)
Technological novelty	Novelty value and advancement of the technology used in an investment.		*"EZ Plovdiv Sever will be the most modern cogeneration plant in all of the Balkans"* (EVN 13.9.2010)
Normalization justifications **Strategy**	Compatibility of the investment with the targets and visions of the company or the nation.	Strategy alignment Growth, Portfolio building, diversification,	*"With this project, I&M will further broaden the diversity of our power generation, with three sources of renewable energy – solar, wind and water"* (AEP 8.7.2014)
Moralization justifications **Environment**	Impacts that the investment will have on its natural environment via emission level, land use, material efficiency and conservation measures.	Environmental values, Emissions reduction, Land use, Waste and recycling	*"The fully-operational plant is able to generate over 250 million kWh of clean energy annually, therefore avoiding atmospheric emissions of over 100 thousand tonnes of CO2 every year."* (Enel 9.7.2012)
Society	Impacts that the investment will have on societies via provision of goods, employment, economic development and effects on health and safety of humans.	Employment, Economy boost, Research and education, Community participation, Electrification, Safety	*"Hinkley Point C also has the potential to give a massive boost to the economy with 25,000 people working on the power station during its construction, and 900 during its lifetime."* (EDF 19.3.2013)
Authorization justifications **Regulation**	Local regulations and policies concerning the investment.	Regulatory approval, Compliance with regulations, Support schemes, Price and market regulation	*"Furthermore, this project constitutes a security against the restrictive objectives of the European Union's climate and energy policy"* (PGE 4.9.2014)

Figure 1. Case occurrence of justifications

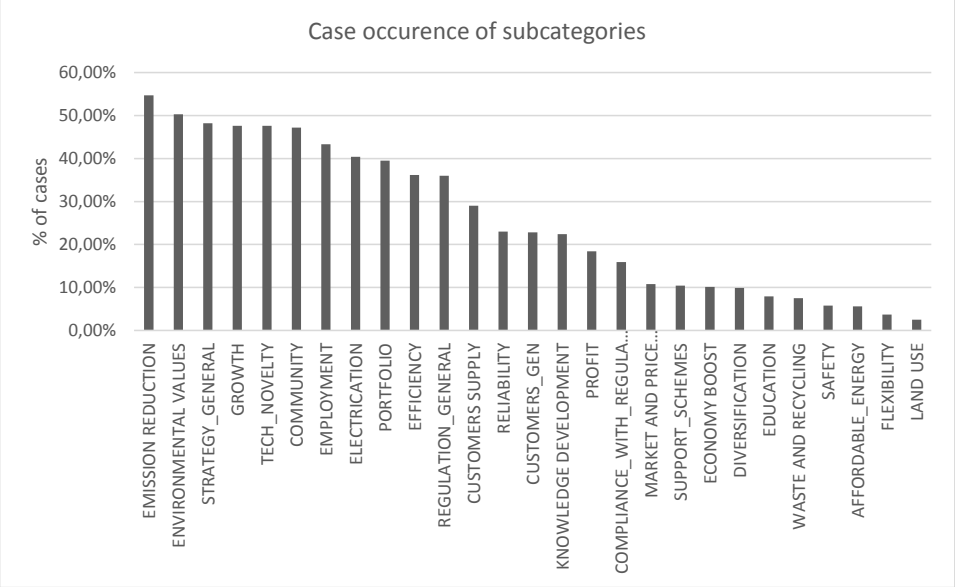


Table 4: Theme occurrence comparison

Subcategory	Category percent, Non-Renewable energy	Category percent, Renewable energy	G2
PROFIT	36,50 %	13,60 %	***25,15
RELIABILITY	49,00 %	15,20 %	***47,57
COMPLIANCE_WITH_REGULATIONS	27,90 %	12,80 %	***12,36
ELECTRICATION	16,30 %	47,20 %	***35,32
EFFICIENCY	72,10 %	26,10 %	***72,67
TECH_NOVELTY	66,30 %	42,10 %	***19,34
EMISSION REDUCTION	71,20 %	50,10 %	***14,98
SAFETY	13,50 %	3,70 %	***11,64
CUSTOMERS_GENERAL	33,70 %	20,00 %	**8,062
STRATEGY_GENERAL	37,50 %	51,20 %	*6,182
CUSTOMERS SUPPLY	38,50 %	25,90 %	*6,08
WASTE AND RECYCLING	13,50 %	5,90 %	*5,94
ECONOMY BOOST	15,40 %	8,30 %	*4,23
AFFORDABLE_ENERGY	9,60 %	4,50 %	†3,45
ENVIRONMENTAL VALUES	57,70 %	47,50 %	†3,42
PORTFOLIO	32,70 %	41,90 %	†2,91

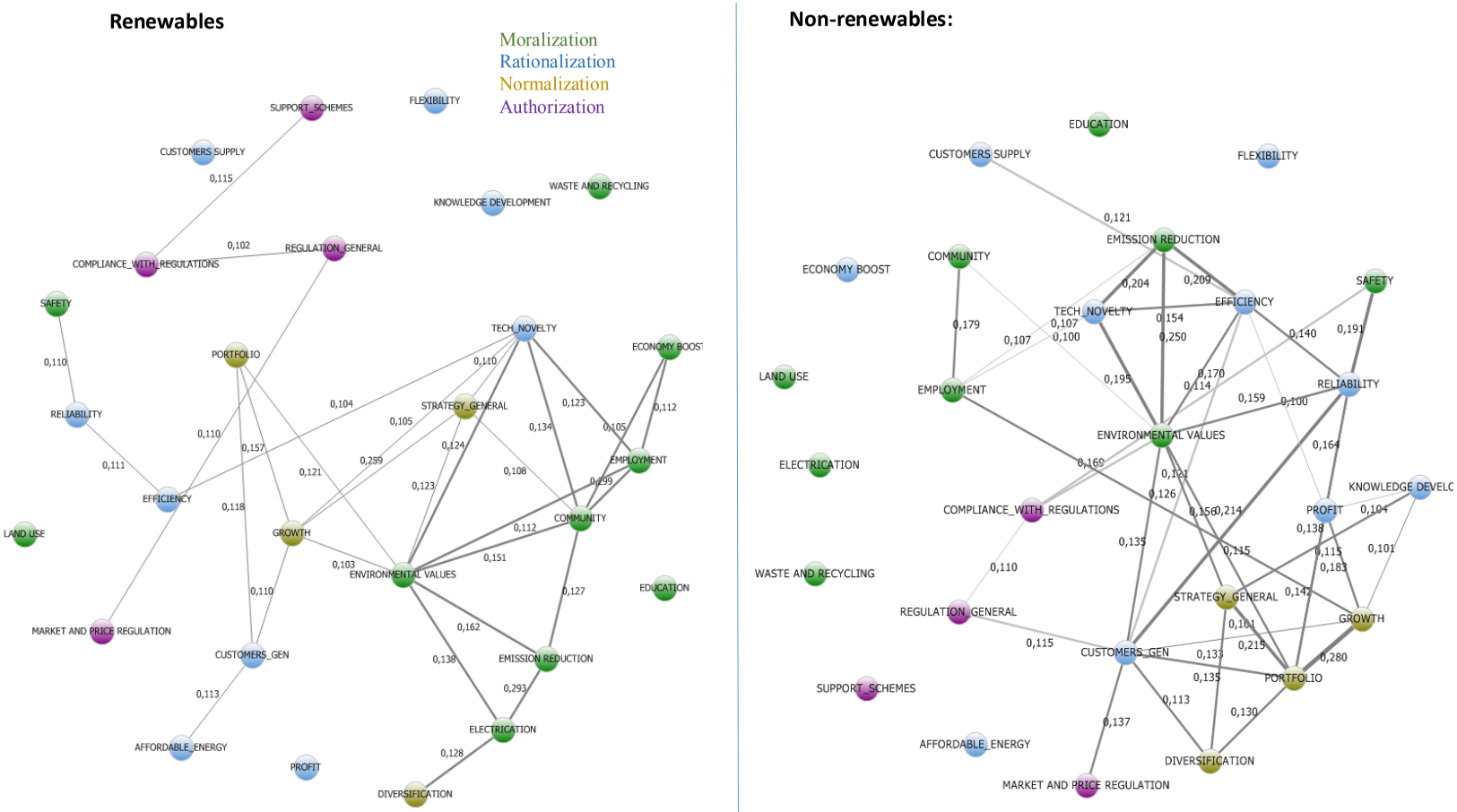
MARKET AND PRICE REGULATION	6,70 %	11,70 %	2,35
REGULATION_GENERAL	42,30 %	34,10 %	2,33
SUPPORT_SCHEMES	6,70 %	11,50 %	2,14
LAND USE	1,00 %	2,90 %	1,59
FLEXIBILITY	5,80 %	3,20 %	1,34
COMMUNITY	50,00 %	46,40 %	0,42
DIVERSIFICATION	11,50 %	9,60 %	0,33
EMPLOYMENT	45,20 %	42,40 %	0,26
GROWTH	45,20 %	48,00 %	0,26
KNOWLEDGE DEVELOPMENT	22,10 %	22,70 %	0,01
EDUCATION	7,70 %	7,70 %	0,00

† $p < 0.10$
* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Table 5: Average similarity coefficients for the rhetorical strategies

	RE	Non-RE	RE	Non-RE
	Average similarity coefficient	Average similarity coefficient	Average similarity coefficient excl. co-occurences in same rhetorical category	Average similarity coefficient excl. co-occurences in same rhetorical category
Rationalization	0,0314	**0,0441**	0,0295	**0,0388**
Moralization	**0,0366**	0,0336	0,0284	**0,0306**
Authorization	**0,0278**	0,0260	0,0225	**0,0251**
Normalization	0,0440	**0,0519**	0,0371	**0,0392**

Figure 2: Co-occurrence networks based on Sorensen-Dice similarity coefficient



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Towards a broader perspective on the forms of eco-industrial networks

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ABSTRACT

This paper explores various forms of eco-industrial networks in advancing environmental sustainability. Prior research on environmental sustainability primarily identifies industrial actors as autonomous entities or considers the role of networks in advancing environmental sustainability from a rather narrow perspective. However, the networks of ties in which industrial firms are embedded profoundly impacts not only their own performance, but also the natural environment in which they operate. Based on a systematic literature review, we identify four forms of eco-industrial networks that have the potential to advance environmental sustainability: 1) symbiosis networks, 2) sustainable supply networks, 3) environmental issue networks and 4) environmental solution networks.

The paper presents important insights on the operational logic for each of these network forms and the dimensions of their network architecture. The main implications of this comparison are that policymakers and practitioners need to become aware of the various mechanisms through which inter-organisational networks can reduce environmental load. Furthermore, there is a need to build broad coalitions of organisations that are mobilised to address environmental issues. We suggest that network architecture which maximises its members' capability to self-organise while also including a coordinating organisation can be highly suitable for eco-industrial networks. We also suggest some fruitful avenues for future research on eco-industrial networks. In integrating research on eco-industrial networks with existing research on inter-organisational alliances and networks, the paper provides more understanding on the multifaceted role played by various forms of eco-industrial networks in advancing sustainability.

1. Introduction

Firms and industries do not accomplish the goals of environmental sustainability in isolation. Organisations are embedded in networks of social, professional and exchange relationships with other organisational actors (Ahuja et al., 2012; Gulati et al., 2000). In addition, problems relating to environmental sustainability are embedded in a complex web of actors comprising businesses, consumers, NGOs and governmental agencies which are involved in collaboration and contestation concerning the problems and their solutions (Wittneben et al., 2012). However, in the extant literature on organisations and the environment, the unit of analysis primarily lies at the level of individual actors instead of a network of actors. As the locus of change primarily lies in the network of interactions between organisations and individuals, we need a better understanding on the linkages between environmental issues and organisational networks. This paper advances the shift of focus in the unit of analysis by examining *eco-industrial networks*, defined here as industrial networks that advance environmental sustainability through inter-organisational collaboration.

However, research on eco-industrial networks is surprisingly limited and has focused primarily on industrial symbiosis (IS), which refers to inter-firm activities that focus on the re-utilisation of waste and by-products and the exchange of resources (e.g. Chertow, 2000; Doménech and Davies, 2011). While the IS literature focuses on the potential of energy and material linkages between firms, it provides a limited perspective on the forms of eco-industrial networks in advancing sustainability. Thus, we suggest that a broader understanding is needed on the mechanisms

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through which industrial networking can advance environmental sustainability. Analysis of the operational logic and network architecture of eco-industrial network forms could shed light on the processes advancing environmental sustainability. Operational logics of networks describe the focus of environmental action and the mechanisms through which a network aims to achieve environmental benefits. Network architecture represents the form of networks in response to their function (Fjeldstad et al., 2012). A better understanding on the underlying structural elements of these networks is needed to gain a deeper understanding on how these networks operate. Our main objective in this research is to make salient the potential mechanisms that have been addressed in the extant literature and establish a starting point for further empirical work. Specifically, we address two research questions: What forms of eco-industrial networks with the potential to advance environmental sustainability can be identified in the literature? What are the principal operational logic and architecture of these network forms? We answer these questions through a systematic literature review by analysing four different literature streams.

The paper begins with a general discussion on networks and sustainability, followed by an introduction to four forms of eco-industrial networks that have been identified through a systematic literature review. Subsequently, the identified forms of eco-industrial networks are compared and their similarities and differences evaluated through dimensions adopted from the literature on inter-organisational alliances and networks. The paper ends with conclusions and implications for practice and research.

2. Networks and sustainability

There is an extensive body of knowledge on how networks can contribute to the creation of various types of outcome. Networks enable organisations to access resources that might otherwise be difficult to develop or acquire (Ahuja et al., 2012; Gulati et al., 2000). They transfer information that gives rise to attitude similarity, imitation and generation of innovations (Ahuja, 2000; Brass et al., 2004). Thus, networks are powerful carriers of new norms, values and practices. In addition, they serve as governance mechanisms that can constrain opportunism and enhance trust (Ring and Van De Ven, 1992).Conversely, networks also have inertial properties that can constrain change (Kim et al., 2006).

Networks are potentially powerful tools with which to influence the context and shape the practices of involved actors. However, we have limited understanding on the transformative power of networks in addressing the problem of environmental sustainability. Prior network research primarily focuses on the outcomes of networks for individual firms and industries, rather than on the functioning of the natural environment. From the perspective of an individual firm, network-based collaboration has been shown to reduce risk, speed products to market and decrease the cost of process improvement and product development (for a review, see Fjeldstad et al., 2012).

Environmental sustainability, however, is profoundly affected by complex networks of actors that comprise industries, NGOs and governmental agencies. These networks are involved in collaboration and contestation over the urgency of environmental problems and the role of government and markets in addressing these problems (Wittneben et al., 2012). In addition, specific forms of collaborative networking can contribute to reducing the environmental load of industrial operations. For example, Ostrom (2009) regards environmental degradation as a problem of collective action and proposes a polycentric approach that relies on small-scale regional institutions and governance mechanisms which take advantage of local incentives for cooperation.

Collaborative inter-organisational networks are often characterised by novel ways of organising that suit the collective purpose of the network (Fjeldstad et al., 2012). It is thus vital to understand these networks' architecture, which can be defined as the synthesis of their form in response to their function. These collaborative arrangements can be conceptualised through an actor-oriented network architecture, which is focused on enabling the set of involved organisations to dynamically form collaborative relationships. Actor-oriented network architecture comprises three major elements: actors, commons and also protocols, processes and infrastructures (Fjeldstad et al., 2012). Furthermore, a study by Gulati et al. (2012) identified two other elements through which a network's architecture can be characterised. The first element is the permeability of boundaries; in other words, the extent to which a network's boundaries are open or closed. Also, the internal stratification of decision making affects a network's design (Gulati et al., 2012).

Research on business and sustainability appears to draw surprisingly little from the substantial literature on inter-organisational alliances and networks. We propose that research on eco-industrial networks will benefit from better integration with traditional network research. In addition, more understanding on the potential and characteristics of network cooperation in addressing environmental problems is needed.

3. Methodology

As the existing research on industrial networks and sustainability is divided into mostly unrelated research streams, we adopted a multidisciplinary systematic literature review to address our research questions. A systematic literature review can provide a more comprehensive analysis of the literature in comparison to traditional, more subjective literature reviews (Denyer and Tranfield, 2006). It includes a clear statement on the purpose of the review, a comprehensive search protocol to obtain the relevant literature and explicit criteria for qualifying the relevant literature. Its strength lies in reproducibility due to careful documentation of the search protocol, thus enabling other researchers to generate similar findings by following the same protocol (Denyer and Tranfield, 2006).

First, the search was conducted by two researchers on two different academic databases to cover a diverse range of publications. The two chosen databases were Scopus and Web of Science. The date range chosen for analysis was 1990–2012, and the selected keywords were as follows:

("*Industrial*" OR "*Business*" AND "*Network*" AND "*Sustainability*" OR "*Environmental*") OR "*eco-industrial network*" OR "*industrial symbiosis*" OR "*eco-industrial park*" OR "*eco-cluster*" OR("*industrial ecology*" AND "*network*")

Both databases were searched individually with the chosen keywords. The search covered the title, keywords and abstracts of the articles and found a total of 808 articles. Based on a review of their abstracts, 160 articles were qualified and their full texts scanned. This resulted in 36 articles being chosen for further analysis. An additional three articles were identified through a snowball method of scanning the references of the 36 selected articles, bringing the total number of articles to 39. After this process, a need for more recent articles on some eco-industrial network forms became apparent. For this reason, selected journals from industrial ecology, supply chain management and marketing, which are named in the next chapter, were scanned for the years 2012 and 2013. Along this process, two more articles matching the employed criteria were found. Thus, in total, 41

articles are included in the final review. The details of the inclusion and exclusion criteria employed to qualify the papers for analysis are listed in Table 1.

The final set comprised peer reviewed journal articles in English for which full texts were available. We focused on conceptual, normative and descriptive articles that put forward a direct contribution to the theoretical and/or operational understanding on industrial networks. As the purpose of this literature review is to advance understanding on the different forms of industrial network in advancing sustainability, we chose to include articles that would provide as comprehensive a perspective on these network forms as possible, thereby enabling us to compare the characteristic dimensions of the identified forms. The systematic review process is shown in Fig. 1.

The full set of 41 articles was analysed in detail by two researchers, both of whom gathered data on the articles on a predefined data collection form. The gathered data comprised study-type methodological factors (i.e. research method; data set; data analysis), objectives of the study, theoretical background, country of study, and the main concepts and primary findings. In the next section, we put forward a detailed description of the articles chosen for the final analysis.

4. Description of the literature

The majority of the articles that met the inclusion criteria (78%, $n = 32$) were published between 2007 and 2012, which demonstrates the considerable academic interest on eco-industrial networks in recent years. The three most common journals represented in our article set were the Journal of Cleaner Production (34%, $n = 14$), the Journal of Industrial Ecology (24%, $n = 10$) and Business Strategy and the Environment (12%, $n = 5$). In addition to two other journals in the area of environmental management (i.e. Ecological Economics; Annual Review of Energy and the Environment), the journals represent the fields of industrial marketing (Industrial Marketing Management; Journal of Business and Industrial Marketing), geographical sciences (Geoforum; Local Economy), supply chain and operations management (Journal of Supply Chain Management; Journal of Operations Management; International Journal of Production Research) and knowledge management (Industrial Management and Data Systems).

After careful analysis of the main concepts and theoretical backgrounds of the selected articles, we were able to identify four distinct literature streams with a common focus on industrial networks that aim to decrease environmental impacts through cooperative action. However, there are key differences in the operational logics and network structures among the networks described by these four streams. In essence, the four streams represent various forms of eco-industrial networks. The first, an *industrial symbiosis network*, has received the greatest attention over recent years in the fields of industrial ecology and environmental management. According to the review, it seems that industrial symbiosis has developed through exchange of material based resources (e.g. waste and by-products) to exchange of non-material based resources (e.g. knowledge), and social embeddedness has been highlighted in the discussion only during recent years. The second form, a *sustainable supply network*, is grounded on the supply chain management discipline. The third and fourth network forms, an *environmental issue network* and an *environmental solution network*, have received less attention and have been studied mainly in the field of industrial marketing, in which industrial and business networks have a long research tradition. We will next discuss each of these models in more detail.

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Journal articles; Full text available; Conceptual, normative, and descriptive studies that advance understanding on industrial networks.	Conference proceedings; Reviews, commentaries, editorials; Specific technical models of networks; No abstract available; Non-English articles.

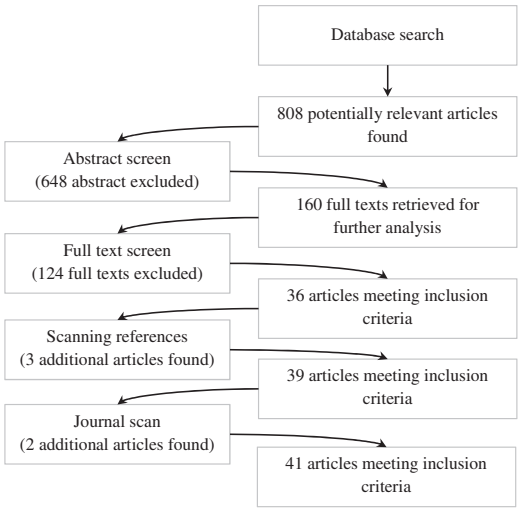

Fig. 1. Summary of the systematic review.

4.1. Industrial symbiosis networks

Industrial symbiosis (IS) focuses on the cooperative management of resource flows through firms' networks. IS has been defined as "traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products" (Chertow, 2000). In addition, exchange of non-material resources such as knowledge and expertise is central in IS (Lombardi and Laybourn, 2012).Thus, key issues that relate to IS are the exchange of resources (i.e. material and non-material), geographic proximity of actors and collaboration between industries. Geographic proximity has been regarded as central to IS due to facilitation of material exchanges, transportation, trust and collaboration (Lombardi and Laybourn, 2012; Taddeo et al., 2012), and also the sharing of information and norms within social networks (Ashton and Bain, 2012). Repeated interactions lead to the creation of shared norms that influence actors' behaviour and patterns of relationships (Ashton and Bain, 2012).

Symbiotic collaboration between firms and industries yields financial and environmental benefits through the exchange of complementary resources (e.g. Behera et al., 2012; Dimitrova et al., 2007; Tudor et al., 2007). Companies can also share utilities such as energy, water and wastewater treatment, and also services such as transportation, landscaping and waste collection (Ashton, 2008). Furthermore, IS aims at sustainable strategies in industrial development (Baas and Boons, 2004). Creating and sharing knowledge through IS networks facilitates implementation of modern technologies, eco-innovations and cultural change in organisations (Behera et al., 2012; Lombardi and Laybourn, 2012; Mirata and Emtairah, 2005). For instance, as a comprehensive state policy, the Chinese government has implemented a so-called circular

economy that relies on cleaner production, development of eco-industrial parks and ecological modernisation; for example, an eco-city (Yuan et al., 2006).

IS is a subset of industrial ecology that examines the sustainability of material and energy flows and cycles through industrial systems. It encompasses studies on *eco-industrial parks* (see e.g. Gibbs and Deutz, 2005; Sakr et al., 2011; Tudor et al., 2007) and *industrial ecosystems* (see e.g. Ashton, 2008; Liu et al., 2012). Some authors have employed related terms such as *eco-industrial network* (Ashton and Bain, 2012; Van Ha et al., 2009), *eco-cluster* (Dimitrova et al., 2007) and *green industry park* (Tudor et al., 2007).

4.2. Sustainable supply networks

A *sustainable supply network* is a form of eco-industrial network that focuses on taking full advantage of by-products and reusable materials while minimising waste in the supply chain (Zhu and Cote, 2004). Sustainable supply networks, also termed green supply chain management (GSCM), have their origin in the supply chain management literature. Sustainable supply chains aim to balance environmental concerns with performance across the supply chain, leading to better operational efficiency and less wasted resources, with the ultimate goal of sustainable competitive advantage (Tudor et al., 2007). Activities extend over the entire life-cycles of products, and comprise cooperation with suppliers for waste reduction, improved efficiency in manufacturing and transport and the development of reverse supply chains for recycling and reusing used products (Zhu and Cote, 2004).

Bansal and McKnight (2009) compared GSCM and IS as two distinct strategies for the reuse of industrial waste and by-products. They identified a key difference in the strategic logic between IS and GSCM actors. In conventional supply chains, firms manufacture and design products to meet customer needs and identify strongly with the end products that they sell, and seek to minimise waste and emissions along the supply chain. In contrast, firms in IS networks have a more entrepreneurial mindset, seeking new opportunities to extract value from waste and by-products, which might be completely independent from the firms' main identities. The reuse of waste and by-products in IS networks is focused on the system-level reduction of environmental impacts, while, in GSCM, it is more focused on single firms and value chains (Bansal and McKnight, 2009).

Zhu and Cote (2004) identified GSCM as being important for the development of localised eco-industrial parks, provided that the integration of GSCM begins to form a web-type structure instead of concentrating on the supply chains of single products. They found that an integrated approach to GSCM bears many similarities to the formation of eco-industrial networks (Zhu and Cote, 2004). Seuring (2004) also referred to an integrated approach to supply chain management and found that it requires wider cooperation and network-level environmental goals among actors along the value chain compared to traditional supply chain management. However, there remain focal firms which are largely responsible for the coordination of activities in the supply chain. Vachon and Klassen (2007) studied how supply chain integration relates to focal companies' selection of environmental technologies in which to invest. They found that integration with downstream suppliers is positively linked to a larger share of investments in pollution prevention technologies (e.g. product and process innovation that decreases the environmental footprints of products), whereas integration with upstream suppliers is positively linked to a larger share of investment in pollution control technologies (e.g. end-of-pipe solutions to decrease environmental impacts). Kocabasoglu et al. (2007) found that developing reverse supply chain activities, which relate to decreasing environmental impacts, should not be conducted in isolation; instead, they should be integrated with the development of forward supply chain activities such as demand and order management.

4.3. Environmental issue networks

The third form of eco-industrial network identified from the literature was an *environmental issue network*. Environmental issue networks refer to relatively loose collaborative coalitions formed around specific issues such as environmental problems or policies. They aim for institutional change through collective action and focus on developing policies, norms and values among the network actors. They are often temporary in nature, varying in length depending on the life-cycle of the focal issue. They also involve a diverse set of actors with asymmetrical power and resources, comprising private sector firms, governmental authorities, NGOs and even powerful individuals (Ritvala and Salmi, 2010, 2011).

Ritvala and Salmi (2010) studied how environmental issue networks are formed through mobilisation. They describe three separate initiatives that aim to improve the state of the Baltic Sea, a contemporary environmental concern that requires the mobilisation of actors from the region's various countries to address the issue. Ritvala and Salmi (2010) conceptualise environmental issue networks to be triggered by actors with strong values for taking responsibility to solve the focal issue. These actors act as mobilisers which challenge other actors to join the network through high media visibility and public framing. This mobilisation is enabled by social capital and shared values among the actors and, while their cooperation aims at environmental benefits, participating firms can also gain business benefits and improved public image (Ritvala and Salmi, 2010). In another study by Ritvala and Salmi (2011), motives of target firms to participate in issue networks are explored. It seems that, here, individual and organisational values and also relationships play important roles. Furthermore, network benefits such as potential new business opportunities and partners are good motivators (Ritvala and Salmi, 2011).

Another example of environmental issue networks is presented in Andersson and Sweet's (2002) paper in which the role of a mobiliser in the development process of a recycling system was studied in a food retail chain in Sweden. They highlight the mobiliser's role as a bridging point between different actors. Furthermore, there are several relationship changes between participating organisations during the development process, which lead to changes in organisational structures, exchanges of information and knowledge, and administrative routines. Thus, due to the activity of a dominant change agent, recycling ideas spread further into the food retail system and to other business networks (Andersson and Sweet, 2002).

Veal and Mouzas (2010) examine environmental issue networks on a global scale, focusing on the global network that addresses climate change. This network comprises various actors including governments, private sector businesses, research institutions, NGOs, international governance bodies and business associations. They found that environmental issue networks can be hindered by various cognitive biases that act as barriers to collaboration. Three processes were identified through which collaboration between actors develops: 1) the development of cognitive frames, 2) negotiation with each other and 3) attempting wise trades that lead to joint gains among the actors. The barriers to each of these processes need to be overcome for successful collaboration.

4.4. Environmental solution networks

The fourth identified network form was an *environmental solution network*, which refers to a collaborative approach that involves combining knowledge, technologies and other resources across organisational boundaries to create an eco-efficient solution. These

Table 2
Comparison of the operational logic and network architecture of eco-industrial network forms.

	Industrial symbiosis networks	Sustainable supply networks	Environmental issue networks	Environmental solution networks
Operational logic				
Focus of environmental action	Improving eco- efficiency of production through by-product and waste reuse, utility and service sharing, information exchanges.	Decreasing environmental footprints of products through life-cycle thinking.	Pollution control/prevention measures and increased awareness on environmental challenges through collaborative projects.	Developing eco-innovative solutions that integrate the resources and capabilities of multiple network actors.
Drivers	Economic and environmental benefits; legislation; personal values.	Consumer demands; stakeholder pressures; legislation; personal values.	Existing environmental challenges; personal and organisational values; network benefits.	Acquisition of knowledge on new environmental solutions (i.e. technologies and/or services); personal values.
Network architecture				
Actors	Complementary industrial firms from various industries; authorities; NGOs.	Industrial firms, typically from the same supply chain; vertical connections.	Industrial firms; municipalities; authorities; NGOs; research organisations.	Horizontally and vertically connected actors with complementary resources, mostly industrial firms, their customers, and research institutes.
Commons	Shared knowledge, and tangible resources and/or energy.	Shared GSCM information and product life-cycle knowledge.	Shared knowledge and potential other intangible assets (e.g. legitimacy and brand).	Shared knowledge; potentially shared intellectual property rights and technology.
Protocols, processes, infrastructures	Formal exchange of resources, shared norms, social embeddedness.	Formal mechanisms for flows of information and materials; standard operating practices; cooperative green actions.	Mobilisation of actors; negotiations; formal agreements.	Mobilisation of network resources; co-development; technology adaptation.
Stratification of decision making	Ranges from hierarchical (i.e. planned) to heterarchical (i.e. self-organising)	Mostly hierarchical with formal supply chain relations.	Typically heterarchical, but can include hierarchical aspects.	Typically, hierarchical management by hub firms.
Permeability of boundaries	Regionally constrained.	Supply chain constrained.	Geographical constraint depending on scale of the issue (i.e. local or global); temporal limitations.	Constrained by core technology/ solution.

solutions often require a combination of products and services from several suppliers that are combined, usually through a central actor which acts an integrator, to create a new marketable solution. The benefits of technological innovation and integration can lead to an offering that has lower environmental impacts in comparison to its alternatives (Baraldi et al., 2011).

Baraldi et al. (2011) examined the Leaf House project and its accompanying network, which is an example of a technological network that promotes eco-sustainability. The Leaf House project focused on developing the first zero-emission house in Italy, which was a large step forward in terms of energy efficiency relative to existing alternatives. The project was coordinated by the Loccioni group, which acted as the technological integrator. The project comprised 80 involved partners, ranging from suppliers of standardised products to full subsystem suppliers. Some of the involved partners were Whirlpool (i.e. energy efficient appliances), IKEA (i.e. sustainably produced furniture) and Cisco Systems (i.e. ICT systems for smart energy usage) (Baraldi et al., 2011).

The project, while serving the main function of an integrated solution that provided revenue for the involved network actors, also served other purposes. Several of the more prominent network members could utilise the Leaf House in its development phase as a testing facility for new environmentally friendly technologies. In addition, many of the network members utilised the Leaf House project as a PR tool to boost their corporate sustainability image. The study also highlighted the concept of embedding technology for the successful operation of the network. To successfully develop an integrated solution, the involved network needed to evolve, through actions such as co-development and mutual technology adaptation, to diffuse the new technology (Baraldi et al., 2011).

5. Comparison of network forms

In this section, we compare the four identified forms of eco-industrial networks to identify their differences and similarities. A detailed comparison is shown in Table 2. Based on the analysed literature, we found key differences and similarities in the operational logic and also in the architecture of the network forms. The proposed categorisation shows the perspective, (and the potential bias), of the extant literature regarding the forms of eco-industrial networks. As it is based on an emerging field of research, the categorisation is suggestive rather than exhaustive. The typology should be perceived as an initial step towards shedding light on the mechanisms through which industrial networking can advance sustainability. It makes salient the potential mechanisms that have been addressed in the extant literature and establishes a basis for further empirical work.

The identified network forms are empirically overlapping although analytically distinct as they differ fundamentally in terms of the primary logic through which they seek to advance environmental sustainability. While the network forms might facilitate advancement of similar *outcomes*, each form advances environmental objectives through primarily different *operational logic*, or the mechanisms through which it pursues environmental benefits. For example, all four network forms have the potential to facilitate waste reduction. In industrial symbiosis networks, this objective is achieved primarily by turning waste and by-products into material inputs. In sustainable supply networks, the same objective can be achieved by implementing waste minimisation standards across the supply chain. In environmental issue networks, the object can be addressed by creating awareness on waste management and, in environmental solution networks, by facilitating the co-development of new technologies and solutions for waste reduction. A combination of operational logics can also be present in some networks. For example, recent work on industrial symbiosis networks suggests that simultaneous issue networks can form as the network evolves and industrial symbiosis becomes a collective network-level goal. However, as suggested by the identified articles on issue networks, these networks can take various forms that are not always focused on resource exchanges and, thus, we classify them as a separate network form.

The architecture of the network forms are compared through the three dimensions that comprise an actor-oriented architecture: actors, commons and also protocols, processes and infrastructures (Fjeldstad et al., 2012). *Actors* are the members of the network who have the capabilities and values to self-organise. Actors can be organisations such as private firms or key individuals. *Commons* are the tangible or intangible resources that are collectively owned and available to the actors. One example of a common resource is an information system that facilitates network activities. Intangible common resources can include standards for network activities or a brand associated with the network. Lastly, a network requires *protocols*, *processes* and *infrastructures* that enable collaboration. Protocols are the codes of conduct employed by the actors in their collaborative activities, while infrastructures are the systems that connect actors. In addition, various network-level processes can be utilised to coordinate the network's activities (Fjeldstad et al., 2012). In addition to these three dimensions, two additional ones are employed to describe network architecture: the permeability of boundaries and decision-making stratification (Gulati et al., 2012). The extent to which a network's *boundaries* are open or closed can vary greatly in collaborative arrangements. A network can be open to all relevant actors or membership can be restricted by some criteria. A collaborative supply network is an example of a restricted network in which membership is typically limited to industrial firms involved in the network's economic activities. Open network models include, for example, open-source software projects such as Wikipedia or business ecosystems formed around mobile operating systems such as Android or iOS. Lastly, the internal *stratification of decision-making* affects a network's design. Many networks have some structural hierarchy. This is typical, for example, of networks in which an integrator is in charge of aggregating the innovative efforts of multiple members. Stratification helps reduce the complexity of coordination by dividing the collective into smaller subgroups that can specialise in specific activities. Conversely, heterarchical networks with low decision-making stratification give all members similar or overlapping rights or responsibilities, resulting in a "community of equals". This can increase members' sense of ownership and commitment to network activities, but can also discourage task specialisation and make coordination of the network more difficult (Gulati et al., 2012). In the following, we compare the operational logic and architecture of the four network forms in detail.

5.1. Operational logic

The analysed forms of eco-industrial networks have primarily different operational logics. These range from material reuse and reduction of environmental footprints through life-cycle thinking to taking collective action that addresses problems and generates eco-innovations.

Industrial symbiosis (IS) networks concentrate mainly on the exchange of material resources, although participating companies can also share utilities and services (Ashton, 2008), and also information (Chertow, 2007; Chertow and Ehrenfeld, 2012; von Malmborg, 2004; Van Ha et al., 2009). Collaboration in symbiosis networks can yield financial and environmental benefits (e.g. Behera et al., 2012; Dimitrova et al., 2007; Tudor et al., 2007). In fact, economic advantages are essential for IS as, without them, companies are not motivated to participate and develop symbiotic relationships. Opportunities to improve competitiveness by means of IS networks include the reduction of operating costs and/or increasing revenues through more efficient use of materials and energy (e.g. by-product sale; waste minimisation), and innovative product and process changes (Dimitrova et al., 2007; Lombardi and Laybourn, 2012; Taddeo et al., 2012; Tudor et al., 2007). Environmental benefits such as increasing efficiency of resource use, reducing emissions and eliminating waste are also important drivers of IS (Ashton and Bain, 2012; Chertow, 2007). This helps participating firms to gain legitimacy and comply with environmental legislation (Ashton, 2011; Dimitrova et al., 2007). Governmental policy that supports and enables waste exchange is important for the development of IS networks (Chertow, 2007; Doménech and Davies, 2011; Gibbs and Deutz, 2007).

Sustainable supply networks are mainly driven by stakeholder pressures and regulations for manufacturers to improve the eco-efficiency of their operations and develop reverse supply chains to manage used products (Bansal and McKnight, 2009). Stakeholder demands from governmental agencies, NGOs, employees and environmentally conscious customer segments bring pressure to bear on companies to introduce measures aimed at reducing environmental impacts across the supply chain (Vachon and Klassen, 2007). The main focus of sustainable supply networks is to decrease the environmental footprints of products through life-cycle thinking. While symbiosis networks focus on waste reduction across entire systems of firms, the focus in sustainable supply networks is usually on firms' waste reduction through product and process innovations. Thus, activities of sustainable supply networks, such as pollution prevention within a single firm, can be counter-productive for IS activities as a potentially valuable resource can be reduced beyond reusable levels (Bansal and McKnight, 2009). Similarly, governmental regulation mechanisms designed from a sustainable supply networks' perspective, such as restrictions for the handling and transportation of waste, can be a hindrance to IS activities (Bansal and McKnight, 2009).

In the analysed literature, it is possible to find two distinct operational logics of *environmental issue networks*. The Baltic Sea initiatives described by Ritvala and Salmi (2010, 2011) were mostly formed through the mobilisation of actors which chose to voluntarily participate in the projects, driven by existing environmental challenges and also personal and organisational values. In contrast, the global climate change network (Veal and Mouzas, 2010) comprises actors which are not necessarily involved to promote collective environmentally sustainable action but rather to promote their self-interests, such as keeping the restriction of CO_2 emissions as small as possible to minimise short term costs in respect of pollution prevention. Common to both of these network examples is their focus on pollution prevention and control measures concerning a specific environmental issue. Furthermore, collaboration with a diverse set of actors can also result in business benefits, such as new business opportunities, to participating firms (Ritvala and Salmi, 2011). It also facilitates the alteration of actors' mindsets (Andersson and Sweet, 2002).

The focus of *environmental solution networks* is to develop integrated solutions that decrease environmental impacts in comparison to existing alternatives. The activities in the network include co-development, knowledge sharing, joint adaptation and also standard market transactions to achieve technology embedding and integration. Integration can increase environmental sustainability due to a higher focus on the service element instead of physical goods, as highlighted by the literature on product-service systems (e.g. Morelli, 2006). Collective creation of product, process or service innovations is the primary operational logic of environmental solution networks, in which involved actors can benefit from the combination of complementary firms' resources, improved fit of solutions and customer preferences, and enhanced user adoption and public image (Baraldi et al., 2011; Chesbrough, 2003).

5.2. Network architecture

5.2.1. Actors

The key actors in *IS networks* are participating industrial firms, often from different industries. Heterogeneity between participating

companies facilitates the development of IS by creating more opportunities to find suitable partners (Dimitrova et al., 2007; Taddeo et al., 2012). Furthermore, a dense web of relationships is typical of IS (Bansal and McKnight, 2009). In addition, governmental organisations and NGOs might be involved as knowledge providers or coordinators.

Two key factors differentiate the types of actor involved in *sustainable supply networks* and IS. Supply networks are usually regarded with a vertical orientation of the flows of physical goods downstream in the chain, and used products and components upstream in reverse logistics, funds upstream and information throughout the chain (Bansal and McKnight, 2009). Although supply chains involve multiple customers and suppliers in a larger supply network, industrial firms generally have a smaller subset of strategically important suppliers and customers and, thus, supply networks are usually conceptualised in a linear manner (Bansal and McKnight, 2009).

Environmental issue networks differ from the other identified network types by encompassing a broader variety of involved actors. In addition to private firms from different sectors, environmental issue networks typically comprise public authorities, NGOs, interest associations and research organisations (Veal and Mouzas, 2010). This results in a complex network structure with potentially conflicting interests (Veal and Mouzas, 2010).

Environmental solution networks are often headed by a hub firm which acts as an integrator for the technological solution and brings together the products, services and subsystems provided by various suppliers and partners (Baraldi et al., 2011). The hub firm can integrate actors vertically across the supply chain and also horizontally to obtain complementary products and services for the integrated offering. In addition to industrial firms, other actors such as research organisations and customers might be involved in technological development.

5.2.2. Commons

Typically, *IS networks* have shared knowledge bases that enable actors to find new opportunities and potential new partners for exchange (Chertow and Ehrenfeld, 2012). Commons can also include tangible resources through the pooled use and management of shared resources such as energy and water (Chertow, 2007).

Sustainable supply networks include the sharing of information that relates to supply chain management activities and also deeper product life-cycle knowledge to find opportunities for pollution control and prevention in manufacturing processes (Seuring, 2004).

Environmental issue networks aim to diffuse knowledge on the state of specific environmental issues and also to related possible pollution prevention and control (Ritvala and Salmi, 2010). This creates a shared situational awareness on challenges and opportunities in the environment and available resources with which they might be addressed (Fjeldstad et al., 2012). Issue networks can also provide other intangible assets to the network members such as shared legitimacy that facilitates further opportunities for resource mobilisation by, for example, access to political actors (Ritvala and Salmi, 2010).

Environmental solution networks are also characterised by knowledge sharing as a common resource to achieve integrated solutions. Existing research on innovation networks suggests that they can potentially include further commons such as shared intellectual property rights and technologies to strengthen relationships between network actors (Baraldi et al., 2011).

5.2.3. Protocols, processes and infrastructures

There are three different methods by which an *IS network* evolves: 1) self-organising, 2) facilitation by organisations or individuals and 3) planning (see e.g. Chertow and Ehrenfeld, 2012; Paquin and Howard-Grenville, 2012). Self-organised networks develop by themselves without a coordinator, whereas an executive coordinator develops planned networks. Thus, in planned networks a coordinator (e.g. a governmental organisation) influences a network's structure and norms. Between self-organised and planned networks lie facilitated networks, in which a coordinator's main task is to find potential partners among participating companies (Paquin and Howard-Grenville, 2012). For example, the National Industrial Symbiosis Program (NISP) in the UK facilitates the formation of IS relationships by sharing information and analysing potential exchanges between participating companies (Doménech and Davies, 2011). To operate, regardless of how a network has evolved, an IS network requires partnerships based on trust, shared norms, long mutual dependence and personal relationships for knowledge transfer (Baas, 2011). Tangible resource exchanges between actors are usually governed by formal market mechanisms.

Coordination in a *sustainable supply network* is usually accomplished through formal information exchanges, such as orders, forecasts and inventory information and also market-based transactions for the flow of goods between actors (Bansal and McKnight, 2009). Supply networks are also characterised by highly standardised operating practices between actors to achieve efficiency (Bansal and McKnight, 2009). Standards can also be employed to coordinate green actions; for example, by imposing environmental criteria on suppliers (Seuring, 2004). However, studies have shown that "greening" actions aimed at decreasing environmental impacts within the supply network also require cooperation and integration among actors in the network (Seuring, 2004).

An *Environmental issue network* can display considerable variance in protocols, processes and infrastructure to achieve collaboration. Collaborative action in voluntary issue networks can be achieved through processes such as network mobilisation and framing and communication of environmental challenges (Ritvala and Salmi, 2010), whereas more coercive forms of issue network require negotiations and wise trades to achieve consensus, which can be formalised through binding agreements such as, in the case of climate change, the Kyoto protocol (Veal and Mouzas, 2010).

An *environmental solution network* requires coordination processes by hub firms to mobilise the required network resources for the development of a solution and also to manage the network's evolution. Coordination processes in the network also include co-development, knowledge sharing and joint action to achieve the embedding and integration of technology (Baraldi et al., 2011).

5.2.4. Hierarchy of decision making

As previously noted, *IS networks* evolve in different ways and these evolutionary paths differ in the extent of decision-making stratification within a network. Planned IS networks are the most hierarchical form; network coordinators can even design the network by top-down planning and recruiting suitable companies to join the network (Gibbs and Deutz, 2005). This is especially typical in eco-industrial parks. Facilitated networks have some formal coordination mechanisms for managing the network's evolution, diffusing knowledge and finding new exchange opportunities; however, they are also partly driven by serendipitous relations that arise between network actors. Self-organised IS networks have the most heterarchical decision-making processes that emphasise community, shared values and embedded relations between actors, which enables the actors to find exchange opportunities (Chertow and Ehrenfeld, 2012).

Sustainable supply networks are often dominated by large and powerful global firms, leading to more hierarchical control and coordination mechanisms (Fjeldstad et al., 2012; Gulati et al., 2012).

Relationships between actors are often formal in nature and actors might employ competitive tactics to achieve more power in the network. They often lack the informality of social relations that have been found to be important for the identification of new exchange opportunities in self-organising IS networks (Bansal and McKnight, 2009).

Environmental issue networks also have varied forms of decision-making, depending on the scale and importance of the issue. At one end of the scale, they can be characterised by heterarchical self-organisation and voluntary cooperation among actors with shared values (Ritvala and Salmi, 2010), while, at the other end, highly important global issues such as climate change also require hierarchical decision-making, such as enforced restrictions on CO_2 emission limits (Veal and Mouzas, 2010).

Environmental solution networks are characterised by hub firms which act as integrators for the network. While network members are autonomous actors, hub firms have a largely hierarchical role in managing the integration. Hub firms need to coordinate various involved partners and suppliers to manage possible conflicts of interest, controlled expansion of the network and various contexts of embedding technology: development activities such as R&D, production operations and usage activities on the customer's side (Baraldi et al., 2011). However, some innovation networks, such as open source communities in the IT sector, can also be highly heterarchical in nature (Gulati et al., 2012). This suggests that, depending on the extent of control exercised by hub firms, environmental solution networks can also be heterarchically formed.

5.2.5. Permeability of boundaries

The degree of openness in a network was the final examined dimension of the identified eco-industrial network forms' architecture. It is difficult to classify them as distinctly open networks (e.g. open source communities) or those that are closed (e.g. strategic alliances). However, all network forms have some constraining factor that limits expansion. *IS networks* are distinguished by a regional focus, as best demonstrated by eco-industrial parks. Long transportation distances for waste and by-products are not desirable due to added transportation costs and environmental impacts. The proximity of involved actors also plays a major role in enabling the development of embedded relations that foster a network's development. Conversely, *sustainable supply networks* are rarely confined by geography; rather, global relationships between suppliers and customers are common and driven by cost concerns (Bansal and McKnight, 2009). Thus, geographic proximity between actors plays a smaller role than in IS networks. However, unlike IS networks in which cross-industry relationships are more common, supply networks are commonly constrained to actors along a single supply chain (Liu et al., 2012).

Environmental issue networks are the most open form of the identified networks, especially in the case of voluntary participation. However, depending on the scale of the environmental issue, they can still be limited by geography. Regionally limited issues typically mobilise actors which are closely affected by that particular issue (e.g. contamination of a ground or water area), while global challenges call for global cooperation. It is also noteworthy that some environmental issue networks are temporary and might disband as the issue loses significance. However, many environmental issues are difficult to solve and, thus, require long-term collaboration (Ritvala and Salmi, 2010). The global climate change network is a good example of one that is very likely to have a long lifespan (Veal and Mouzas, 2010).

Environmental solution networks are typically constrained by the same membership criteria as many innovation networks (Gulati et al., 2012). Members are chosen depending on the technology, resources and capabilities that they possess, so that they complement the central technological solution (Baraldi et al., 2011). Some degree of redundancy in network resources might be desirable to provide flexibility in a changing environment, but it might also restrict cooperation by creating a competitive situation between actors (Gulati et al., 2012). Technological fit is ultimately the most important membership criteria in solution networks (Baraldi et al., 2011).

6. Discussion

According to our findings, we believe that this study advances the interaction of industrial symbiosis (IS), sustainable supply, environmental issue and solution networks and also the identification and analysis of alternative forms of eco-industrial networks. In addition, our results contribute to calls for shifting the focus of sustainability research from individual actors to a more systemic and network-based perspective (Manring, 2007; Wittneben et al., 2012). The study's findings yield the following implications for practice, policymakers and future research on networks and sustainability.

6.1. Implications for policy-making and practice

Our analysis of the operational logics of eco-industrial networks offers three key implications for policy-making and practice. *First*, policymakers and practitioners need to become aware of the different mechanisms through which industrial networking can reduce environmental load. By acknowledging the variety of different operational logics and mechanisms, policymakers can form a wider portfolio of platforms that serve the alternative networking forms and enable firms to identify potential collaborators. To facilitate the development of various types of eco-industrial network, policymakers need to build systems that take into account the differences and similarities in alternative network forms that enable actors to connect with each other and access relevant information in a meaningful and purposeful manner. For example, the advancement of symbiosis networks requires comprehensive regional databases on the inputs and outputs of production plants, whereas the advancement of environmental solution networks requires information on ongoing and planned technology development projects and platforms to pair firms with synergistic R&D opportunities. While sustainable supply networks can be promoted by raising consumer awareness, the emergence of issue networks can be facilitated by arranging networking events and opportunities for firms that share an environmental concern to take collective action.

To date, legislation is often a trigger for eco-industrial networking. Good examples of this are Kalundborg in Denmark, the National Industrial Symbiosis Program (NISP) in the UK and the municipality of Chamusca in Portugal (Costa and Ferrao, 2010; Doménech and Davies, 2011), which were all encouraged to form IS networks by regional regulations. Furthermore, government support and incentives are essential for advancing environmental sustainability, as was the case with, for example, the Ulsan eco-industrial park in South Korea and the NISP in the UK (Behera et al., 2012; Doménech and Davies, 2011). However, regulation can be an obstacle to turning waste into raw materials, as with the IS case in the Gulf of Bothnia in Finland and Sweden (Salmi et al., 2011) and in Sarnia in Canada (Sakr et al., 2011). Although these are examples of IS, similar situations concern, at least, sustainable supply chains and environmental solution networks. Similarly, policies promoting transparency in the use of resources by industrial firms can facilitate especially sustainable supply networks, but can also promote other eco-industrial network forms. However, there is a need for all mentioned forms of governmental support because significant opportunities for reducing environmental load

might be missed by designing programs that facilitate only one particular form of eco-industrial networking.

Second, environmental issue networks highlight the role of issue-based mobilisation of actors for solving environmental problems. While these networks do not always have a concrete agenda for providing business benefits to participants, this form of organising can be utilised for the formation of other types of eco-industrial networks. For example, recent research on IS has highlighted the role of social embeddedness for the diffusion of environmental knowledge and values among actors (Ashton and Bain, 2012; Chertow and Ehrenfeld, 2012). We suggest that issue-based mobilisation can be a key activity in promoting social relations and initiating collaboration between actors that can eventually lead to eco-industrial networks. The extant literature on the concept of imprinting in organisational research has shown that organisations adopt elements of their founding environment that can persist well beyond the founding stage (Marquis and Tilcsik, 2013). Networks that emerge through issue-based mobilisation can thus be imprinted with the environmental values that served as the catalyst for their foundation (Ritvala and Salmi, 2010).

Third, industrial firms should consider a broader variety of exchange options available for decreasing environmental impacts through inter-firm relations. One example of this is the option between GSCM and IS; decreasing the output of waste or by-product through GSCM activities beyond a particular limit might prevent it from being re-utilised in IS. As such, the supply chain's limited perspective can be a hindrance. Environmental solution networks provide another set of options for collaboration: those focused on horizontal relations between actors. New technological solutions generated by horizontal collaboration can enable the development of other eco-industrial networks; for example, by generating novel technologies to reprocess by-products in IS networks or pollution prevention solutions for GSCM activities. For example, IS might be a feasible solution for an industrial firm only after it acquires sufficient technological resources for reprocessing waste.

The analysis of the identified eco-industrial network forms' architectures can also offer some interesting insights for policy-making and practice. First, collaboration among a wide variety of organisations is needed for eco-industrial networks. Collaboration can span vertical relations in supply chains and also horizontal collaboration with competitors or actors possessing complementary offerings. IS typically requires cross-industrial relations to find novel usages for waste and by-products. In addition, eco-industrial networks should also span different sectors, bringing together private sector firms with governmental organisations and NGOs, which can bring new knowledge on opportunities for environmental protection. We suggest that strategic coalitions should be formed around key environmental issues, which maximise knowledge on opportunities by bringing together a wide variety of organisations from different sectors that are stakeholders in the issue. A polycentric governance approach for environmental issues suggested by Ostrom (2009), which maximises local-scale opportunities and incentives for cooperation, could facilitate these types of coalition.

The dilemma between central coordination and self-organisation is another key issue that has received much attention, especially with regard to IS. Much of the literature makes a sharp distinction between these two evolutionary forms of IS (e.g. Baas, 2011). Our review suggests that this issue is more complex. The facilitated model of IS in the UK has proved to be highly successful for developing relations. Green supply networks and environmental solution networks also favour some degree of hierarchy in the coordination of the networks' activities. Often, this might be because smaller firms in the networks lack the resources or knowledge to be able to undertake purposeful initiatives for developing environmental activities. This suggests that an eco-industrial network needs one or several key organisations actively furthering the collective goal of the network. Simultaneously, the network architecture should also facilitate opportunities for serendipitous relations, as an overly hierarchical network can also hinder progress (Paquin and Howard-Grenville, 2012).

With this in mind, we suggest that a modified form of the actor-oriented network architecture, which has proven successful in areas such as innovation, would be highly suitable for the development of eco-industrial networks. The key elements of this architecture, common norms and protocols for network activities and also common resources and infrastructure that enable members to serendipitously self-organise, are well suited for promoting environmental awareness in industrial firms and facilitating the flexible formation of environmentally friendly business relations. However, a coordinating organisation can provide a tremendous boost to a network's activities. It can take a broader perspective on developing elements of the network's architecture and also gain new resources for the network through issue-based mobilisation. For example, a coordinating organisation for IS can communicate the network's activities to the wider society, actively facilitate the formation of new network relations and also influence political decision-making to develop a legal environment that supports IS. However, as our review suggests, eco-industrial networks can take different forms through the operational logic by which they aim to provide environmental benefits and, thus, the most suitable form of network architecture is likely to be context dependent.

6.2. Implications for further research

Our research uncovered several fruitful avenues for academic research. *First*, given the potential transformative power of networks in advancing environmental sustainability, it is surprising that studies on networks and sustainability are relatively scarce and dispersed into separate streams of the literature. For example, IS has had only a little influence in the supply chain literature; however, there is a considerable opportunity to combine these perspectives (Bansal and McKnight, 2009). Moreover, insights from the extensive research on alliances, networks and inter-organisational collaboration (Ahuja et al., 2012; Brass et al., 2004; Fjeldstad et al., 2012; Gulati et al., 2000) are not integrated with studies on eco-industrial networks. Based on our findings, we propose that researchers need to acknowledge the multifaceted potential of industrial networks in advancing environmental sustainability and focus their attention on the design, functioning and processes of multi-actor collaborative networks. One way to accomplish this might be to explore *hybrid eco-industrial networks* that simultaneously enact multiple logics to reduce the environmental load. Concurrent materials reuse, collective action, value-chain optimisation and co-innovation among network partners might result in highly influential networks that play a substantial role in advancing environmental sustainability. Research methodologies from network research could offer new insights for the study of eco-industrial networks. Social network analysis can uncover the underlying structural elements and dynamics of business networks (Ahuja et al., 2012) and is already gaining interest among eco-industrial networks, especially with regard to IS research (Ashton, 2008). Qualitative methodologies focusing on network processes and focal events can also help to gain a rich understanding on the dynamics of eco-industrial networks (Halinen et al., 2013).

Second, further research on the role of specific network forms in addressing particular environmental issues is also needed. For example, IS networks and environmental solution networks are

critical for the development of renewable energy systems, an important area for further research on eco-industrial networks.

Third, more research is needed on the interplay between heterarchical processes of self-organisation and the more hierarchical processes of central coordination in the development of eco-industrial networks. For example, decision-making in IS networks is described as inherently mostly heterarchical, with self-organisation among actors. However, some examples (Paquin and Howard-Grenville, 2012, 2013) suggest that coordination of an IS network can be very effective when orchestrated by a third party organisation. As mentioned in the previous section, our research found a variety of network architectures that can support the development of eco-industrial networks. Future research could study how contextual factors, such as the operational logic of the network or the institutional environment in which the network operates, affect the success of different architectural arrangements.

Finally, our research focused on inter-organisational networks aiming at beneficial environmental action and not on the potential negative consequences that networking can have in this context. For example, networks can also facilitate the diffusion of environmentally hazardous practices among industrial firms. Industry associations also commonly attempt to influence political decision-making to create a more favourable operating environment for firms in their sector, which can include lobbying against tighter environmental laws. Further research is needed to determine how these potential negative network effects impact eco-industrial networks.

7. Conclusions

Network-based collaboration is critical to the solution of complex problems such as the environmental load of production and consumption. A substantial body of the literature documents how collaborative networks operate and yield several benefits for involved actors. However, research on networks and sustainability is at a relatively early stage and dispersed among different streams of the literature. By analysing various forms of eco-industrial networks, their operational logics and architecture, this study's objective is to broaden the relatively limited understanding on ways by which networks can advance environmental sustainability.

Prior research perceives the potential of eco-industrial networks primarily from the perspective of industrial symbiosis. However, a multidisciplinary literature review suggests that the potential role of networks in advancing environmental sustainability is much broader. Based on a systematic literature review, we identified four forms of eco-industrial networks: 1) symbiosis networks, 2) sustainable supply networks, 3) environmental issue networks and 4) environmental solution networks. There are major differences in the logics through which these network forms advance environmental sustainability. Analysis of these network forms suggests that collaborative eco-industrial networks have the ability to rationalise and improve resource utilisation through industrial symbiosis and sustainable supply networks, accelerate the diffusion of more sustainable practices and foster environmental awareness and collective action through environmental issue networks, and also generate novel technologies and solutions for reducing environmental impacts through environmental solution networks. Firms can achieve cost reductions resulting from improved resource efficiency and increased revenues through selling reusable waste and by-products, and also through eco-innovative solutions. In addition, all identified network forms have the potential to improve participating firms' corporate images, which is important for the management of key stakeholders' expectations and to achieve legitimacy. However, orchestrating the rather complex network architecture and the potential conflicts of interests and goals between network participants appears to be a key challenge for all forms of eco-industrial networks.

It seems that there is a need to build broad coalitions of organisations that are mobilised to address environmental issues. Thus, network architecture that maximises the members' capability to self-organise while also including a coordinating organisation can be highly suitable for eco-industrial networks. By providing some fruitful avenues for future research on eco-industrial networks, we hope that this study advances the integration of IS, sustainable supply, environmental issues and solution networks, and also the identification and analysis of alternative forms of eco-industrial network. We suggest that this broader perspective will benefit future research by providing more understanding on the multifaceted role of eco-industrial networks in advancing sustainability.

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Appendix

Author	Year	Name	Journal	Major concepts
Andersson and Sweet	2002	Towards a framework for ecological strategic change in business networks.	Journal of Cleaner Production	Network, strategic change.
Ashton	2008	Understanding the organization of industrial ecosystems. A social network approach.	Journal of Industrial Ecology	Industrial symbiosis, social network theory/analysis, industrial ecosystem.
Ashton	2009	The Structure, Function, and Evolution of a Regional Industrial Ecosystem.	Journal of Industrial Ecology	Industrial ecosystem.
Ashton	2011	Managing performance expectations of industrial symbiosis.	Business Strategy and the Environment	Industrial symbiosis.
Ashton and Bain	2012	Assessing the "Short Mental Distance" in eco-industrial networks.	Journal of Industrial Ecology	Social embeddedness, social capital, industrial symbiosis.
Baas	2011	Planning and uncovering industrial symbiosis: comparing the Rotterdam and Östergötland regions.	Business Strategy and the Environment	Industrial symbiosis, social embeddedness.
Bansal and McKnight	2009	Looking forward, pushing back and peering sideways: analysis the sustainability of industrial symbiosis.	Journal of Supply Chain Management	Industrial symbiosis, supply chains, sustainability.

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Author	Year	Name	Journal	Major concepts
Baraldi et al.	2011	Network evolution and the embedding of complex technical solutions: The case of the Leaf House network.	Industrial Marketing Management	Industrial networks, technology embedding, sustainability.
Behera et al.	2012	Evolution of "designed" industrial symbiosis networks in the Ulsan eco-industrial park: "research and development into business" as the enabling framework.	Journal of Cleaner Production	Industrial symbiosis, eco-industrial park.
Boons and Spekkink	2012	Levels of institutional capacity and actor expectations about industrial symbiosis. Evidence from the Dutch stimulation program 1999–2004.	Journal of Industrial Ecology	Industrial symbiosis, institutional capacity.
Boons et al.	2011	The dynamics of industrial symbiosis: a proposal for a conceptual framework based upon a comprehensive literature review.	Journal of Cleaner Production	Industrial symbiosis, institutional capacity, institutional theory.
Chertow	2000	Industrial symbiosis: Literature and Taxonomy.	Annual Review of Energy and the Environment	Industrial symbiosis, eco-industrial park.
Chertow	2007	"Uncovering" industrial symbiosis.	Journal of Industrial Ecology	Industrial symbiosis, eco-industrial park.
Chertow and Ehrenfeld	2012	Organizing self-organizing systems: towards a theory of industrial symbiosis.	Journal of Industrial Ecology	Industrial symbiosis, self-organising systems, complexity.
Chertow and Miyata	2011	Assessing collective firm behavior: comparing industrial symbiosis with possible alternatives for individual companies in Oahu, HI.	Business Strategy and the Environment	Industrial symbiosis.
Costa and Ferrão	2010	A case study of industrial symbiosis development using a middle-out approach.	Journal of Cleaner Production	Industrial symbiosis.
Côté and Cohen-Rosenthal	1998	Designing eco-industrial parks: A synthesis of some experiences.	Journal of Cleaner Production	Eco-industrial park.
Desrochers	2004	Industrial symbiosis: the case for market coordination.	Journal of Cleaner Production	Industrial symbiosis, Austrian economics, central planning.
Dimitrova et al.	2007	Managerial factors for evaluating eco-clustering approach.	Industrial Management and Data Systems	Eco-clustering.
Doménech and Davies	2011	The role of embeddedness in industrial symbiosis networks: phases in the evolution of industrial symbiosis networks.	Business Strategy and the Environment	Industrial symbiosis, social embeddedness.
Gibbs	2003	Trust and networking in inter-firm relations: the case of eco-industrial development.	Local Economy	Eco-industrial park.
Gibbs and Deutz	2005	Implementing industrial ecology? Planning for eco-industrial parks in the USA.	Geoforum	Industrial ecology, eco-industrial parks.
Gibbs and Deutz	2007	Reflections on implementing industrial ecology through eco-industrial park development.	Journal of Cleaner Production	Industrial ecology, eco-industrial parks; economic development policy.
Kocabagsoglu et al.	2007	Linking forward and reverse supply chain investments-the role of business uncertainty.	Journal of Operations Management	Reverse supply chains.
Liu et al.	2012	Going beyond the sectoral boundary: a key stage in the development of a regional industrial ecosystem.	Journal of Cleaner Production	Industrial ecosystem.
Lombardi and Laybourn	2012	Redefining industrial symbiosis: crossing academic-practitioner boundaries.	Journal of Industrial Ecology	Industrial symbiosis.
Paquin and Howard-Grenville	2012	The evolution of facilitated industrial symbiosis.	Journal of Industrial Ecology	Industrial symbiosis, serendipitous and goal-directed processes.
Ritvala and Salmi	2010	Value-based network mobilization: A case study of modern environmental networkers.	Industrial Marketing Management	Value-based networks, mobilisation, common issues.
Ritvala and Salmi	2011	Network mobilizers and target firms: the case of saving the Baltic Sea.	Industrial Marketing Management	Mobilisation, issue networks.
Sakr et al.	2011	Critical success and limiting factors for eco-industrial parks: global trends and Egyptian context.	Journal of Cleaner Production	Industrial symbiosis, eco-industrial park.
Salmi and Toppinen	2007	Embedding science in politics – "Complex utilization" and industrial ecology as models of natural resource use.	Journal of Industrial Ecology	Industrial ecology, complex utilisation, political embeddedness.
Salmi et al.	2012	Governing the interplay between industrial ecosystems and environmental regulation: heavy industries in the Gulf of Bothnia in Finland and Sweden.	Journal of Industrial Ecology	Industrial symbiosis, environmental regulation, common pooled resources.
Seuring	2004	Integrated chain management and supply chain management-comparative analysis and illustrative cases.	Journal of Cleaner Production	Integrated supply chain management.
Sterr and Ott	2004	The industrial region as a promising unit for eco-industrial development – reflections, practical experience and establishment of innovative instruments to support industrial ecology.	Journal of Cleaner Production	Eco-industrial networks, regional industrial ecosystems, material flow management.

(*continued*)

Author	Year	Name	Journal	Major concepts
Taddeo et al.	2012	Implementing eco-industrial parks in existing clusters. Findings from a historical Italian chemical site.	Journal of Cleaner Production	Eco-industrial park.
Tudor et al.	2007	Drivers and limitations for the successful development and functioning of EIPs (eco-industrial parks): A literature review.	Ecological Economics	Eco-industrial park.
Vachon and Klasssen	2007	Supply chain management and environmental technologies: the role of integration.	International Journal of Production Research	Integrated supply chain management.
Van Ha et al.	2009	Techno policy aspects and socio-economic impacts of eco-industrial networking in the fishery sector: experiences from An Ging Province, Vietnam.	Journal of Cleaner Production	Eco-industrial network
Veal and Mouzas	2010	Learning to collaborate: a study of business networks.	Journal of Business & Industrial Marketing	Networks, collaboration.
Von Malmborg	2004	Networking for knowledge transfer: towards an understanding of local authority roles in regional industrial ecosystem management.	Business Strategy and the Environment	Industrial ecology, local authority, public-private partnerships, knowledge bank, knowledge broker.
Zhu and Cote	2004	Integrating green supply chain management into an embryonic eco-industrial development: a case study of the Guitang Group.	Journal of Cleaner Production	Integrated supply chain management, green supply chain management, eco-industrial network.

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Publication IV

Patala, S., Hämäläinen, S., Oinonen, M., Salmi, A.
Governance of cross-sectoral sustainability collaboration: a polycentric perspective

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The governance of collaborative approaches to sustainability: a polycentric perspective on eco-industrial networks

Abstract

Public and private sector actors often collaborate to manage the environmental impacts of industry, leading to the creation of eco-industrial networks. However, we know very little about how such collaborations are governed. Thus, we examine how polycentric governance models are formed in eco-industrial networks. Polycentric governance brings together multiple organisations on multiple levels to jointly affect collective benefits and costs. A literature review identifies polycentrism as arising through public-private sector collaboration, distributed power and the formalisation of a network's governance. An empirical case study of three nested eco-industrial networks, suggests three archetypes of polycentric governance: loosely-coupled coalitions, polycentric coordination and polycentric governance systems. Additionally, we identify four key characteristics of a network's goals and structure that affect the degree of polycentrism.

Keywords

Eco-industrial networks, network collaboration, polycentric governance, industrial symbiosis, green supply chains, sustainable R&D network

INTRODUCTION

Collaborative networks are increasingly common in the creation of sustainable value. One example of such networking is the emergence of eco-industrial networks, such as industrial symbiosis and green supply chains, which combine business and sustainability logics. Eco-industrial networks are "industrial networks that advance environmental sustainability through inter-organisational collaboration" (Patala et al., 2014, p. 2) and they often bring together very different types of organisations from different fields of society to address common environmental concerns.

Scholars are increasingly interested in the governance of eco-industrial networks, but most studies focus on only one level of analysis, addressing either local (Chertow & Ehrenfeld, 2012; Spekkink, 2015; Tachizawa & Wong, 2015) or national (Paquin & Howard-Grenville, 2012, 2013) networks. Consequently, an understanding of how these different levels of governance are integrated is under-researched. Recently, Elinor Ostrom (2014) has focused on polycentric governance models for combating climate change, which involves various actors working together on multiple levels to achieve collective goals. While climate change is perhaps the most salient context for polycentric governance, polycentric governance models may prove essential for understanding and advancing networking around other sustainability issues as well. Ostrom (2014) defines a polycentric governance system as existing when multiple public and private organisations merge on multiple scales (levels) to jointly affect collective benefits and costs. We follow her definition, and focus on *collaborative governance* between public and private sector organisations and also on *distributed power* across different network levels, e.g., local, national and global networks. Furthermore, *formalised* governance mechanisms are characteristic of polycentric networks (Galaz et al., 2012).

Eco-industrial network activities often occur locally or in specific industrial supply chains, but national governments also build networks that promote these activities. Consequently, a polycentric view of governance provides a relevant perspective on eco-industrial networks and their promotion. Ostrom (2014) believes a macro-level of governance is necessary for establishing the larger frameworks that guide a network's activities, thus preventing the sub-optimisation of sustainability targets. Simultaneously, building the trust and commitment necessary for collaborative innovation can be effectively accomplished within smaller-scale and micro-level governance units.

The analysis of polycentric systems has focused on issues that are primarily the responsibility of the public sector, like environmental protection and national energy policies (see e.g. Galaz et al., 2012; Ostrom, 2014; Sovacool, 2011). Hence, the governance of these polycentric systems is dominated by the public sector. Polycentrism in eco-industrial networks is more nuanced since the focal issues are intertwined with business interests and key actors include industrial firms. Network governance builds on the notion of the relevance and legitimacy of actions by both public and

private actors (Arellano-Gault, Demortain, Rouillard, & Thoenig, 2013), suggesting eco-industrial networks require joint governance from the public and private sectors. However, such hybrid governance has not been adequately addressed in the existing research.

Our aim is to empirically investigate how *polycentric governance manifests itself in eco-industrial networks* and forms *archetypes of different polycentric governance models.* This conceptualisation will provide better understanding of network governance regarding different forms of environmental sustainability collaboration. We therefore conduct an in-depth qualitative study of three nested networks that focus on advancing industrial symbiosis, green supply chains and sustainable R&D collaboration among industrial firms. In addition to investigating features of polycentric governance, we aim to identify factors that influence polycentrism in eco-industrial networks. The analysis concerns eco-industrial networks in Finland, consequently the institutional context is always the same.

A better grasp of polycentric governance models is important for understanding how companies and other organisations can enhance collaborative actions for collective goals that support sustainable development despite having different backgrounds and individual, even paradoxical (Stadtler & Wassenhove, 2016), goal settings. This study's key contribution is to offer a fine-grained conceptualisation of polycentric governance and demonstrate the versatility of networking behaviour regarding environmental cooperation. Furthermore, we propose three different types of polycentric governance, which we term loosely coupled coalition, polycentric coordination, and polycentric governance systems, referring to low, medium and high polycentrism, respectively. They are based on our empirical material and the three dimensions of polycentrism we identified in the literature: the degree of public-private collaborative governance, the formalisation of governance and the distribution of power in the networks. Lastly, our findings elaborate on four factors that influence polycentrism and which result from the main aim of a network and the network's structure: the need for external resources, the alignment of actor goals, structural holes and local network centralisation. We propose that polycentric governance models are effective at addressing the tension between efficiency and resilience, recognised as one of the critical issues in sustainability management (Hahn, Pinkse, Preuss, & Figge, 2015).

Our paper is structured as follows. First, we review existing literature on polycentric governance and on governance in eco-industrial networks . We then discuss the methodology of our empirical case studies, and present the three eco-industrial network case studies. In the findings, we analyse and compare the cases, building a model containing three archetypes of polycentric governance, along with the network characteristics that influence polycentrism. A brief conclusion ends the paper.

Polycentrism in eco-industrial networks

Polycentric network governance

Based on Ostrom's (2014) definition of polycentric governance, *joint governance* between public and private sector organisations and *distributed power* across the different levels of the network are two vital characteristics of a polycentric system. Decision-making in a polycentric network is thus stratified but within different autonomous units of governance (Ostrom, 2014). The existing studies on polycentric governance systems have focused on various environmental issues, such as climate change (Ostrom, 2014), national electricity and ethanol programmes (Sovacool, 2011), global water governance (Gupta & Pahl-Wostl, 2013) and global water and marine life (Galaz, Crona, Österblom, Olsson, & Folke, 2012). These studies mainly focus on issues found in the public sector sphere, thus emphasising its role in governance. In this study we examine collaborative governance and cooperation across the public and private sectors, addressing recent calls for research into hybrid forms of governance (Denis, Ferlie, & Van Gestel, 2015; Mair, Mayer, & Lutz, 2015). Public sector actors can enter into *joint governance* arrangements with non-public actors to foster collective action for a common cause (Behera, Kim, Lee, Suh, & Park, 2012; Gibbs, 2003; Keith G. Provan & Lemaire, 2012; von Malmborg, 2004) and, indeed, they seem to play an essential role in networks that consist of multiple stakeholders, such as private organisations, research institutes and NGOs (Behera et al., 2012). Public-private collaboration has been studied in the context of public-private partnerships, which have become increasingly common in the governance and co-management of sustainability issues (Plummer, 2013; Selsky & Parker, 2005). The effectiveness of these partnerships often depends on how well the parties can integrate their interests and activities for the common cause (Ritvala, Salmi, & Andersson, 2014). Collaborative governance can be achieved through several key processes: open information

sharing, inclusive decision-making and the coordination of activities, capacity building and implementation, as well as by setting rules for accountability, value sharing and conflict management (Andonova, Betsill, & Bulkeley, 2009; Galaz et al., 2012; Sovacool, 2011).

Polycentric governance models have been suggested as a viable alternative for governing environmental issues (Meadowcroft, 2002; Ostrom, 2010, 2014). According to Newig and Fritsch (2009) polycentric governance 'yields higher environmental outputs than rather monocentric governance'. Polycentric models have the capability to promote resilience in a governance system (Olsson, Galaz, & Boonstra, 2014; Ostrom, 2014). For example, in industrial symbiosis networks a network administrative organisation (NAO) can facilitate the building of a more resilient network structure by ensuring that several firms or organisations are able to participate in industrial symbiosis network activities (Zhu and Ruth, 2014). Resilience refers to the capability of a system to withstand shocks and reorganise itself (Carpenter et al., 2012). It is often dependent on a diversity of methods and activities to ensure positive outcomes (Poocharoen & Sovacool, 2012). Resilience frequently works against efficiency, which is the key target of many management approaches in neo-classical economics (Hahn et al., 2015). Due to this, the relationship between efficiency and resilience has been recognised as one of the key tensions in sustainability management (Hahn et al., 2015). Polycentric models represent participatory forms of governance, which preserve alternate methods of action and thereby improve a system's resilience (Ferraro, Etzion, & Gehman, 2015).

Power distribution in a network refers to how power and decision-making rights are distributed among the different levels and organisations in a network. Literature has identified three generic types of governance models, which directly influence power distribution (K. G. Provan & Kenis, 2007). At one end, hub-organisation led networks have a focal organisation, which usually has the most power and the largest responsibility for coordinating a network, while also participating in it (K. G. Provan & Kenis, 2007). Hub firms have been found to have a particularly strong role in forming cross-level connections in multi-level networks (Gallemore, Di Gregorio, Moeliono, Brockhaus, & Prasti H., 2015). At the other extreme, networks with shared governance are self-organising and decision-making is distributed among network members (K. G. Provan & Kenis, 2007). The third form of governance falls between these two extremes; it generally includes a

network administrative organisation (NAO), which is in charge of coordinating the network and bridging organisations, but is not directly involved in the network's activities (Klerkx & Aarts, 2013; Kowalski & Jenkins, 2015; K. G. Provan & Kenis, 2007). NAOs are commonly public sector organisations (Klerkx & Leeuwis, 2009) but can also be NGOs (Milward, Provan, Fish, Isett, & Huang, 2010).

In practice, many collaborative networks often have some degree of polycentric governance (Galaz et al., 2012). Existing research has generally found that as network collaboration develops, governance mechanisms become gradually more institutionalised and formalised over time. Strong polycentric networks often contain a structure with *formalised governance mechanisms* across a tightly integrated core group of actors and more loosely connected peripheral actors (Galaz et al., 2012). However, depending on the degree of development, polycentric governance models can include both relational and hierarchical governance mechanisms (Giest & Howlett, 2014). Relational governance mechanisms are often informal in nature and based on norms and joint understanding, which form a common macro-culture in the network and promote self-organisation (Jones, Hesterly, & Borgatti, 1997). Hierarchical governance mechanisms are mostly formal in nature. They establish decision rights and acceptable behaviour through contractual arrangements (Fjeldstad, Snow, Miles, & Lettl, 2012; Zaheer, Gulati, & Nohria, 2000). However, informal hierarchical structures and processes are also formed in networks (Diefenbach & Sillince, 2011). Participant-governed networks emphasise relational governance mechanisms, while hierarchical governance takes on a larger role in hub-firm led networks. The NAO model includes elements from both types of governance mechanisms (Dhanaraj & Parkhe, 2006).

Network structure can have a large impact on the effectiveness of a network's governance mechanisms (Poocharoen & Ting, 2015; Robins, Bates, & Pattison, 2011). High network density, i.e. the amount of ties existing between network actors, has been suggested as being associated with the development of relational governance mechanisms and outcomes linked to novelty and innovativeness. Networks with high relational governance commonly have several champions or promoters at various levels, who actively develop the network (Goduscheit, 2014; Klerkx & Aarts, 2013). In contrast, networks with high centralisation have only a few actors occupying highly central positions in a network and the peripheral actors are not linked to each other. This structure

has been linked to hierarchical governance mechanisms and outcome efficiency (Tracey, Heide, & Bell, 2014).

The *operational logic* of the network also influences the network's governance by affecting the goals of the network and its members as well as the amount of network resources required by the members to accomplish their goals (Bansal & McKnight, 2009; Patala, Hämäläinen, Jalkala, & Pesonen, 2014). Shared governance has been found to be effective when there is a strong consensus on its goals, while hub-firm and NAO models can also work effectively with weaker levels of goal consensus (K. G. Provan & Kenis, 2007). It can also be effective when the amount of network resources needed is relatively low, while hub and NAO models become more effective as the need for network resources increases (K. G. Provan & Kenis, 2007).

Our discussion shows that in addition to joint governance by the public and private sector, the formalisation of the governance and distribution of power are central elements that may help in understanding of polycentric governance. Moreover, the degree of polycentrism can be affected by network structure and the network's operational logic.

Governance in eco-industrial networks

Collaborative partnerships and networks are common methods for organisations wishing to gain access to external resources and knowledge as collaboration makes it is possible to enhance environmental performance and access the innovations of participating organisations (Dimitrova, Lagioia, & Gallucci, 2007). However, sustainable development often requires collaboration with non-traditional partners, for example between public sector regulators and development organisations, private sector firms and NGOs (Hahn & Pinkse, 2014; Selsky & Parker, 2005). This is evident in the emergence of eco-industrial networks that combine business and sustainability logics (Patala et al., 2014) and include, for example, industrial symbiosis, which focuses on creating value by reusing waste and its by-products in cross-industry relationships (Ashton & Bain, 2012; Chertow & Ehrenfeld, 2012). Further examples include sustainable supply chains, where firms collaborate inside supply chains to decrease environmental impacts (Seuring, 2004); innovation and R&D networks, focusing on sustainable technologies (Foxon et al., 2005); and

environmental issue networks, where firms collaborate with various public and third sector actors to solve environmental problems (Ritvala & Salmi, 2010). While eco-industrial network forms might facilitate the advancement of similar outcomes for environmental sustainability, each form advances environmental objectives through different *operational logic* (Patala et al., 2014). We use the term operational logics to refer to the mechanisms through which a network seeks economic and environmental benefits. For example, industrial symbiosis aims to find novel uses for waste and by-products, while green supply chain management targets decreases in environmental impacts during a production process.

The governance of different eco-industrial networks has received considerable research attention, for example, industrial symbiosis networks and green supply chains are found to differ considerably in their form of governance (Bansal & McKnight, 2009). Industrial symbiosis networks have been found to be generally effective when they grow organically – through self-organising governance processes, rather than central planning (Chertow & Ehrenfeld, 2012; Gibbs & Deutz, 2005), although a midway form of facilitating industrial symbiosis has also seen considerable success (Paquin & Howard-Grenville, 2012). Sustainable supply chains are typically governed internally – with large firms coordinating decision-making (Bansal & McKnight, 2009). Studies on the governance of sustainable innovation networks have taken a wider view when examining national-level innovation systems that have multiple levels (Foxon et al., 2005; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007).

Most of these studies limit the analysis to local, e.g. eco-industrial parks where industrial symbiosis takes place; or national levels, e.g. the national facilitation of industrial symbiosis; or the supply network level, e.g. sustainable supply chain management. Thus, they do not consider the effects of polycentric systems where governance is conducted by multiple autonomous units on different levels. An exception is the innovation systems perspective, which considers the diverse set of actors and multiple levels needed to support innovation. National innovation systems typically show characteristics of polycentrism (Hekkert et al., 2007).

Methodology

The governance of eco-industrial networks is studied through an in-depth qualitative study of three nested networks and focuses on industrial symbiosis, sustainable supply chains, and sustainable R&D collaboration among industrial firms. Case studies and data collections were conducted in Finland, which provides the institutional context for the cases. The case studies allow us to gain a deeper understanding of the multiple aspects involved in the governance of eco-industrial networks (Yin, 2013). Multiple case studies are suitable for studying novel and complex phenomenon and they allow cross-case comparisons for forming theoretical inferences (Eisenhardt, 1989). Studying different forms of eco-industrial networks can shed light on the commonalities and differences present in polycentric governance models.

Case selection

The primary method for choosing the cases was theoretical sampling (Miles & Huberman, 1994): the three nested networks have different operational logics and network structures, thus allowing for variation and the finding of rich data on polycentric governance. Three main criteria were behind the choice of the different networks: a network had to involve public-private sector collaboration and multiple actors, it had to include distinct goals for environmental sustainability and network governance had to involve national (or cross-national) and local levels. To obtain a comprehensive view of the forms and influencing factors of polycentrism, we chose networks with different operational logics. While the four national-scale issue networks are the main units of analysis, they all include smaller local level subnetworks. Thus, the empirical material includes evidence from four national level networks and 14 local level networks.

Data collection and analysis

The data was obtained through 36 semi-structured interviews and a focus group discussion with the managers involved in the sustainability collaborations. The respondents represented 27 different organisations, including 19 corporations, five public sector organisations, two universities/research centres and one industry association. The data was gathered from both

organisations involved in national-level governance and organisations participating in the local networks. The details of the participating organisations are listed in Table 1.

Table 1: Data collection

Case network	Data	Participating organisations
Industrial symbiosis	15 interviews	Six firms: Metal waste management expert (IS1), Environmental consultant (IS2), food waste reprocessing solution supplier (IS3), Waste management service provider (IS4), Biofuel producer (IS5), Waste management technology supplier (IS6) Four public sector organisations: energy and material efficiency service provider (NAO1), innovation fund (IS7), regional development organisations (NAO2 and NAO3), Two expert partners: university (IS8), technical research centre (IS9)
Sustainable supply chains	17 interviews	Eleven firms: forestry industry producer (SC1), consumer electronics producer (SC2), energy producer (SC3), forestry biorefineries (SC5 and SC6), technology providers (SC7 and S3), chemical producer (SC9), feedstock procurement companies (SC10, SC11 and SC12) Two public sector: energy and material efficiency service provider (NAO1), environmental ministry (SC4)
Sustainable R&D collaborations	4 interviews	Three firms in three different R&D networks: oil distributor (S1), gas supplier (S2), equipment manufacturer (S3)
General	1 focus group (4 informants)	2 firms (SC1 and SC9), 1 industry association (G3), 1 public sector (NAO1)
Total	1 focus group, 36 interviews (39 informants total)	27 organisations

The data was analysed abductively through an interactive process between existing theory and the data gathered (Dubois & Gadde, 2002). Existing theory informed our data analysis in three ways. Firstly, we used the three elements of polycentrism as a starting point for comparing the polycentric governance of the case study networks. Secondly, we followed the view advocated by Galaz et al. (2012) that polycentric governance can exist to different degrees. Thirdly, we examined the factors influencing polycentric governance, primarily from two viewpoints established in previous literature, which are network structure and each network's operating logics and goals. The empirical data added two major insights to our proposed theory. Firstly, it elucidated the specific forms of polycentric governance in eco-industrial networks, referred to here as archetypes. These archetypes go beyond simply illustrating the different degrees of polycentrism and represent specific types of structural arrangements of polycentric governance. Secondly, working inductively, we identified the specific mechanisms through which the influencing factors affect polycentrism.

The transcribed interviews were analysed qualitatively by using content analysis. Three of the authors were responsible for the interview analysis. The data were analysed by following general guidelines on qualitative data analysis (Miles & Huberman, 1994). The raw textual data were coded and meanings were extracted from it. Next, a spreadsheet that contained various descriptive information on all the networks and subnetworks was produced, including the type of actors involved, the initiator of the collaboration, the starting time and length of the collaboration, the goals of the network, the network's governance mechanisms as well as the structure of the network. Based on the network descriptions, we conducted within-case and cross-case analyses to identify the networks' similarities and differences. Using the studied empirical cases, we then formed the theoretical models of polycentric governance that are presented in the findings.

Case descriptions

Industrial symbiosis network

The first case study is of an emerging industrial symbiosis network. The roots of industrial symbiosis go back decades in Finland, where waste materials and by-products have often been utilised effectively especially in the forestry industry. However, a systematic nationwide effort to

promote industrial symbiosis has arisen in the 2010s. The Finnish Industrial Symbiosis programme (FISS), inspired by examples from countries such as the UK, began in 2012. The programme facilitates industrial symbiosis on the national level, by spreading awareness of the issue, by bringing industrial firms together in specific resource workshops to find new resources synergies and by aiding firms in development projects to put the synergies into operation.

The programme is nationally coordinated by a public sector owned organisation and also by specific regional coordinators. Industrial symbiosis projects generally occur within smaller geographical areas such as cities and municipalities. While the FISS coordination efforts have led to new resource synergies, many industrial symbiosis networks have also emerged through self-organisation. These networks are often led by private sector hub-firms, which usually have resource synergies closely aligned with their core business. Good examples are technology suppliers for resource reprocessing and biofuel producers using material from forestry and agricultural waste as well as waste management firms.

Sustainable supply chain management network

The second network focuses on promoting sustainable supply chain management and production life-cycle impacts. In Finland, the promotional programme TUORE began in 2011. However, industry-specific coordination efforts existed well before then. For example, industry associations and coalitions are responsible for forming new standards for supplier assessments and eco-labelling practices in the forestry, energy and high-tech industries. The TUORE programme is coordinated nationally by a public sector organisation, mostly focusing its activities on information sharing between different industries and providing direct consultation activities. The industry representatives are generally multinational enterprises (MNEs), which coordinate sustainable supply chain activities in their own supply chains. Although some initiatives were initiated by the MNE's suppliers, the coordination is mostly hierarchical in nature, MNEs act as hub-firms.

The second initiative related to sustainable supply chain management (the FBR network) includes three supply chains related to Finnish forestry industry biorefineries. The drivers of the network create new business opportunities using waste and side streams to create new value for customers.

The focal actors of the supply chains are international forestry industry companies – a new bio-based production network has developed around those firms. In addition to the forestry industry, feedstock procurement, the oil industry, logistics, technology providers and the chemical industry are the key actors in the biorefinery network. Financial institutions, legislators and research institutes are also actors within the network. Thus, the forestry biorefinery network includes large international firms and local SMEs. On the industry level, different supply chains have separate governance, which is mainly based on contracts between partners. The network structure is centralised, meaning decision-making is dominated by the hub-firm. On a national level, network members collaborate by doing research within Finnish Bioeconomy Cluster Oy (FIBIC). While industry level supply networks continually seek new partners, research collaboration in FIBIC is restricted since it is based on membership and invitations. However, governance in FIBIC is shared – a selected board makes decisions and multiple actors participate.

Sustainable R&D networks

The third case focuses on the development of sustainable technologies or innovations that solve environmental issues. Typically, innovation networks involve suppliers, customers, research agencies and governmental institutions based on formal projects in closed networks. Three different networks focusing on collaborative innovation were studied. The first network, initiated in 2007, focuses on developing new technology for extracting bio oil. The collaboration involved an equipment manufacturer, two potential customers, a research organisation and a financier. The second studied a development network focused on providing fuel from feedstock. The collaborative project started in 2012 and involved an oil distributor; potential customers, who process waste; companies who have waste; and a research unit for developing the required technology. Both initiatives were part of research programmes initiated and funded by the Finnish Foundation for Technology and Innovation (Tekes). However, the networks also had joint governance as decisions were made in collaboration during formal project meetings. In the second network, collaboration was based on new relationships that were characterised by high power imbalances, consequently formal agreements on intellectual property rights were used.

The third development network was formed by a state-owned gas supplier facing pressure from the government to produce more biogas. Thus, it collaborated with food manufacturers and a food distributor to build a new system. The waste from food manufacturers is processed into biogas to be used for producing ecologically sustainable food and began in 2013. The network's governance was based on new partnerships and the gas supplier had to use time to create new partnerships. Challenges for the network's governance were caused by a strong power imbalance between the actors because the gas supplier and food distributor are significantly larger than the food manufacturers and there are asymmetric customer relationships within the network. Furthermore, the wide diversity of the actors and challenges related to sharing the created value characterise the collaboration.

Archetypes of polycentric governance

In this section, we will present the findings of the analysis of the polycentric governance models used in the case networks. Firstly, Table 2 lists the governance mechanisms identified in the case study networks. We identified specific governance mechanisms – first order themes – in the data and classified them according to the three main elements of the network's governance: the form of *information sharing* in the networks, the *control and coordination* mechanisms for setting and monitoring goals and achieving stable network activities, and the *membership criteria* for new members.

Table 2: Governance mechanisms in the case study networks

	Case: Industrial symbiosis	**Case: Sustainable supply chains**	**Case: Sustainable R&D**
Information sharing	Seminars, consultation, network information system	Steering group meetings, consultations, informal discussions	Seminars, public reporting, steering group meetings, internal information sharing

Control and coordination	Contracts, performance assessments, regional planning shared values and understanding, trust	Performance assessments, supplier audits, standardisation shared values and understanding, trust	Programmes, projects, joint decision-making, contracts, non-disclosure agreements, trust, R&D management systems
Membership criteria	Open for suitable industrial firms	Limited to supply chain members and specific experts	Need –based recruitment, assessment criteria

Secondly, we used the three dimensions of polycentrism identified in the literature for a comparative analysis of the case networks: the degree of public-private collaborative governance, the formalisation of governance and the distribution of power between the networks' levels. All of these dimensions can be analysed as a continuum on a low to high degree of prevalence. Figure 1 illustrates how the examined networks fit into these continua.

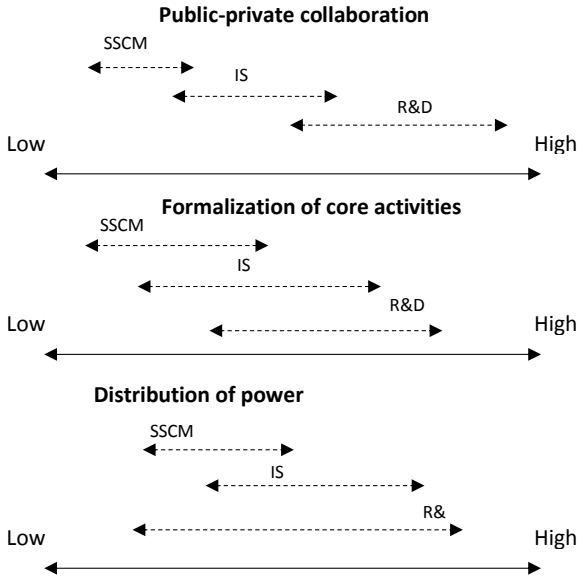

Figure 1: Degrees of polycentrism in the case networks

Sustainable supply chain networks (SSCM) had a relatively low level of public-private collaboration and formalisation. This can be due to the generally small role of national governments in global supply chain governance, which is beyond the scope of the governmental organization's activities. The management of sustainable supply chains is generally dominated by large MNEs, and therefore the power distribution in this network was relatively low.

The industrial symbiosis (IS) network mostly belongs in the medium range in all of the three dimensions, but there are some differences in the range of variety across the different subnetworks. Public-private collaboration was found to be on a medium level across the whole network, but formalisation ranged from low to medium, with some subnetworks having mostly relational and informal governance mechanisms. This is partly due to the novelty of IS networks. The activity itself has existed for a longer time, but planned IS networks have only emerged in the last 10 to 15 years. Power distribution in the IS networks also varied – NAO and hub-firm governance were the most common, but some subnetworks also had a more distributed decision-making process.

Lastly, the R&D network was on the higher end in all three dimensions. This is most likely due to the prevalence of a national innovation system that has existed for a longer time than most sustainability issues. The R&D network had a high degree of public-private collaboration as well as the formalisation of key activities due to high-valued resource exchanges, although some subnetworks also had informal governance mechanisms. However, the distribution of power is greater. Most R&D activities had stratified decision-making, but high imbalances in the sizes of the organisations involved could cause relatively hierarchical hub-firm led governance.

From the empirical data, we can derive three archetypes for polycentric governance models (see Table 3). These archetypes represent low, high and medium cases of polycentrism. It is important to note that these archetypes are theoretical constructs and that real-world polycentric networks often lie somewhere in-between the archetypes – as they do here. However, these archetypes help us to better understand the degrees of polycentric governance.

Table 3: Archetypes of polycentric governance in eco-industrial networks

	Archetypes		
	Type 1: Loosely coupled coalition (Low polycentrism)	**Type 2: Polycentric coordination (Medium polycentrism)**	**Type 3: Polycentric governance system (High polycentrism)**
Degree of public-private collaborative governance	Private sector and public sector governance mostly separate	Governance includes public sector coordination and private sector champions	Collaborative governance involves both public and private sector
Formalisation of governance	Governance mechanisms mostly informal	Increasing formalisation, but some mechanisms informal	Formalised governance mechanisms
Distribution of power (levels)	Power resides on national or local level	Power is more stratified but typically one actor coordinates	Power divided between national and local levels

Type 1: Loosely coupled coalition

The first archetype represents a weak form of polycentrism, where separated and mostly hierarchical governance systems – from the public and private sectors – form a loose coalition around the focal issue. This coalition generally includes the central actors from the hierarchies coming together for early-stage collaborative activities, such as information sharing and forming a joint understanding. The national network for developing sustainable supply chains exemplifies this form of polycentric network. The coalition in this case included representatives from the hub-firms in different industrial supply networks, a public sector organisation, environmental regulators as well as expert partners from the university sector.

The degree of collaborative governance in this example is relatively low. In the TUORE network the public sector organisations are in charge of the governance of their own domains, i.e. network development and regulation, while the private sector hub-firms are largely responsible for the governance of their respective supply chains, but there is some overlap between these domains. The public sector influence on private supply chains is limited to regulations and the small-scale consulting conducted by the network development organisation and expert partners. The private sector's influence on the public sector is mostly focused on attempting to guide regulations. In the

FBR network, firms and research institutes collaborate nationally by doing research together in FIBIC Oy, which is partly publicly funded. FIBIC research focuses on basic research and each firm then conducts their own R&D based on that collective research. Thus, public and private sectors are mostly separated.

Formalisation within the networks' governance is on a low-medium level. The supply chains' internal governance is generally quite formal – predominantly contracts, auditing and performance assessment projects for greening the supply chain. Nevertheless, the collaborative network between the two sectors is governed by mostly informal activities. Participation in the network is voluntary, and network interactions, such as meetings and consulting work is done informally. This dimension of polycentrism can progress towards the medium level if, for example, the coalitions start to adopt more formal rules and norms to guide network activities.

The distribution of power is also low in this type of network. In the TUORE network, supply networks are mostly characterised by hierarchical governance. Suppliers for the hub-firms are autonomous organisations, but activities for greening the supply chains are generally led by them and the resulting criteria for environmental performance are often forced on the suppliers through preferential procurement practices and specific performance standard requirements. Power also largely resides in the hub firms of each supply chain in the FBR network since they lead development work by influencing other actors in the network. The hub firms also make most decisions about new members joining the network. On the national level, the distribution of power is somewhat greater. Decision-making is generally done in the coalition steering group meetings, which represents the key actors from both the public and private sectors. However, coordinating and developing the network is mostly the responsibility of the NAO. Overall, the power and decision-making in the supply chain networks is concentrated in a few actors.

Type 2: Polycentric coordination

The second network archetype represents a medium level of polycentrism. In this form of governance, public-private collaboration becomes deeper and its formal activities are more

organised. Decision-making also becomes more stratified, with smaller autonomous units emerging to govern a specific part of the network. The industrial symbiosis network (FISS) shows characteristics of this form of governance. While the NAO still play a large role, private sector champions and local level coordinators have an increasingly prominent role in *coordinating* a network's activities.

Public-private collaboration is more intensive in this form of network. Private sector-firms become involved in network coordination by acting as champions and aligning network goals with their own. We found examples of industrial firms acting as champions in the local networks of the industrial symbiosis. Waste biofuel producers, technology suppliers for waste reprocessing and environmental consultants are examples of organisations that had industrial symbiosis as an integral part of their core business model, thus they often functioned as hub-firms and champions in their respective local networks. The public sector also has a more influential role in private sector activities in this network form. For instance, the NAO often acted as a catalyst for developing new symbioses by arranging workshops or taking an active consulting role in developing symbiosis projects. Another example of industrial firm acting as a champion was found in an R&D network in which an oil distributor acted as the hub and invited actors to join the network. However, the collaboration took place in Tekes's Green Growth programme research project for which a NAO provided the platform and financial support for the collaboration.

The formalisation of core activities is higher in this network form, although participation in the workshops was mostly voluntary and informal in the first stage of the programme. However, the NAO is planning a more formal system of membership that is motivated by the example of NISP in the UK (Paquin & Howard-Grenville, 2012). This formal membership – an annual membership fee – will provide access to a resource database coordinated by the NAO and access to the joint activities. The network also included a designated local partner organisation from either the public or private sector, which can act as a NAO in a smaller region.

The distribution of power is also higher in this network form compared to type 1. The coordination of the FISS network is divided between the national and local levels, with local coordinators having

relatively autonomy for coordinating their own network. Local network coordination can also include several organisations, for example, a regional development organisation can be in charge of bringing firms together and facilitating the permit and funding processes for industrial firms, while a central industrial firm can act as the anchor-tenant that guides the actual development of the new symbioses. The FISS has two key organisations and an expert partner network for coordinating national-level activities. In one of the sustainable R&D networks, coordination is divided between the national and local levels, thus decisions are made in project meetings and in smaller groups that focus on local-level issues. The oil distributor and financier represent the national level but the oil distributor also tries to solve local challenges with local actors, for example, transporting waste.

Type 3: Polycentric governance system

The third type of network archetype represents a highly polycentric system. In this form of network, a core group of organisations from both the private and public sector are jointly in charge of the governance of the network and the network's governance mechanism is formalised. The national network focuses on sustainable R&D and has the strongest characteristics of this network form.

On the national level, Tekes, along with other public sector organisations, organised two specific research programmes to support the R&D projects for the creation of environmentally sustainable business and a bioeconomy. The private and public sectors have since worked together on the national level to focus on specific areas, set goals for the programme and fund it. The projects include formal collaboration between firms, the public sector, universities and research agencies, depending on the specific scope of the project.

The formalisation of core activities is this network form is strong; national-level coordination happens through official programmes, formed through a standard collaborative process where participants are allowed to make formal proposals for the programme's topics. These topics lead to specific project calls for the submission of proposals. The projects are governed through a formal system, which includes a steering group, a specific timeframe and goals. The interface between

the national and local level is governed by specific consortium contracts between the participating parties and the funders.

The distribution of power in such networks is broad; national-level actors provide general frameworks for the programme, which are designed in collaboration with the participants. Research and R&D consortia can propose suitable projects of their own design if they fall within the general framework of the programme. Local-level goals are autonomously set by the participants but are subject to approval by the national level at the proposal stage. Inside the projects, decision-making is generally collaborative among the main parties of the steering group. However, power relationships inside a project can affect stratification, for instance, in the biorefinery development project, two of the participants were considerably larger than the other collaborators, leading to somewhat asymmetric relationships.

To summarise, polycentric governance can take different forms and varies according to the degree of polycentrism in the network. Based on our empirical study, three archetypes of polycentric network governance are identified: low, medium and high degrees of polycentrism. The networks did not perfectly represent the three archetypes, but there was considerable difference between the governance forms of the three eco-industrial networks. In the next stage of the empirical research, we set out to determine which structural and contextual factors promote the formation of specific types of polycentric governance. Specifically, we examine how elements of a network's structure and operational logics influence the degree of polycentric governance.

Factors influencing polycentric governance

In this section, we will discuss how specific contextual and structural factors influence the development of polycentric governance systems. Research has shown that a network's operational logic (Patala et al., 2014) and network structure (Tracey et al., 2014) have an impact on the choice of governance model. For this reason, our objective was to find out how these specific network characteristics affect elements of the governance model. We found four network characteristics to be important in affecting elements of polycentrism, see Figure 2. Two of these, *external resource*

need and the *alignment of actor goals*, are characteristics directly related to a network's operational logic, while, *structural holes* and *local network centrality* are related to a network's structure.

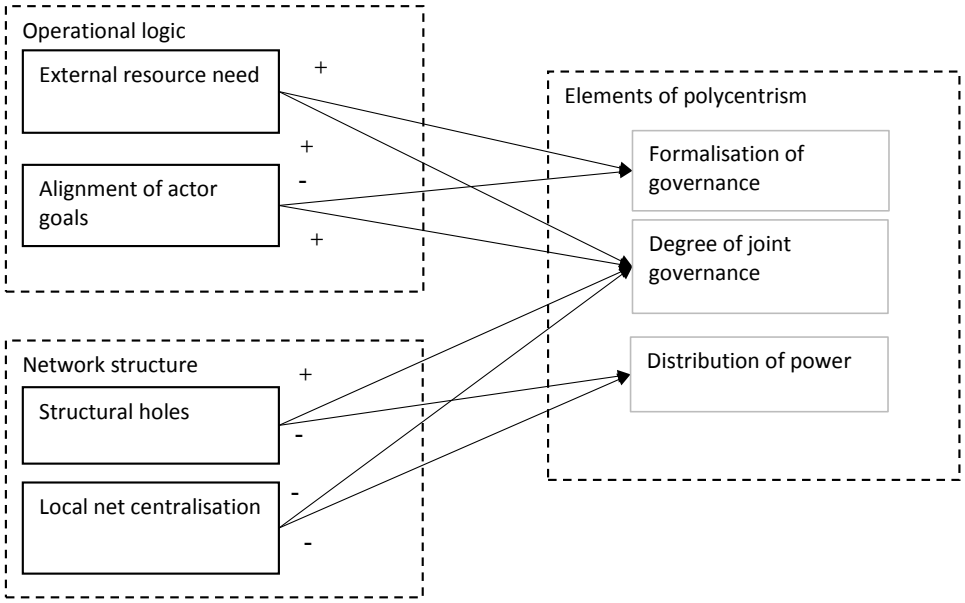

Figure 2: The factors influencing polycentric governance

Operational logic

External resource need is a primary reason for a firm to enter into inter-organisational network collaboration (Zaheer et al., 2000). The extent of external resource need depends on a network's goals and the resources available to the participants. We found that in the green supply chain network, external resource need was primarily limited to knowledge resources, while tangible resources were commonly available inside the hub-firms or inside supply chains. In industrial symbiosis, the resource need was higher since the realising of new resource synergies often requires expert consultancy services or new technologies. The participants, many of them SMEs, often lacked such resources:

> ‘There are different kinds of organisations involved in this programme (sustainable supply chains) compared to the industrial symbiosis programme. With industrial symbiosis it’s mostly SMEs, while here we have large firms. Because of that it’s different methods that we use with them. Large firms usually have internal resources and the expertise to do most things by themselves, while SMEs need more assistance from us.’ (Expert, NAO1)

We found that higher external resource need generally deepens public-private collaboration because public sector coordinators have a larger role in mobilising resources for network activities. The industrial symbiosis programme included a national-level resource information system and a group of expert partners to support the formation of new resource synergies. Secondly, the exchange of higher value resources will increase the likelihood of formal governance mechanisms, such as contracts, being used. For example, in the R&D network, the use of contracts became increasingly common as sensitive knowledge and technological resources were exchanged between parties. Similarly, formal governance mechanisms were common in the supply chain network between the supply chain actors, where the value of resource exchanges is high for business, but informal on the national level, where resource exchanges were limited to knowledge. Furthermore, collaborative working requires formal mechanisms for resource distribution between partners, especially when resources have to be procured from outside the network as there is a need for formal contracts in order to avoid opportunistic behaviour. Therefore, we propose that external resource need has two effects on the degree of polycentric governance:

> P1a: A higher external resource need increases joint governance between public and private sectors

> P1b: A higher external resource need increases the use of formal governance mechanisms in the network

The second important characteristic related to a network’s operational logic is how well the actor’s individual goals are *aligned* with the network’s goals. Eco-industrial networks combine economic, environmental and societal goals, driven by diverse sets of actors from the public and private sectors. If these goals and interests are closely aligned, collaboration between these sectors is intensive and will typically result in mutually beneficial outcomes (K. G. Provan & Kenis, 2007). This is an important characteristic of industrial symbiosis:

> ‘When we are involved with these companies, most of them have a very positive reaction to our support activities. They can see that it’s a win-win situation with both environmental and economic benefits.’ (Expert, NAO1)

In IS, new resource synergies typically result in economic and environmental benefits (Chertow & Ehrenfeld, 2012). This is even more evident in sustainable R&D collaboration, where the activity is generally closely aligned with the strategic interests of the collaborating parties. Sustainable supply chains are often characterised by competing interests. Firms inside the supply chains are not always in agreement on how strictly the sustainability standards should be implemented. On the societal level, industrial firms and other field-level participants, such as NGOs, often engage in adversarial relationships on sustainability issues (MacKay, 2012) . Closely aligned interests make joint governance easier to implement because private and public sectors share similar goals for the collaboration. On the other hand, closely aligned interests can decrease the need for contractual arrangement, which decreases the formalisation of the network’s activities. This was evident in some of the local industrial symbiosis networks, which relied mostly on relational governance based on trust and informal relationships between managers – and which had been formed over time through memberships in local business associations and other similar networking organisations. We therefore propose that the alignment of actor goals can affect polycentrism in two ways:

> P2a – A higher alignment of actor goals increases joint governance between public and private sectors

> P2b – A higher alignment of actor goals decreases the need for formal governance activities

Network structure

The first key characteristic of a network’s structure that was found to influence polycentrism is the presence of *structural holes*. These are vital parts of a network that lack connections between actors, leading to a lower degree of knowledge transfer inside the network. At the same time, certain actors can bridge these structural holes, giving them an advantageous position. We found this to be especially evident in the industrial symbiosis network. Even on the local level, where firms typically have many informal connections beforehand, the role of the public sector in brokering and providing knowledge was found to be significant:

> ‘When you get involved in industrial symbiosis, you have to network with many parties. In this sense, the local development organisation has been a huge help. They have such a wealth of information available and many entrepreneurs aren’t even aware of how much they can help you.’ (Manager, IS3)

The NAO worked to improve this by hosting meetings designed to build new relationships between industrial firms in order to improve knowledge transfer and find new synergies. The workshops and networking events provided participants with the opportunity to find otherwise undetected cross-industry opportunities. This facilitating action increases collaborative action between industrial firms and brokers, who are common in the public sector. At the same time, the brokering activities and the advantageous bridging position also gives NAOs a larger network role. Previous studies (Gibbs & Deutz, 2005; Paquin & Howard-Grenville, 2013) have shown that over-engineering industrial symbioses generally results in less successful networks compared to networks where self-organisation is given its natural role(Paquin & Howard-Grenville, 2013). Brokering activities can lead to a network coordinator taking on a larger role in governing the network’s activities, resulting in lower levels of distributed decision-making and power in the network’s governance. In essence, this generally means there is a concentration of power on the national level as the network brokers are generally public sector actors who have a broad field of operation and wider networks of contacts compared to local level networks.

We thus propose that structural holes affect polycentrism through two main mechanisms:

> P3a: Structural holes in a network increase joint governance between public and private sectors
>
> P3b: Structural holes in a network reduce the distribution of power within it by concentrating power on the national level (network brokers)

Secondly, the *centralisation of local networks* is an important factor influencing the degree of polycentrism. In highly centralised networks, one or a few actors will act as a hub connecting all other members, but who will have weaker connections to each other. This was especially evident in the sustainable supply chain network and some of the industrial symbiosis subnetworks. These networks generally had a single highly connected actor like the hub-firms in the supply chains. For example, in the TUORE network, the hub-firms were typically the only participants from their

respective supply chains. These actors also largely kept firm control over the supply chain activities in which the public sector had only a little involvement. One possible reason for this is that the geographical scale of supply chains often exceeds the scope of activities of the public sector organisations:

> 'For us it's a bit challenging, even if these network activities are related to advancing sustainable supply chains, we don't have any suppliers in Finland. That's why our activities (in the national network) are usually related to knowledge sharing.' (Sustainability director, SC2)

The centralisation of the supply chains will limit the degree of public-private collaboration on governing a network. In the studied case, the public sector actors had primary responsibility for coordinating the national network, while the supply chain governance was coordinated by larger MNEs. The coordinators described the methods they used in collaborating with the industrial firms in the sustainable supply chain network as quite informal compared to the industrial symbiosis network:

> 'The methods we've used here (sustainable supply chain network) are mostly personal discussions. We have tried to make them informal interactions – where we try to get to the bottom of things and understand the big picture that these firms operate in.' (Expert, NAO1)

In effect, strong local network centralisation will lead to the hub actors of these local networks gaining more power in the network. Thus, in a polycentric network with many highly centralised local networks, the national-level network has a tendency to become a loosely coupled group of actors with a large degree of autonomy and power in the governance of their local networks. In essence, this means a shift in power from the national to local level governance.

Thus, we propose that this form of centralised local network structure will affect the degree of polycentrism in two ways:

> P4a: Strong local network centralisation will decrease joint governance between public and private sectors

P4b: Strong network centralisation will decrease the distribution of power throughout a network by concentrating it on local levels

Conclusion

Polycentric models have become an increasingly prevalent way for the public sector to govern across multiple geographical areas. The objective of our research was to elaborate on the role of polycentric governance in eco-industrial networks, where private-sector organisations play an important role in governing alongside the public sector. We examined the different forms of eco-industrial networks and the elements of polycentric governance: public-private collaboration, the formalisation of governance, and the distribution of power between different levels. We empirically studied the issue through three nested networks, focusing on different forms of eco-industrial activities. We found out that polycentric governance can exist to different degrees in eco-industrial networks, depending on the operational logic and structure of the network. We found that the main determinants of polycentrism were external resource need and the alignment of actor goals, which relate to the operational logics at hand, structural holes and local network centralisation, which in turn, are characteristics of the network structure.

Our main theoretical contribution concerns the governance of environmental collaboration. Firstly, we elaborate on the concept of eco-industrial networks as public-private sector collaborative networks for managing environmental business issues. Our focus on networks brings to the fore the capacities and efficiency of different types of actors in tackling environmental issues (Arellano-Gault et al., 2013). Hence, having a large number of collaborators helps to connect several rival logics, e.g. business and sustainability ones (Mair et al., 2015). Thus, we demonstrate that polycentrism is important in the governance of eco-industrial networks since it helps to reconcile business and environmental goals. This also has implications for the emerging literature on hybrid organisations which combine a plurality of logics (economic and ecological) within single organisations (Battilana & Dorado, 2010; Haigh & Hoffman, 2014; Mair et al., 2015). Eco-industrial networks can be seen as virtual or temporary hybrid organisations, where hybridity is present in network level goals and logics. Future research could examine this issue. Potential topics include analysing the contextual factors which affect the development of hybridity in networks

compared to single organisations. Comparative studies could also examine the similarities and differences between hybrid organisations and hybrid networks. Secondly, our findings demonstrated that it is possible to simultaneously govern these networks on multiple levels, and that the three archetypes of polycentric governance demonstrate how this can be achieved. Thus, this study contributes to a more integrative theory of the governance of public-private eco-industrial collaboration.

Thirdly, our study contributes to inter-organizational network theories. Polycentric network governance has been advocated by researchers interested in the public sector governance of common-pool resources, but its application in the business management field has been scarce. We contribute to the existing knowledge on polycentrism by expanding the theory into a domain that requires that private sector governance plays a larger role. Polycentrism can offer network researchers a new perspective with which to study the governance of nested networks that reach across multiple levels. For example, the generic governance models outlined by Provan and Kenis (2007) can co-exist within the same network but on different levels. Therefore, future research could study how, for example, the potential conflicts that may arise between participatory organisation led governance and hub led governance within the same network.

Fourthly, we contribute to the literature focusing on the relationship between organisations and the natural environment. Recent research in this stream has identified the relationship between efficiency and resilience as a key tension affecting progress towards sustainability (Hahn et al., 2015). Efficiency is generally accomplished by focusing on core competences and improving those as far as possible. However, sustainable systems also require resilience, or the capability to withstand external shocks. This is generally accomplished by having a variety of solutions at the system level because tension primarily occurs between organisational and systemic levels (Hahn et al., 2015). Thus, we suggest that polycentric governance systems may be a key organisational form for resolving this tension as distributed power allows for more variety in solutions for accomplishing tasks that are similar. In addition, deeper collaboration between the public and private sectors allows for effective coordination to integrate organisational and system-level goals. Thus, polycentric governance improves a network's resilience and innovativeness, helping to obtain the required external resources.

Both corporate managers and public sector policymakers are able to use our findings to design and develop the governance of their collaborative networks. By carefully assessing their network's goals and the network structure, decision-makers can develop governance mechanisms that steer the network towards a desired level of polycentrism. While polycentric governance has been shown to improve the effectiveness of governance and to foster diversity in innovation, it is unlikely that all collaborations can be governed by a fully polycentric system. As our findings demonstrate, some forms of eco-industrial networks, like sustainable supply chains, have characteristics that bring challenges to polycentrism and therefore a more loosely coupled governance system may be more appropriate for them.

While our findings offered an in-depth analysis of polycentric governance in three different forms of eco-industrial networks, we identified only some factors that can influence polycentric governance. Different factors affect polycentrism positively or negatively and, in practice, several factors exist simultaneously. More research on the topic is needed in order to answer, for instance, the question of what would be the optimal combination of factors to advance polycentrism. Quantitative studies on a larger number of eco-industrial networks would help to ascertain the validity of the causal mechanisms that we have proposed in our study.

Network collaborations are also fluid in nature, and governance models are therefore likely to be dynamic. While our findings on the archetypes of polycentrism provide some suggestions on how polycentrism develops through the retrospective views described by the interviewees, a deeper understanding of the dynamics of polycentric governance requires longitudinal studies, which will help understand the effect of the age of the network as the studies were of recently formed networks. Our cases also have a limited geographical scope since the networks were regionally based in Finland. Comparative studies between different countries are also needed to identify how international contextual and institutional factors may affect polycentric governance. Future studies could also incorporate transnational levels of governance – for those issues which have international initiatives.

Collaboration between the public and private sectors is needed in order to achieve sustainable development. This requires new models of governance which can combine the strengths of both sectors. Polycentric governance allows for diverse methods and initiatives for achieving collective goals, while also allowing local networks to come up with efficient solutions that best match their competencies. In the future, it is expected that polycentric governance will further blend the domains of private and public sector organisations, leading to novel arrangements to achieve collective goals.

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ANALYSING BARRIERS TO SUSTAINABLE BUSINESS MODEL INNOVATIONS: INNOVATION SYSTEMS APPROACH

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Business model innovations are recognised as a key to the creation of sustainable business, but their adoption by firms has been slow. Organisations can only be sustainable when the whole societal system is sustainable. Both structural and cultural changes are required to facilitate firm- and system-level sustainability. The central idea of this paper is to examine how societal transition towards sustainable business models (SBMs) can be achieved. Through a qualitative Delphi study, we assess and categorise the key structural and cultural barriers to sustainable business model innovation (SBMI). By applying the innovation system approach, we explain how to overcome existing barriers by strengthening the functions of the innovation system. We analyse how these barriers can be overcome through the activities of governments, firms, and consumers, and discuss the wider implications of our research for practitioners, policy-makers, and researchers.

Keywords: Barriers; business model innovation; Delphi; innovation system; institutional theory; societal change; sustainable business model; sustainable innovation.

Introduction

Sustainable development is an increasingly important concern for business managers. If the current population and consumption trends continue, we will need the equivalent of two Earths by the 2030s (Global Footprint Network, 2014). Empirical studies have shown that CEOs see sustainability as more important than ever for long-term success, and believe that sustainability issues should be fully

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integrated into the strategy and operations of a company (Lacy *et al.*, 2012). To address this, radical and systemic innovations are needed (Boons *et al.*, 2013). Sustainable business model innovation (SBMI) is an approach for firms to re-conceptualise their purpose and value-creation logic to improve their environmental and social sustainability (Bocken *et al.*, 2014).

Existing research on sustainable business models (SBMs) has identified several archetypes of strategies firms can pursue for SBMI, such as promoting eco-efficiency, creating value from waste or delivering functionality rather than ownership. Although the question of how companies can transform their business models to become more sustainable is highly relevant for the society and management, it is poorly understood (Sommer, 2012), and the adoption of the strategies by firms has been slow. More research is needed on the wider social and political changes that are required to make these archetypes mainstream (Bocken *et al.*, 2014).

The research on sustainable innovation has recently become more focused on the co-evolutionary process in which technologies, social practices, and institutions turn towards sustainability (Boons *et al.*, 2013). Organisations can only be sustainable when the whole societal system is sustainable. Both structural and cultural changes are required to facilitate firm- and system-level sustainability (Stubbs and Cocklin, 2008). Business model innovation is conventionally focused on firms' internal strategic activities, but these activities are greatly affected by the institutional environment in which the firms operate (Zott and Amit, 2007). It is thus important to take a step beyond the business model of the individual firm and identify and analyse the structural and cultural driving forces and barriers which have an impact on SBMI.

This study applies institutional theory to examine the barriers to SBMI and the innovation system approach to understand the successful process of SBMI diffusion. Through a qualitative Delphi study, we assess the key barriers which have an impact on the adoption of SBMI. We then discuss how these barriers relate to the archetypes of SBMIs and how the transition towards SBMs can be promoted. By applying the innovation system approach, we explain how to remove the existing barriers by strengthening the functions of innovation system. The main objective of this research is to examine how the societal transition towards SBMs can be achieved. Specifically, we aim to answer the following questions: What are the key structural and cultural barriers to SBMI? How societal change towards SBMs be promoted?

This paper is structured as follows. The theory and concepts used, such as SBMI, institutional theory, and innovation system are described in Secs. 2 and 3. A short overview of the research methodology is given in Sec. 4. Sections 5 and 6 summarise the findings of our analyses. Finally, we conclude and discuss the findings and suggest possible avenues for future research.

Sustainable Business Model Innovation

There is a growing interest in research connecting two young disciplines: Strategic sustainability management and business model research. Business model reflects the firm's realised strategy (Casadesus-Masanell and Ricart, 2010). It describes the rationale of how an organisation creates, delivers, and captures value (Osterwalder and Pigneur, 2010).

Business model innovation is recognised as a key to the creation of sustainable business (e.g. Boons *et al.*, 2013; Boons and Lüdeke-Freund, 2013; Carayannis *et al.*, 2014; Girotra and Netessine, 2013). The business model concept provides a link between an individual firm and the larger production and consumption system which it is part of (Boons *et al.*, 2013). Business model innovations for sustainability are innovations that create significant positive or significantly reduced negative impacts for the environment and/or society, through changes in the way the organisation and its value-network create, deliver, and capture value or change their value propositions (Bocken *et al.*, 2014).

While the current literature does not offer a general conceptual definition for the SBM (Boons and Lüdeke-Freund, 2013), several important requirements have been identified. Stahel (2007) sees the SBM as a resource-miser business model, which is based on closed material loops, closed liability loops, and selling performance instead of selling products. Wu and Pagell (2011) see it as a question of how sustainable practices are adopted in internal operations and supply chain management, what the role of environmental management in their product and service value proposition is, and what is the impact of environmental initiatives on financial performance. Stubbs and Cocklin (2008) define that SBM encompasses both a system's and firm-level perspective, draws on economic, environmental, and social aspects of sustainability in defining an organisation's purpose and measuring performance, considers the needs of all stakeholders and treats nature as a stakeholder.

A wide range of examples on specific companies, e.g., Interface Inc. and Bendigo Bank (Stubbs and Cocklin, 2008), Grameen (Yunus *et al.*, 2010), Toyota (Porter and Derry, 2012), as well as examples of solutions and mechanisms, e.g., extended producer responsibility and end-of-life strategies (Gehin *et al.*, 2008; Rizzi *et al.*, 2013), sustainable supply chain management (Linton *et al.*, 2007; Wu and Pagell, 2011), sustainable design strategies (Niinimäki and Hassi, 2011) and base of pyramid solutions (Chaurey *et al.*, 2012), which can contribute to business model innovation for sustainability have been identified in the literature. Bocken *et al.* (2014) have introduced a more comprehensive view of how firms should approach embedding sustainability in their business models by introducing SBM archetypes that are groupings of mechanisms and solutions that may contribute to

business model innovation for sustainability. These archetypes are introduced in order to develop a common language that can be used to accelerate the development of SBMs in research and practice. We have adapted the SBM archetypes of Bocken *et al.* (*ibid.*) as follows (Table 1). The archetypes are: (1) Pollution control, (2) Maximise material and energy efficiency, (3) Create value from "waste", (4) Substitute with renewables and natural processes, (5) Deliver functionality rather than ownership, (6) Adopt a stewardship role, (7) Encourage sufficiency, (8) Re-purpose the business for society/environment, and (9) Develop scale-up solutions. Further, the archetypes are classified in higher order groupings, which describe the main type of business model innovation: Technological, social, and organisational-oriented innovations (Boons and Lüdeke-Freund, 2013). Different archetypes lead to divergent sustainability benefits, and firms can use one or a selection of SBM archetypes for shaping their own transformation. Real sustainability almost certainly demands combined use of different archetypes (Bocken *et al.*, 2014).

The first four (1–4) archetypes are technologically oriented and focused on innovation in products and manufacturing processes. Pollution control and maximising material and energy efficiency aim at eliminating emissions and optimising the use of resources. Creating value from waste aims at eliminating the whole concept of waste by turning existing waste streams into useful and valuable input to other production. This archetype seeks to both reduce waste to the minimum and create new value from what is currently perceived as waste. Substituting with renewables and natural processes addresses the resource constraints associated with non-renewable resources, and consider the potential of renewable resources and benefits from nature-inspired innovations.

The next three (5–7) archetypes are described as socially oriented innovations that focus on changing consumer behaviour and innovations in consumer offering. Delivering functionality rather than ownership is based on the literature on Product Service Systems (e.g., Beuren *et al.*, 2013; Gaiardelli *et al.*, 2014; Tukker, 2004), which concern reducing consumption by offering a combination of products and services. The supply of services contains also tangible elements. From the sustainability perspective it is more important to focus on the difference between tangible and intangible or non-ecological and ecological solutions than the difference between products and services. Adopting a stewardship role aims at ensuring stakeholders' long-term health and well-being, and maximising positive social and environmental impacts through upstream and downstream stewardship. It aims at engaging the consumer with the full story of production and the supply chain. Encouraging sufficiency seeks to reduce both production and demand-side consumption by ensuring product durability and longevity, and responsible product distribution and promotion.

Table 1. SBM archetypes.

Innovation type	Technological				Social			Organisational	
SBM archetype	Pollution control	Maximise material and energy efficiency	Create value from waste	Substitute with renewables and natural processes	Deliver functionality rather than ownership	Adopt a stewardship role	Encourage sufficiency	Re-purpose the business for society/environment	Develop scale-up solutions
Aim	Elimination of emissions via new product innovations, cleaner production, and efficient supply chains	Optimised use of resources; "do more with fewer resources"	Elimination of the concept of waste; Reduced waste and virgin material use	Reduced use of non-renewable resources, emissions associated with burning fossil fuels, and synthetic waste to landfill	Maximised use of products; Business focus on satisfying user needs without users having to own physical products	Stakeholders' long-term health and well-being, and maximised positive social/environmental impacts through upstream and downstream stewardship	Reduced production and consumption; Reduced overconsumption on systems level	Prioritised delivery of social and environmental benefits (rather than economic profit maximisation)	Maximised benefits for the society and the environment by delivering sustainable solutions at a large scale
Examples	Low carbon manufacturing; low carbon supply chain; low carbon solutions	Lean manufacturing; dematerialisation (of products/packaging); increased functionality (to reduce the total number of products required)	End-of-life strategies (reuse, refurbish, remanufacture, recycle); closed-loop supply chain management; cradle-to-cradle; industrial symbiosis	Substitute with renewable resources; move from non-renewable to renewable energy sources; Renewables-based energy innovations; biomimicry; green chemistry	Product-oriented product service systems; use-oriented product service systems; result-oriented product service systems	Ethical trade; fair trade; biodiversity protection; resource stewardship; radical transparency about environmental/social impacts; consumer care	Consumer/user education; product durability and longevity; responsible product distribution and promotion; market places for second-hand goods; shared ownership; collaborative consumption	Not for profit; social business; hybrid business; base of pyramid solutions; alternative ownership; cooperative collectives	Licensing; franchising; collaborative models; co-creation; open innovation; crowdsourcing; crowdfunding; crowd co-production; lobbying

Source: Adapted from Bocken *et al.* (2014).

The last two (8–9) archetypes seek wider organisational and cultural changes in business practices. Re-purposing the business for the society/environment aims at prioritising the delivery of social and environmental benefits rather than economic profit maximisation through close integration between the firm and local communities and other stakeholders. Developing scale-up solutions aims at maximising the benefits by delivering sustainable solutions at a large scale, which means innovation in partnering, new unusual business relationships, and collaborative models (Bocken *et al.*, 2014).

Innovation Systems and Institutional Theory

The new institutional theory has emerged in recent decades as one of the dominant theories to examine the societal context of organisations (Dimaggio and Powell, 1993; Scott, 2014). The new institutionalists in sociological fields define institutions as regulative, normative, and cultural-cognitive elements which provide stability to social activities (Scott, 2014). Organisations adapt to these elements to establish themselves as socially acceptable or legitimate actors (Suchman, 1995). Legitimacy gives the actors improved access to resources, which are central for sustained competitive advantage (Oliver, 1997).

The literature on evolutionary economics also considers institutions as important aspects of the socio-technical system. Institutions are considered to be the factors and forces that hold *social technologies*, or the modes of organisation and activities that are related to physical technologies, together (Nelson, 2008). While physical technologies generally play the leading role in innovation, social technologies are needed to implement them and the two are thus highly interrelated. Changes in social technologies can be considered an integral part of business model innovation, defined as adding new activities or changing existing activities in the operations of a business (Amit and Zott, 2012). Thus, SBMI involves the development of new social technologies that advance the sustainability of a firm.

The traditional institutional theory emphasises the constraints that institutions place the on actors and consequently views their agency as limited. However, the branch of research that focuses on institutional entrepreneurship is concerned with how the actors can enact purposeful institutional change (Maguire *et al.*, 2004). By definition, business model innovation requires change in existing systems and is driven by entrepreneurial actions, and therefore entrepreneurial actions also involve creating a favourable institutional environment for new innovations (Farla *et al.*, 2012).

An important link to the external societal environment which facilitates the development of new technological innovations is provided by the *innovation*

system — concept (Nelson and Nelson, 2002; Hekkert *et al.*, 2007). Innovation systems can be considered as the broader institutional structures that support technological innovation, including such elements as universities, governmental funding programs, and regulations (Nelson and Nelson, 2002). Several studies have attempted to dissect innovation systems to categorise the various activities that they include (e.g., Bergek *et al.*, 2008; Hekkert *et al.*, 2007). Table 2 offers an overview of these functions.

The actors involved in the innovation system include not only the innovating firms and their shareholders, but also their various stakeholders (Farla *et al.*, 2012). Policymakers and public authorities can play a large role in creating a favourable regulative environment for an innovation. Consumer demands have a vital role in guiding the characteristics of an innovations. Employee values can play a role in the development of sustainable innovations, and also various civil movements and the perceptions of the wider society have an impact on decision-making for innovators.

The innovation system concept has received considerable attention in regard to societal issues such as sustainability. The success of sustainable innovations depends to a large part on their environment, and the structure, and dynamics of the innovation system (Alkemade *et al.*, 2007). The support of an innovation system for specific technological sectors, such as renewable energy (Foxon, 2005; Shum and Watanabe, 2009) sustainable transport technologies (Farla *et al.*, 2010) and sustainable water management (Ward *et al.*, 2012) has been studied. However, the focus in these studies has been mostly on the physical technologies involved in the innovation system. As demonstrated by the archetypes of SBM, SBMI can also take the form of innovations in social technologies. There is a lack of a holistic perspective on innovation systems and SBMI.

Table 2. Functions of innovation systems.

Function	Example
Entrepreneurial activities	Encouraging experimentation with new technologies
Knowledge development	Pilot projects
Knowledge diffusion through networks	Workshops and conferences
Guidance of the search	Governmental R&D funding
Market formation	Forming "nursing markets" from pilot projects
Resource mobilisation	Human capital (e.g., education), financial capital, complementary assets
Creation of legitimacy	Supportive regulations, lobbying

Sources: Hekkert *et al.* (2007) and Bergek *et al.* (2008).

Methodology

This explorative study is part of a more extensive foresight research. Our analysis is based on data from themed expert interviews and a two-round qualitative Argument Delphi (Kuusi, 1999). The aims of the Delphi study were to explore how sustainability is integrated into firms' business models in 2030, and identify how the transition towards SBMs will be achieved. This complex issue requires knowledge from people who understand the different economic, social, environmental, and political issues there. By reason of this complexity the Delphi method was applied in this study.

The Delphi is a qualitative research method that is applied widely to a variety of problems. Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals to deal with a complex problem (Linstone and Turoff, 1975). The key characteristics of a traditional Delphi study are anonymity in the responses, iteration of the questionnaires, controlled opinion feedback, and group statistical response (Landeta, 2006; Rowe and Wright, 1999). Traditionally, Delphi studies have aimed at reaching consensus among experts, when Policy Delphi (Turoff, 1970) studies have acknowledged also disagreement of preferable futures. Argument Delphi (Kuusi, 1999) that is used in this study can be seen as variant of the Policy Delphi.

The Delphi typically entails two or more survey rounds, and the procedure relies on a panel of experts. Delphi is an appropriate method to bring a large number of qualified experts who have heterogeneous backgrounds together. The selection of experts is the crucial phase of the process. The exact procedure (Okoli and Pawlowski, 2004) that is based on nominal group technique by Delbecq *et al.* (1975), and the matrix of expertise (Kuusi, 1999) for selecting appropriate experts were followed.

In order to prevent overlooking any important class of experts a research team of five academic researchers first identified relevant categories of experts without identifying them by names. After careful consideration and discussions with other research group and practitioners a team ended to use the matrix (Table 3) where each heading at rows and columns represents a different lens for considering and identifying experts. Experts were categorised in six groups: (1) Business managers/executives, (2) Consultants, (3) Researchers, (4) Government/authorities, (5) Non-profit organisations, and (6) Students. To achieve more variation among panellists their different background and expertise were ensured by PESTEL point of view. The group of non-profit organisations was chosen because new collaborative partnerships and alliances with non-profit organisations (Dahan *et al.*, 2010; Michelini and Fiorentino, 2012) are highlighted in building some SBM

Table 3. Delphi panel.

	Political Economical Social Technological Environmental Legal
Business managers	CEOs and Business, Technology, Energy, Environmental and R&D Managers at large companies and SMEs
Consultants	Business consultants
Researchers	Academic researchers, Professors and Scientists in Technology, Business, Law, Corporate Responsibility, and Consumer research
Government/authorities	Ministry of the Environment, Ministry of Employment, and the Economy, Ministry of Agriculture and Forestry
Non-profit organisations	Corporate Responsibility Network
Students	Bachelor, Master, and Doctoral students in Technology, Business, and Law

archetypes. By reason of the time horizon the students who are the future business executives and decision-makers, were selected. Web searches, literature review, personal contacts, and snowball sampling were used to populate the categories with actual names. The experts were selected based on their expertise on the subject matter, capacity and willingness to participate, and effective communication skills. Altogether 42 experts were named to the Delphi panel. The experts represented Finland.

Survey procedure

This study was carried out during October 2012–March 2013. The themed semi-structured interviews that took place between October and November 2012 started the study process. Eight experts who represent business, academia, and politics were interviewed. On an average each interview lasted about 90 min. The objective was to shed more light on the role of the business to enhance sustainable development, the enablers and barriers to SBMI, and visions of ideal SBM in order to focus on the important issues and form the interesting statements for the following online Delphi rounds that were carried out during February 2013–March 2013. Further, the comments among the experts in the first round served as a basis for the second round questionnaire.

The main dimensions of the questionnaires were (1) drivers and barriers to SBMI and (2) elements of SBMs. The questionnaires of the both rounds contained closed and open-ended questions. The experts evaluated the statements first on a 7-point Likert scale (e.g., ranging from totally probable to totally improbable and ranging from totally desirable to totally undesirable) and after that they gave written arguments. The open-ended questions allowed the experts to comment

relatively freely on the SBMI. The experts were encouraged to interaction. Real-time Internet-based Delphi format allowed the possibility of having synchronic dialogue between experts. After both the rounds the experts had the opportunity to comment other panellists' answers, and they also had the opportunity to clarify their own comments during the process. The responses were anonymous.

Data analysis

From the 42 experts, 40 responded to the first round Delphi inquiry, and 27 participated in the second round. The overall Delphi procedure produced a rich set of data. Written comments on the statements as well as the former transcribed interview data were analysed with qualitative methods. The qualitative analysis of the data was carried out based on the content analysis. The main focus in the analysis was on identifying the similarities and dissimilarities, and describes divergent themes and types.

We proceeded in three steps. First, we identified the major barriers to the different SBM archetypes. Second, we grouped the barriers to the diffusion of the SBMs under three main categories. Third, we analysed how these barriers can be overcome by strengthening the functions of the innovation system.

Barriers to SBMI

Barriers to SBM archetypes

Existing research on SBMs has identified several archetypes of strategies firms can pursue for SBMI, but their adoption by firms has been slow. Several obstacles stand in the way of their diffusion. Based on the expert interviews and Delphi rounds different barriers to technological, social, and organisational oriented SBMIs have identified (Table 4), and the following observations can be made. Lack of strict legislative pressure and economic incentives are seen as main barriers to technological oriented SBMIs, and lack of consumer or customer acceptance and economic incentives to social oriented SBMIs. Dealing with organisational oriented SBMIs attitudes and values and larger structural barriers are emphasised.

Technological oriented sustainable innovations related to pollution control, resource efficiency, and renewable-based business are quite well supported by regulation mechanisms. However, the world is currently using equivalent of 1.5 planets to support human activities. The experts in this study think stricter legislative pressure and supportive economic incentives are needed to achieving sustainable economy. Radical resource scarcities lead to remarkable increased prices

Table 4. Barriers to SBM archetypes.

Innovation type	SBM archetype	Main barriers
Technological	Pollution control	• Lack of strict legislative pressure • Lack of economic incentives
	Maximise material and energy efficiency	• Lack of strict legislative pressure • Lack of economic incentives • Lack of awareness and understanding
	Create value from waste	• Lack of legislative pressure • Lack of economic incentives • Lack of awareness and understanding
	Substitute with renewables and natural processes	• Lack of clear legislative pressure • Lack of economic incentives
Social	Deliver functionality rather than ownership	• Lack of consumer/customer acceptance • Lack of economic incentives
	Adopt a stewardship role	• Lack of consumer/customer acceptance • Short-term profit maximisation • Lack of transparency (challenging supply chain control in global environment)
	Encourage sufficiency	• Lack of consumer/customer acceptance • Lack of economic incentives • Lack of legislative pressure • Lack of international agreement (e.g., substitutes from Asia)
Organisational	Re-purpose the business for society/ environment	• Attitudes and values • Lack of awareness and understanding • Lack of incentives/support • Short-term profit maximisation • Structural barriers
	Develop scale-up solutions	• Attitudes and values • Lack of awareness and understanding

and further resource efficiency because of its cost-effectiveness. However, resource scarcity is a relative concept. It is easier to use resources today than predict resource scarcity of the future. Without strict price control for resource usage and significant waste charges the real value of raw materials and waste will not be noticed. Lack of economic incentives for cleaner production methods, technologies and solutions, and lack of sanctions and prohibitions for unsustainable ones are noticed. Low carbon and renewables-based solutions are high-priced, and incentives that motivate to pick cleaner technology in every circumstance are not encouraging enough. In addition to regulatory barriers, lack of awareness and understanding is emphasised. The broad perspective over the whole value network

is missing. Resource efficiency and creating value from waste require new partnerships across industries and new business models.

Sustainable technologies hold the promise to reduce harmful emissions and use resources more efficiently that is important in tackling environmental challenges. The experts pointed out that it is not clear that consumer habits change towards sustainability through new technologies. Efficiency in material and energy use generates rebound-effects. The driver who replaces a car with a fuel-efficient model, only to take advantage of its cheaper running costs to drive further and more often is an example of a rebound effect (UK Energy Research Centre, 2014). Hence, social and organisational oriented SBM innovations that focus on changing consumer behaviour and seek wider organisational and cultural changes in business practices are crucial.

While lack of legislative pressure is emphasised with technological oriented innovations, lack of consumer or customer acceptance is seen as main barrier to social oriented SBM innovations. The experts do not see social oriented innovations as dominant today. Consumer habits are handed down from generation to generation and the youth of today will also supply material need. Consumers or customers appreciate rather cheap price than sustainability aspects, and firms answer these calls. We have created a "disposable" culture where is more profitable to produce or buy cheap and short-lived products than offer or buy e.g., more sustainable repair services. The public sector support private ownership and free consumption. Many industries are based on extremely fast cycles of fashion, and firms focus on short-term profit maximisation. Radical changes in consumer preferences are needed, but there is still call for cheap products. Thus regulation that offer cost-benefits for customers, and do not encourage to overconsumption is needed.

Attitudes and values and common understanding are seen major barriers to the diffusion of organisational oriented SBM innovations. Business aims to maximise economic profit and short-term financial gain, not focusing on long-term strategic planning. Profitability indicators do not support prioritised delivery of social and environmental benefits. Different forms of businesses, e.g., social businesses, cooperatives, collectives, are not well supported by regulatory bodies. In order to SBMs become common at large scale structural changes in legislation and economy are needed.

Barriers to the diffusion of SBMs

Overall, the above-mentioned key barriers to the diffusion of SBMs can be structured following three categories: (1) Regulatory, (2) Market and financial, and (3) Behavioural and social (Table 5). What is notable, the diffusion of SBMs is not

Table 5. Barriers to the diffusion of SBMIs.

Regulatory barriers	Market and financial barriers	Behavioural and social barriers
• Lack of long-term strict legal regulatory frameworks • Inconsistent and overlapping regulatory mechanisms • Lack of economic incentives • Lack of encouragement to innovativeness • Lack of flexibility • Lack of involvement of stakeholders in decision making • Lack of normative rules/industrial standards	• Financial risk • Short-termism • Lack of awareness and understanding among market participants • Lack of marketing know-how	• Attitudes and values • Lack of consumer/customer acceptance • Lack of risk-taking • Enterprise culture • Leadership, management • Lack of motivation • No stakeholder pressure • Profitability of existing business models/satisfaction

seen as technologically focused issue. The experts think the technologies (such as Internet, 3D technology, renewables-based energy innovations) of today make sustainable business entirely possible. It is not a question of new technologies; it is more like a question of attitudes and values and regulation mechanisms. The crowd does not see sustainability attributes as dominant. Consumers appreciate good products and services at an affordable price, and they do not see environmental and social problems, until middle of the crisis. Firms comply with regulation, but they do not take steps above it voluntarily.

Particularly the responsibility of the regulatory bodies was emphasised in every discussions. As mentioned before the experts in this study demand stricter legislative pressure and supportive economic incentives. The experts underline the importance of regulatory and financial mechanisms that lead to the introduction of new technological innovations, but also guide to use old technologies in a sustainable manner. However, regulation is extremely challenging. Lack of long-term regulatory frameworks leads to uncertainty and short-term investments, but politicians' time frame differs from firms'. Too loose regulation does not motivate, but too strict regulation at the early phase of development discourages to develop rival innovations. Lack of stakeholders' involvement in decision-making process not only leads to inconsistent and overlapping regulation mechanisms but also opposition to the regulation.

From a market perspective a distinct lack of awareness and understanding of SBMs amongst firms, financiers, and consumers can serve to limit the both supply and demand. Firms (particularly small and medium enterprises) do not have adequate understanding and market participants cannot identify partnerships that are

needed to developing sustainable business. Firms do not master sustainable marketing and customers do not know how to make sustainable choices. Many firms are financially successful in their current form and in the current environment, therefore, they may be unwilling to change as they have a vested interest in maintaining the status quo. Enterprise culture does not fully support sustainable business, and financial risks lower the motivation. Holistic change is required to tackle the challenges. The diffusion of SBMs requires collaboration and involvement both at the society and individual level. Changes in consumer habits and legislation as well and new business models are prerequisites for a more sustainable society.

Transition Towards SBMIs

To understand the successful diffusion of SBMs, we will next examine the technological innovation system functions in relation to the barriers to SBMI (Table 6). We will explain how the different functions can act to removing or decreasing the identified regulatory, market and financial, and behavioural and social barriers to SBMI.

Entrepreneurial activities

Entrepreneurs, incumbents as well as new entrants, have a vital role in the development of new SBMs. Visionary executives who are willing to change and challenge the status quo are needed to overcome the behavioural and social barriers to SBMI. Entrepreneurs should also be encouraged to collaborate and form partnerships with various stakeholders that have an interest in their activities. Such collaboration can be promoted by forming platforms and coalitions around key sustainable development issues, which can act as a catalyst for new innovations. Policy-makers also need to support entrepreneurs with regulations that encourage potentially risky experimentation and pilot projects.

Knowledge development

Knowledge development is a vital function for advancing the understanding of sustainable business. For policy-makers, it is vital to understand the exact impacts of regulative mechanisms on firm activities. Firms need to be able to understand the meaning of sustainable value and its relation to sustained competitive advantage. This can be accomplished by increasing the understanding of the positive connections between corporate environmental performance and

Table 6. Functions of innovation system and for overcoming the barriers.

Barriers Functions	Regulatory	Market and financial	Behavioural and social
Entrepreneurial activities	Long-term legal frameworks; various encouraging regulative mechanisms	Collaboration	Adventurism; visionary executives and game changers
Knowledge development	Understanding of practical regulative mechanisms	New partnerships; New indicators	Education
Knowledge diffusion through networks	Stakeholders involvement; industrial norms	Communication; guidelines and instructions	Education
Guidance of the search	Structural changes in legislation and economy; long-term legal support	Incentives	Enterprise culture
Market formation	Stricter regulation; specialised policy instruments	Incentives	Eco-labels; eco-indicators
Resources mobilisation	Fair support for different technologies	Collaboration; ethical investments	
Creation of legitimacy	Lobbying	Informing; transparency	Media attention

financial performance. For example, increased understanding is needed on the financial impacts of environmental problems such as global warming. This understanding will help form new indicators for profitability that are more suited for sustainable development. Universities and research centres have an important role in advancing the knowledge on sustainability as well as diffusing this knowledge through educational activities.

Knowledge diffusion through networks

In addition to developing new knowledge, an important function of innovation systems is the diffusion of the knowledge through the relevant networks of actors in the system. In terms of removing the regulatory barriers of SBMI, political decision-making should aim to involve relevant stakeholders in decision-making and the preparation of policy instruments. Cooperation between governmental organisations and businesses can promote the formation of voluntary industrial norms in addition to regulations. The market and financial barriers can be addressed by sustainability-oriented communication in the innovation system. For example, the

development of guidelines for sustainability reporting can diffuse knowledge of sustainability issues between businesses and their stakeholders. Eco-labelling practices can make sustainable buying behaviour easier for consumers. The behavioural and social barriers can be lowered by improving education on sustainability, which can increase both consumer and producer acceptance of SBMs.

Guidance of the search

Innovation systems must also be able to focus on the limited resources that are available with them. Guidance of the search can be provided by governmental interventions, for example, by forming regulative frameworks that aim for long-term sustainable change (Hekkert *et al.*, 2007). Examples of these types of regulations are reduction targets for carbon emissions of market-share targets for renewable energy production. These forms of regulations can act as a catalyst for innovations in these sectors. Overlapping and inconsistency in regulations should be addressed to provide more clear goals for innovation activities. In regard to market and financial barriers, governments can also provide financial incentives such as tax cuts for sustainable technologies or deterrents such as emissions taxes that guide entrepreneurial activities through market mechanisms.

Market formation

The fifth key function of innovation systems is forming markets for new technologies. As new technologies often have difficulties initially to compete with incumbent technologies, governments can create temporary niche markets to aid their commercialisation. Favourable regulations, sustainability standards, and tax incentives can all promote this. The market and financial barriers can be decreased by promoting a functional local home market, an important catalyst for commercialisation. Governments should ensure that home markets for new SBMs are functioning to provide a test market for firms before their technologies reach the mass market phase. Consumer acceptance can be advanced by improving the price competitiveness of sustainable products and services compared to unsustainable ones, as high prices are often a barrier for the mass-market appeal of sustainable products. Public procurement practices can also support the adoption of SBMIs.

Resources mobilisation

New innovations also require resources, such as human and financial, to take off. Governments can design R&D programs that channel resources towards specific innovations. In terms of overcoming the barriers to SBMI, programs should aim to

support a diverse range of new technologies and innovations, such as biofuels, electric cars, and fuel cells in the case of sustainable transportation. This ensures a range of options for moving to SBMs. The market and financial barriers can be overcome by forming collaborative alliances and coalitions, increasing the amount of available resources for specific innovations.

Creation of legitimacy

Lastly, a vital function of innovation systems is also to create legitimacy for the focal innovations, as incumbent technologies and parties with vested interests often cause resistance to change (Hekkert *et al.*, 2007). The innovators for SBMI need to form new associations and use positive lobbying for policy-makers to gain resources and a more favourable environment for new technologies. Dissemination of success cases and stories among business actors is important for overcoming the market and financial barriers, to create awareness of the possibilities for SBMIs that are also profitable. Behavioural and social barriers can be overcome by promoting awareness of environmental/social problems in the media as well as success stories of solutions to those problems.

Discussion and Conclusion

In this research, we examined the barriers to the diffusion of SBMIs. We examined the existing theoretical frameworks from SBMI and highlighted the archetypes of SBMI focused on technological, organisational, and social innovations. Through a qualitative Delphi study consisting of a panel of 42 experts, we identified several important barriers to SBMIs. These were focused on three primary areas: *Regulatory*, *market and financial*, and *behavioural and social* barriers. Lastly, we applied the functions of innovation systems-framework (Hekkert *et al.*, 2007) to analyse how these barriers can be overcome through the activities of governments, firms, and consumers. We will next discuss the wider implications of our research for practitioners, policy-makers, and researchers.

First, our research highlights the importance of well-functioning regulatory frameworks for SBMIs. Mechanisms such as emission regulations, taxes, subsidies can aid the commercialisation of new innovations. Regulations should not be formed around short-term political interests, but on long-term societal trajectories for sustainable innovations. Policy-makers should also avoid forming several overlapping, or even inconsistent regulatory frameworks. At the same time, regulations should also support a diverse set of alternate sustainable innovations, as multiple viable solutions can increase sustainable development.

Second, the role of voluntary business activities is also vital for the diffusion of SBMIs. As businesses are mostly driven by economic concerns, they will most likely focus on adopting SBMs that provide win-win situations (Escobar and Vredenburg, 2011). At the same time, visionary entrepreneurs are needed to adopt radical new innovations, and the environment of the innovation system should support this. Businesses need to collaborate with their stakeholders in sustainability issues, and also with each other to form common norms that support SBMI. In addition, sustainability reports and eco-labels are needed to allow consumers to make sustainable buying decisions.

Our study contributes to the research on innovation systems and societal change by giving an example of how the functions of innovation systems-framework can also be applied with a broader view on SBMIs, and not just focused on specific sustainable technologies. This broader view can uncover possible conflicts and overlapping regulations in regard to how the different functions support sustainable innovations. It also aids in recognising synergies between activities that support the various kinds of SBMI, which can help in developing innovation systems with a wider impact. Conversely, this wider view can also lack details related to specific kinds of innovations. Therefore, we suggest that future research could utilise a mid-level approach and focus on specific archetypes of SBMI.

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