From problem to solution

A few stories about design and business for sustainable development

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DOI
10.4233/uuid:69d868ef-33d0-4abf-a33c-dac9a0577e78

Publication date
2020

Document Version
Final published version

Citation (APA)
Baldassarre, B. R. (2020). *From problem to solution: A few stories about design and business for sustainable development*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:69d868ef-33d0-4abf-a33c-dac9a0577e78

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

From problem to solution: A few stories about design and business for sustainable development

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus prof.dr.ir. T.H.J.J. van der Hagen
chair of the Board for Doctorates
to be defended publicly on
Thursday 21 January 2021 at 10:00 o'clock

by

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This research was funded by the European Commission through the Horizon 2020 research and innovation programme, under grant agreement N° 730390.

PREFACE

This thesis is about a research journey, which started long before the beginning of this PhD, driven by curiosity and personal motivation. It is a collection of stories from this journey. The intent is to put on the table a few ideas that may inform, maybe inspire, the work of others. Hoping to make these stories interesting and accessible for a broad audience, I use a simple language, free from academic complexity. Nevertheless, in order to address also an academic audience, each story is followed by a peer-reviewed publication diving into the content using a more orthodox format, as required from a PhD thesis.

ACKNOWLEDGEMENTS

Thank you family, thank you friends. We've already been through this twice, at the end of my undergraduate and graduate degrees. There's no need to repeat again what was already said, and remained unchanged. This time, I want to spend more words to thank the people that I have been working with, because it is them who made this PhD a significant and positive experience.

Thank you Zero Brine stakeholders. For the work done together on this project, that is important to make our sustainable European Union happen. Thank you researchers and innovators at RMIT, Monash University, the Australian Fashion Council and BehaviourWorksAustralia. For being professional and at the same time so friendly, making me feel welcome on the other side of the planet. Thank you Innoboost. For the constructive interactions during the circular business innovation workshops. Thank you members of the Academy for Design Innovation Management Collective. For the work times, and the fun times. Thank you co-authors. For making the academic writing a more collaborative and enjoyable experience. Thank you colleagues in the Design, Organization and Strategy department, and in the Circular Design group at the faculty of Industrial Design Engineering of TU Delft. For the work we do together to explain what design is, how it can be used by organizations, and why it is relevant to build a better future. Producing this knowledge is a shared effort, and I am very proud to be part of this with you. At the same time I am glad that I had the opportunity to know many of you not only as colleagues, but also as wonderful people. In particular, thank you PhDs of room B-4-360, also known as "the aquarium" by those who swim inside it. Thank you for sharing with me an office space every day, and more importantly your friendship throughout this journey. Finally, thank you supervisors. Although in very different ways, you played a fundamental role in my growth as an academic and as a young man. For this, I am truly grateful to you more than anybody else, and I want to thank you on a more personal level.

Thank you Erik Jan. For being an undisputed chieftain who dispenses the advice you need at the right time, talking about the highly important matters concerning research and design, but also about David Bowie, African wilderness, you name it. Whatever the subject, I truly enjoy chatting with you, and appreciate your support and legendary attitude since the good old times of Red Wing Shoes: built to last.

Thank you Nancy. For being open to collaborate with me right away the first time I contacted you, and for proposing me to undertake this PhD: without you, I would not be here today. Thank you for being a great role model. I respect your ideals, admire the pragmatism through which you pursue them, and observing how you operate has been an important learning experience. Thank

you for giving me a map and a compass, but also the freedom to set sail on my own course. I look forward to keep working with you.

Thank you Ingo. For being genuinely interested since we first met, not only in the researcher, but also in the person behind it. This is something I never take for granted, and I appreciate it more than anything else. One time, in Amsterdam, you told me that I ask the right questions. I want to thank you for giving me the right answers. Also, thank you for inviting me to work with you in Melbourne. Arriving Down Under, it did not take me long to realize that you are not only a very cool professor to learn from in a broad sense, but also a friend. I am glad about our friendship.

Thank you Giulia. My gratitude to you is bigger than I can express with words. Thank you for being there and trusting me from the very beginning, when I was still a student, at times worried about becoming a fully-grown professional. Thank you for showing me what it is like to be an academic who believes in the value of dialogue and education. Thank you for pushing me when you thought I had to learn something new, and for letting me do it my way when you saw that I could manage. Thank you for listening and answering all my questions, and for always helping me. Thank you for being a real person and sharing of yourself as well. Thank you for caring. I care too.

This research was funded by the European Commission through the Horizon 2020 research and innovation programme, under grant agreement N° 730390.

SUMMARY

The intensification of human activity, driven by a perpetual growth paradigm, is causing an alarming environmental crisis intertwined with societal issues on a global scale. A solution to this problem is urgently needed. This doctoral thesis discusses how to turn the problem into a solution through innovation. Specifically, the main objective of the research is exploring and explaining how to use design as a support for business innovation toward sustainable development. In this context, the term "design" indicates a creative, yet rational problem-solving process for turning current situations into preferred ones. "Sustainable development" is the overarching problem we are confronted with today, manifesting itself as a set of environmental and societal challenges, such as resource depletion, climate change and massive migratory flows. The expression "using design to support business innovation" means leveraging theoretical knowledge and practical expertise around the mentioned design process, in the context of strategy and innovation management.

Driven by curiosity and personal motivation, I have been working on several projects, engaging with this subject in different ways: as a designer, entrepreneur, innovation consultant, and as academic researcher. Sometimes the boundary between these roles was blurred, which was challenging but at the same time gave me the opportunity to develop and refine theoretical ideas while remaining with my feet grounded into practice. Accordingly, this thesis is structured into several chapters. Each chapter opens with a personal story, followed by a peer reviewed academic publication. In Chapter I, the first story is about my growing understanding of how to play a role in the transition toward sustainable development, working as a professional designer within business organizations. The first publication is based on a literature review and expert interviews, examining in detail how sustainable design theory is applied in business practice. In Chapter II, the second story is about my entrepreneurial work aimed at creating a solution to reduce energy consumption and promote sustainable behavior inside office buildings. The second publication leverages this case, and a research-through-design method, theorizing how to design a startup driven by sustainability objectives. The third story opening Chapter III is about my collaboration with two colleagues, working at the boundary between academia and industry to help business organizations becoming more sustainable. The third publication focuses on a part of this work, using a design science research method to provide organizations with concrete guidance for executing small-scale pilots and therefore implement sustainable business ideas. In Chapter IV, the fourth story is about an eco-industrial cluster in the Netherlands, where waste heat and carbon emissions from a chemical factory are channeled into nearby greenhouses as a resource input for growing tomatoes. The fourth publication is based on the analysis of this case, theorizing how to

design eco-industrial clusters. The last story in Chapter V is about a large European project I am involved in, and related events taking place overseas, which triggered a personal reflection on design, business and policy making for sustainable development. The fifth publication is based on a problematization method, diving into design thinking and responsible innovation theories, to then discuss how business and policy actors can collaboratively foster sustainable development.

These five publications advance knowledge within and across three fields of scientific research located at the intersection of the three main concepts examined in this thesis: design, business, and sustainable development. At the conceptual intersection between design and sustainable development, the contribution to the field of sustainable design is integrating important business and policy concepts, discussing solutions to societal and environmental challenges in terms of innovative products, services and business models within policy frameworks and directives. At the conceptual intersection between business and sustainable development, the contribution to the field of sustainable business innovation is integrating theoretical and practical design expertise, discussing design as the essence of the experimental process dimension needed to move from abstract speculations to tangible societal and environmental impact. At the conceptual intersection between design and business, the contribution to the field of design management is integrating responsible innovation theorizing, discussing the design thinking practices of framing, envisioning, co-creating, and prototyping, as key mechanisms to iteratively turn societal and environmental challenges into solutions.

The five publications also contribute to advance innovation practice. Specifically, they contain relevant implications for designers, business managers and, to a more limited extent, for policy makers. The main implication for designers wanting to play a role as change agents in the transition toward sustainable development is that they need to: become available to work in more strategic positions dealing with business and policy issues; learn to think from different perspectives and to talk multiple “disciplinary languages” for communicating with managers and policy makers; learn new activities and act more entrepreneurially; be aware that while doing all of this, they will be constantly challenged by other professionals to legitimate themselves. The main implication for business managers is that they should: collaborate externally with other organizations, entrepreneurs, policy makers and academic institutions that have relevant knowledge about sustainable innovation; hire designers, and empower them to work in strategic roles as a way to find a balance between what people need, what is technically achievable, what is economically possible, as well as what is ethically acceptable for society and the environment.

Finally, the main suggestion to policy makers is leveraging design expertise and skills as well, in order to foster a more responsive policy making process, which is needed to keep up with a fast-evolving reality.

The main limitation of this work is related to the qualitative approach for data collection and analysis employed within all the five scientific publications encompassed by the doctoral dissertation. Consequently, the proposed findings and insights should be understood as a relevant starting point for better understanding how to address environmental and societal challenges through a design process. Furthermore, objectively evaluating the benefits of performing the design process in business and policy making, as well as quantifying its impact against sustainability problems, is a critical issue that was not examined by this research and remains under-addressed. Future research may focus on this important aspect through a quantitative approach and longitudinal case studies.

TABLE OF CONTENTS

INTRODUCTION

MOTIVATION AND RESEARCH OBJECTIVE

This is probably my oldest memory. When I was three years old, I went to the Alps for the first time. I remember towering purple flowers and the bees buzzing busy around them, while my father tells me to keep walking upward, using the help of my hands to move faster on steep terrain at the feet of the big mountain. The sun warms my back. The wind chills the tips of my ears. The mind is empty: as I line up one step after another, I feel part of a perfect equilibrium. Growing up, I kept going back to the mountains in order to renew this feeling again and again. I still do today. For me, mountains are one of the last places left untouched where it is possible to live fully in the present, and experience from head to toes what it is that makes us human. We are part of nature, and nature is where we come from. If we destroy it, we will ultimately forget who we are. Using my time and skills to give a contribution—however small and possibly insignificant—to protect this beautiful planet has been the rationale that guided my choices so far, first as a student and then as a young professional. I hope that these dramatic opening lines have captured your attention. To be honest, these existential thoughts have not always been so clear in my mind since the days when I was three. Back then my ambition was to become a paleontologist, just like Dr. Alan Grant, my hero from the movie Jurassic Park. In high school, trying to survive the dullness of the math class, I spent a fair amount of time doodling and sketching random ideas on a piece of paper. At the age of eighteen I began to wonder whether it would be possible to make a living out of it. That is how I found myself at Politecnico di Milano studying industrial design.

During my first undergraduate year, the curriculum demanded to design some fancy chairs and revolutionary kitchenware to save time chopping down apples or potatoes. I began to question the value of my studies. I found that most products are designed without even thinking if we really need them or not. Eventually, most of them end up in a landfill, polluting the ground and the water we drink, or in the ocean, swamped by floating plastic that kills marine ecosystems. I understood that this issue is particularly acute in less developed countries, where nature is often most beautiful until we ship all our waste over there, in the silent belief that the well-being of sea turtles and people with no money is less important than our own. These ideas almost pushed me to drop out and change studies. Until one day, I attended a lecture where an inspiring professor explained that design is not about chairs, but rather about a process to solve problems. He said that designers should be active agents of change in the transition toward sustainable development, inventing solutions for improving the quality of life in societies around the world, while also protecting giant pandas, king penguins as well as those bees and purple flowers vividly impressed in my childhood memory. This helped me to finally find in design a sense of purpose that resonated with my personal beliefs. All of a sudden I knew what I wanted to do. In order to learn more on the subject,

I worked as an intern in the design, innovation and sustainability research unit at Politecnico di Milano. Then, I graduated with a focus on water decontamination in developing countries, and shortly after went to Honduras to work on a related project in collaboration with the University of Rome and the United Nations Development Program. These experiences showed me that sustainable design works in practice only if the financial ties will bind. This insight came with the realization that I knew nothing about business. In the meantime, I had found that Delft University of Technology would be a good place to specialize in this direction.

I enrolled in a master program called strategic product design, which promised to teach me about the business aspects related to the specialty of design, in other words, innovation management. Pursuing a minor in sustainable development, I worked on many projects around environmental and social challenges in different parts of the world. For example, together with my fellow students and friends Philip, Phil, Karan and Andrei, I had the opportunity to collaborate with a large German automotive company, designing a concept for a car sharing service powered by hydrogen fuel cells. With Filippo, Daniel and Kathryn, I spent a semester in India working for a social enterprise developing a sustainable solution for urban mobility, while improving the livelihood of people in the slums. In Colombia, I got involved in a project aiming to intervene in the supply chain of fruits and vegetables, in order to support small family-owned businesses in competing with large supermarket chains at the outskirts of Bogotá. These experiences in emerging markets made me realize how difficult it is to implement new design solutions in such contexts. This insight triggered my curiosity of better understanding what are the factors that influence their success, which resulted in my first academic paper presented at a design conference in Cape Town. Around that time, I do not remember exactly how, I started to wonder why the electricity bill that we get delivered to our home every month is written in a way that is hard to understand for most people, resulting in a lack of awareness about energy consumption. Playing with this idea, and discussing with some people and professors around the faculty, eventually got me involved in a graduation project focusing on energy efficiency.

The graduation project took place with Climate-KIC—the largest European public-private partnership for innovation and climate action—as part of an initiative aimed at reducing energy consumption in big office buildings through behavioral change. My contribution was designing and testing a digital service that would motivate office workers to save energy. This could be achieved by empowering them to donate money to environmental conservation projects on behalf of their company every time they made certain actions. For example, when switching off a

light, they could scan their badge on a sensor and the employer will donate 1 Euro to protect the rainforest. Most big companies already have a donation budget in place after all, so the money for that is there anyways. Following graduation, Climate-KIC gave me some funding to work further on this idea and turn it into a new venture together with my good friend Diego, helped by Karel and later by Vittorio. We built a working prototype, developed a business plan and discussed pilot projects with potential customers. It was an intense time of professional as well as personal growth. To pay the bills, I started to work as an independent innovation consultant, growing a professional network, improving my business development skills, and collaborating on sustainability related projects with multiple clients, including large multinational companies, small enterprises and the public sector.

These experiences were valuable to gain a deeper understanding of the business case underlying sustainable innovation, and how the discipline of design can be leveraged to integrate environmental and social criteria with economic ones. As my understanding increased, so did my questions, and this is why I started to read more on the subject. I kept my connection with academia alive. With the support of my mentor Giulia, I used my entrepreneurial work as an input for theoretical investigations. We wrote a journal paper on how to create new business opportunities driven by sustainability objectives. In this process, I came across many academic articles written by a person called Nancy. On her blog, she defined herself a “pragmatic idealist”, and her ideas on sustainable business made good sense to me. I contacted her, we met and she agreed to coauthor the paper with us. In a way, my PhD had already begun. Soon, we submitted additional research work about environmental entrepreneurship to a sustainability conference, and collaborated on a second journal paper. Then, Nancy got me involved in a project to establish collaboration in eco-innovation across Europe and China. Finally, Nancy and Giulia asked me if I wanted to work with them for the coming years as an academic researcher on a large Horizon 2020 project focusing on resource recovery, as part of the circular economy strategy of the European Commission. I accepted and that’s how this PhD officially started.

While explaining my personal motivation, the previous paragraphs put in context the guiding objective of my research work. My goal was to understand how to work with design and business toward sustainable development. The following lines and Figure I summarize and visualize my initial understanding of what this means. As a design student, I realized that sustainable development is a pressing problem that deserves attention. This problem is visualized with the circle on the left side of the figure. Accordingly I decided to focus my time, energy and design

expertise on designing solutions to this problem. The design expertise is visualized with the circle on the right side of the figure. As explained, engaging in project work in this space, I realized that sustainable design cannot occur in the vacuum: it must be grounded into business, which allows turning ideas of a sustainable future into reality. This is visualized with the wider concentric circle on the right side of the figure, which represents the business aspects surrounding design. A simple example to clarify what all of this means, is a company that designs high-quality durable plates, and also aims to provide a supplementary dishwashing service for large events, such as fairs, a public holidays or music festivals. This solution allows the company to increase profits by exploiting a market opportunity. At the same time it contributes to preventing the waste of single-use plastic plates and related environmental issues, such as poisoning our drinking water or choking a wandering albatross in the middle of the Pacific. However, launching this type of business is not easy. It requires assessing to what extent the new product and service design is technically feasible and economically sensible from the perspective of the company producing and selling the plates. Importantly, it is also essential considering if somebody would be interested in paying for the solution. Indeed, this initial understanding was rather basic, going little beyond common sense. Accordingly, the objective of my PhD research has been to dig deeper into this subject:

Better understanding how to work with design, and business, toward sustainable development

Figure I. Visual representation of working from problem to solution, with design and business toward sustainable development

BACKGROUND CONCEPTS

The present doctoral research project investigates how to work with design and business, toward sustainable development. Before following further, it is essential to clarify some background concepts.

Working with design, and business, toward sustainable development: a historical perspective

Most people usually understand design solely as an activity that emerged after the industrial revolution as a way to give a form and a function to products. However, this is not the case (Simon, 1968). Design occurs since our ancestors started to walk the earth, and it is ultimately about connecting an understanding of the (external) natural environment with the (internal) aspirations of the human spirit, in order to devise solutions for improving our living conditions as a species (Archer, 1979). For example, the process by which early humanoid species learned to control fire can be seen as an act of design.

Fast-forward 300,000 years

Long after the days when we were sleeping in the caves, during the French and Industrial Revolution, some empiricist and positivist thinkers became interested in the study of society, with the intention of making it better by redesigning the rules that regulate it. After the Great War, this idea let to architectural modernism, a movement calling for a more rational approach in the creation of industrial objects and buildings that shape the environment we live in, thus our lives (Galison, 1990). That's how the word design eventually assumed the meaning that is commonly associated to it today: "Ferrari! That's some good Italian design indeed". However, the point I am trying to make is that there is much more to design than just objects (Buchanan, 1992). The essence of design is not in the final result: it's in the process (Schön, 1983; Simon, 1968). Scientific research on this subject has been going on for over six decades, since the early definition of design as a rational and creative problem-solving process to "change existing situations into preferred ones" (Simon, 1968). One of the distinctive traits of the design process is its ability to deal with "wicked problems" (Buchanan, 1992)—in other words complex and systemic problems, which cannot be definitively described, and have no single, right or wrong solution (Rittel and Webber, 1973)—by iteratively introducing, testing and improving something new (Simon, 1995). In the 1950s, Richard Buckminster Fuller, an American inventor, architect and philosopher, put forward the concept of a "comprehensive anticipatory design science", mainly as a response to global environmental and societal concerns related to fast growth and industrialization taking place

after World War II (Fuller, 1957, 1969; Galison, 1990; Massey, 2012). Furthermore, he called for a "design science revolution" and heralded the 1960s as the "design science decade" (Chamberlain et al., 2012; Cross, 2001). In this decade, several developments contributed to shaping design as a discipline and research subject (Bayazit, 2004). In 1962, the conference on design methods in London represented the first attempt to apply scientific methods to design (Cross, 2001, 2007; Huppatz, 2015). In 1966, the foundation of the design research society was a further attempt to promote a design methodology and creating a scientific field of inquiry around the topic (Bayazit, 2004; Huppatz, 2015). This decade culminated with the ideas of Herbert Simon, an American economist and psychologist who focused on complexity theory and decision-making processes (Cross, 2001; Huppatz, 2015; Meng, 2009). Influenced by positivist philosophy and contemporary developments in computer sciences and artificial intelligence, Simon wrote "the sciences of the artificial", in which he argued that while "natural sciences" study "how things are", design sciences are concerned with "how things ought to be" (Simon, 1968). With this book, Simon conceptualized design as a rational problem solving process.

Fast-forward 50 years

By the early 2000s, some of these ideas had consolidated enough to become actionable (Bayazit, 2004; Cross, 2001), and stimulate the interest of business (British Design Council, 2007). Around 2008, Tim Brown, a British designer and executive chair of the global consultancy firm IDEO, was very successful in condensing fifty years of former ideas on design—branding them with the (already existing) name of "design thinking" (Buchanan, 1992)—and selling them to companies as the "holy grail" for innovation in an increasingly competitive innovation landscape (Brown, 2008, 2009). One of the keys to his success was turning complex theoretical lucubration into a short and simple explanation: design is an innovation process that entails moving iteratively across three "mental spaces": inspiration, ideation and implementation, in order to find the sweet spot across what people want (desirability), what is technically achievable (feasibility) and what is financially possible (viability) (Brown, 2008, 2009). Consequently, design became a mainstream object of interest for business managers (Dunne and Martin, 2006; Kolko, 2015; Liedtka et al., 2013), not only as a small function of the organization dealing with aesthetics and minor technical issues in product development (Dell'Era and Verganti, 2010), but rather as a relevant strategic subject (Martin, 2010). From this strategic perspective, the design process is currently seen as an approach for firms to gain competitive advantage (Martin, 2009). Academic research clarifies that working with design in business means performing design activities, such as building and

testing prototypes as well as using specific design methods and tools, in the context of strategy and innovation management (Calabretta et al., 2016; Micheli et al., 2019). In turn, doing this also requires adopting design principles such as embracing a holistic focus in integrating technology and business factors with real human needs (Calabretta and Gemser, 2015; Calabretta et al., 2017; Karpen et al., 2017), while reflecting on emerging outcomes and acknowledging that they may be constantly improved (Schön, 1992). Importantly, this mindset has to be integrated into the culture of business organizations (Elsbach and Stigliani, 2018; Micheli et al., 2018), which must become more flexible and risk averse, in order to innovate faster and more radically (Brown, 2008). This is needed to create meaningful outcomes (Verganti, 2011), including new products, but also new services, customer experiences, and more broadly new business propositions (Brown and Martin, 2015). Design can lead businesses to develop innovative solutions that have a meaning in people's lives (Norman and Verganti, 2013; Verganti, 2008). However, looking at innovation from a broader perspective, in the awareness of the environmental crisis (Hardin, 1968; Meadows et al., 1972), it is impossible to ignore its implications, consequences and negative side effects (Whiteman et al., 2013). More precisely, while introducing every year an increasing amount of new "solutions" on the market we are also creating new (wicked) problems (George et al., 2016; Shevchenko et al., 2016). We are altering the climate on a global scale, depleting critical resources, destroying natural ecosystems, polluting the oceans, poisoning our own sources of food (Carson, 1962; Rockström et al., 2009) and on top of it all, we are perpetrating a consumption model that apparently does not even make us happy (Bauman, 1997). The greatest challenge we face today is the transition towards a more sustainable model of development (Brundtland, 1987; United Nations, 2015).

Rewind to the 1960s

While the post-war economic boom was in full swing, the concept of sustainability emerged as a response to increasing concerns about the impact of human activities on the planet (Carson, 1962; Fuller, 1969; Hardin, 1968). Basically, we started to suspect that if we all wanted to own a big house, two cars and a fridge full of red meat, mangoes and pineapples, there wouldn't be enough resources for everybody. At the same time we would end up having a massive problem with waste. The rise of space exploration played a role in making this inconvenient truth apparent by allowing for the first time the possibility to take pictures of our planet from far away. Some thinkers, including Buckminster Fuller, started to talk about a "spaceship earth", to make the point that our planet is not so big, and if we messed it up there wouldn't be anywhere else to go nearby (Fuller, 1969). In 1972, a group of scientist called the Club of Rome published a report titled "the

limits to growth", in which they argued that since our planet is a finite system, human development must not exceed its limits if collapse is to be avoided (Meadows et al., 1972). Sustainability was therefore defined as a dynamic state of development in which a complex system—our planet—can thrive without collapsing (Meadows et al., 1972). While consensus around this idea grew, the question of who would take responsibility for such a daunting problem remained open for a while. In this regard, Garrett Hardin had already written an article for the scientific journal "Science" titled "the tragedy of the commons", where he explained that while individuals are so busy pursuing their own interest within a competitive space, their selfish behavior would result in the pollution of natural ecosystems and depletion of critical resources, ultimately going against the common good (Hardin, 1968). To this end, in 1987 the United Nations drafted a document titled "our common future", in which sustainable development was defined as the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Since this important milestone in our history, the efforts to shift our ways of development in this direction have been—despite the awareness—insufficient. I hope the older readers will forgive me when I say that while the generation of my parents kept busy doing the "cultural revolution", smoking purple flowers, or maybe growing their social status by buying a brand new car every three years, the magnitude of these problems—such as resource depletion, but also climate change, related poverty and injustice—increased, along with the pressure to address them.

Today

In recent years, in order to move from discussion to action, the United Nations put forward a set of goals for countries and organizations to pursue sustainable development together (United Nations, 2009, 2015). The sustainable development goals (SDGs) defined in 2015 provide a comprehensive global agenda for sustainable development (United Nations, 2015). Nevertheless, this important initiative is not the only attempt to operationalize sustainable development: other paradigms exist (Geissdoerfer et al., 2017). One of the sustainability paradigms most commonly found in a business context is the "triple bottom line". The triple bottom line is an accounting framework for organizations, which calls for a more holistic approach in assessing business performance (Elkington, 1998). Specifically, the bottom line refers to the sum that appears at the end of the year at the bottom of the profit and loss statement of a company. The main idea is that this economic indicator should be integrated by evaluating performance also with social and environmental criteria, as articulated by the expression "people-planet-profit". Another key concept connected

to sustainable development in a business context is the notion of "shared value", which calls for more ethical and collaborative ways of doing business, in order to mitigate the negative impacts of the capitalist system (Porter and Kramer, 2011). Related to this, the idea of a "sharing economy" came with the promise of empowering people to exchange goods and services without the need of having as intermediaries large corporations, which serve the private interest in profiting from these transactions (Stephany, 2015). The "WEconomy" proposes an approach to combine environmental and social activism with the sustainability strategy of companies (Kielburger et al., 2018).
Using the word economy to define these alternative paradigms is a "clever device" to decouple the concept of sustainability from the idea of de-growth, and frame it as a business opportunity instead. The United Nations Environment Program adopted this expedient as well, putting forward a report about a "green economy", arguing for the need to pursue economic growth while using natural resources more efficiently (UNEP, 2011). The "doughnut economy" reframes the concept of planetary boundaries—the limits defining a safe operating space for humanity with respect to a set of parameters such as climate change, freshwater use and chemical pollution (Rockström et al., 2009)—arguing that while these limits shall not be exceeded, we must also satisfy the needs of society, which entails seeking a "comfort zone" between a societal floor and an ecological roof (Raworth, 2017). In Europe, the pursuit of a "circular economy" has gained significant momentum, catalyzed by policy making (European Commission, 2015) and by a British Foundation started by Ellen MacArthur, a professional sailor who was triggered to act by her survival experiences amongst the waves of the Pacific Ocean (MacArthur, 2013). The circular economy is not a sailing concept: it is rooted in engineering views (McDonough and Braungart, 2002; Stahel, 1994) and relates to a thriving, regenerative system in which resource input and waste, emissions, and energy leakage are eliminated (Bocken et al., 2017). Currently, the circular economy is one of the main programs on the European innovation agenda: the intention is to use this concept to lead the way globally in the transition toward a sustainable future (European Commission, 2020). This leading role is intertwined with the idea of promoting "responsible innovation", which is an overarching theme in the agenda and refers to a transparent and iterative process, in which—as for the SDGs—multiple stakeholders collaborate internationally to address the main problems of our time (Von Schomberg, 2011).

Definition of "working with design and business toward sustainable development"

The previous paragraphs provided a historical perspective that clarifies the background concepts discussed in this thesis. First, they explain that design is a creative, yet rational process to solve

complex and systemic problems, turning current situations into preferred ones (Buchanan, 1992; Simon, 1968). Second, they explain that working with design and business means using the ways of thinking and doing of professional designers in the context of strategy and innovation management (Calabretta et al., 2016; Micheli et al., 2019). Third, they frame sustainable development as the overarching problem of our times, manifesting itself as a set of environmental and societal challenges (Brundtland, 1987; United Nations, 2015). These challenges may be addressed by mobilizing and organizing collective action around different conceptual paradigms (Geissdoerfer et al., 2017), such as the SDGs, the "triple bottom line", the circular economy and responsible innovation (European Commission, 2020; United Nations, 2015). Building upon these theoretical grounds "working with design in business toward sustainable development" is defined as follows:

Working with design and business toward sustainable development means using rationality and creativity to steer the innovation strategy of organizations into addressing the major environmental and societal problems of our times.

RESEARCH GAPS, METHODS AND STRUCTURE OF THE THESIS

The overall objective of this doctoral research project is to better understand how to work with design, and business, toward sustainable development. This high-level objective can be framed in terms of the three main concepts it encompasses: design, business, and sustainable development. At the intersection of these concepts, there are three fields of academic research. Sustainable design is a field located at the conceptual intersection between design and sustainable development (Ceschin and Gaziulusoy, 2016; Fuller, 1957). Sustainable business innovation is a field located at the conceptual intersection between business and sustainable development (Adams et al., 2016; Elkington, 1998). Design management is a field located at the conceptual intersection between design and business (Brown, 2008; Micheli et al., 2019). Accordingly, the doctoral research project consists of an investigation within and across these three fields, based on five research questions, corresponding to the five main chapters of the dissertation.

Investigation into the field of sustainable design

The field of sustainable design lies at the conceptual intersection between design and sustainable development. The main focus of scholars working in this field is investigating how to address sustainable development problems through design, intended as an applied discipline, and at the same time as a conceptual process, to create a new solution (Bhamra and Lofthouse, 2016; Simon, 1968). The nature of this solution may vary (Ceschin and Gaziulusoy, 2016). For example, it may consist in a pair of shoes that can be recycled (Braungart et al., 2007). It may also be something more complex, such as a service to collect used products from people and sell them again (Dewberry et al., 2013), or a waste management plan for an entire city (Prendeville et al., 2018), and even a new socio-technical system disrupting the way we think of waste on a economic, political and cultural level (Gaziulusoy et al., 2013). Indeed, sustainable design is an important field of academic research that produces theoretical knowledge functional to purse sustainable development. However, how to concretely apply this theoretical knowledge in business practice remains understudied, although it is critical to achieve a tangible impact (Pigosso et al., 2013; Tukker, 2015; Vezzoli et al., 2015). Accordingly, this doctoral research project addresses the following research question:

First research question: How is sustainable design theory applied in business practice?

This research question is addressed in Chapter I of the doctoral dissertation. The chapter opens with a story about my growing understanding about working as a professional designer within

business organizations, aiming to foster a positive sustainability impact. The story is followed by an academic publication, which directly answers the aforementioned research question. From a method standpoint, the publication is based on a review of extant literature on sustainable design theory, integrated with complementary literature discussing sustainability from a business perspective using a snowballing approach (Wohlin, 2014). Consequently, the results of the literature review are strengthened and integrated through an empirical inquiry, based on several interviews with international experts (Patton, 2002). The final outcome is a framework that categorizes the theory into four literature streams and puts forward a set of themes related to its application in business practice (see Chapter I, Figure 4).

Investigation into the field of sustainable business innovation

The field of sustainable business innovation lies at the conceptual intersection between business and sustainable development. The main focus of scholars working in this field is investigating how business innovation can be used to generate economic value while addressing societal and environmental issues (Porter and Kramer, 2011; Schaltegger et al., 2012; Scherer and Palazzo, 2011). To this end, business modeling plays an essential role. A business model is a conceptual framework that can be used to explain how a firm functions in terms of: what sort of value it provides to its customers; how this values is created and delivered by the firm; which are the costs involved, and the revenues that allow the firm to profit from this effort (Richardson, 2008; Teece, 2010). Scholars maintain that this framework can be leveraged to embed, next to the economic ones, also environmental and social criteria into the objectives and operations of a firm, resulting into a sustainable business model (Bocken et al., 2014; Boons and Lüdeke-Freund, 2013; Stubbs and Cocklin, 2008). However, more recent contributions emphasize that doing this requires going through an experimental process, in which the new sustainable business model is strategically designed and gradually improved in collaboration with users and other external stakeholders (Bocken and Snihur, 2019; Weissbrod and Bocken, 2017). Sustainable business innovation research focusing on this subject is still emerging, and quite limited in particular with respect to the involvement external stakeholders, including users. Accordingly, this doctoral research project addresses the following research question:

Second research question: How to design a new sustainable business model by integrating the needs of external stakeholders and users?

In addition, although designing a new sustainable business model is helpful to define how a business organization may become more sustainable "on paper", this is not sufficient to ensure that the organization will then actually be able to make an impact in practice. For that, a sustainable business model must be implemented on the market. Recent research points out that sustainable business models are rarely implemented on the market (Geissdoerfer et al., 2018; Ritala et al., 2018) and often fail when they are (Tukker, 2015). In order to address this design-implementation gap scholars have recently started to develop tools for sustainable business model innovation (Bocken et al., 2019; Breuer et al., 2018), such as the "triple layered business model canvas" (Joyce and Paquin, 2016) and the "flourishing business model canvas" (Upward and Jones, 2016). Aiming to contribute to these relevant efforts, this doctoral research project addresses the following research question:

Third research question: How to support business organizations in bridging the design-implementation gap through a tool for sustainable business modeling?

Finally, it is essential to acknowledge that no organization alone is able to drive the transition toward sustainable development (United Nations, 2015). To this end, the paradigm of a circular economy entails that businesses must collaborate with each other, as a way to make the economic system more efficient from an environmental perspective, avoiding the depletion of natural resources, reducing pollution and waste (Brown et al., 2019; European Commission, 2020). In particular, this can be achieved through eco-industrial clusters, physical communities of businesses that seek enhanced environmental and economic performance by collectively managing services, infrastructure, energy and resources, including virgin materials, as well as waste streams (Ehrenfeld and Gertler, 1997; Massard et al., 2014). From a conceptual standpoint, designing eco-industrial clusters is an effort that can be framed from two perspectives: defining the process to create the cluster in terms of a chronological sequence of actions (Boons et al., 2014); and defining the business model that underlies interactions of collaborating organizations as the cluster operates over time (Bocken et al., 2014). Although these two perspectives are both essential and complementary, extant research has so far focused on them separately, failing to provide an integrated perspective on how to design eco-industrial clusters (Short et al., 2014). Accordingly, this doctoral research project addresses the following research question:

Fourth research question: How to design an eco-industrial cluster from a process and business model perspective?

These three research questions are addressed respectively in Chapter II, Chapter III and Chapter IV of the doctoral dissertation. Chapter II opens with a story about my entrepreneurial work aimed at creating a solution to reduce energy consumption and promote sustainable behavior in large office buildings. The story is flowed by an academic publication that leverages this case. From a method standpoint, the publication is based on research-through-design approach, which allows gradually gathering, and integrating in a structured way, empirical knowledge emerging from a design project (Stappers, 2007; Zimmerman et al., 2007). The final outcome is an iterative process that theorizes how to design a new business driven by sustainability objectives (see Chapter II, Figure 6). Chapter III builds upon the story of the collaboration with my colleagues and friends Jan Konietzko and Phil Brown, working at the boundary between academia and industry to help organizations ideating and implementing sustainable business ideas in a circular economy. The academic publication following the story focuses on a part of this work. From a method standpoint, this publication is based on a design science research approach, which allows structuring a solid scientific inquiry around innovation efforts by gradually developing, applying and evaluating an artifact or tool (Grenha Teixeira et al., 2017; Peffers et al., 2007). Relatedly, the outcome is a tool to support organizations planning and executing small-scale pilots to implement sustainable business models (see Chapter III, Figure 5). Chapter IV opens with a story about a small eco-industrial cluster in the Netherlands, where companies are collaborating to improve their sustainability performance in line with the circular economy paradigm. The story is followed by an academic publication that analyzes the case in depth. From a method standpoint, the publication is based on case study (Yin, 2017), followed by generative session with academic experts aiming to generate prescriptive guidance upon case insights and former literature (Stappers, 2007). The outcome is a process that theorizes on how to design eco-industrial clusters in a circular economy (see Chapter IV, Figure 7).

Investigation into the field of design management

The field of design management lies at the conceptual intersection between design and business. The main focus of scholars working in this field is investigating how of strategy and innovation management can be executed through a design process (Gruber et al., 2015). To indicate this design process, scholars in the field use the expression “design thinking”, which refers in particular to a set of principles and concrete practices (Calabretta et al., 2016; Elsbach and Stigliani, 2018). Importantly, design thinking can support business organization to innovate faster and better (Brown, 2008; Micheli et al., 2018). Extant literature discusses extensively why and how design

thinking enables innovating organizations to gain competitive advantage and achieve economic growth (Liedtka et al., 2013; Martin, 2010). At the same time, limited research is present on how design thinking may be leveraged beyond a firm-centric perspective based on private interests, enabling business organizations to collaborate on the resolution of pressing collective concerns, such as such as climate change, resource depletion, poverty and injustice. Although research in this direction is slowly emerging (Bason and Austin, 2019; Cankurtaran and Beverland, 2020), more efforts are needed to integrate sustainability considerations in the design thinking debate (Eppinger, 2011; Esslinger, 2011). This is particularly important because business organizations are increasingly held morally and politically responsible by governments and citizens alike, for the negative impacts of innovation on society and the natural environment (Scherer and Palazzo, 2011; Scherer et al., 2016). Accordingly, this doctoral research project addresses the following research question:

Fifth research question: How can organizations apply design thinking in the context of Responsible Innovation, to collaboratively address societal and environmental challenges?

This research question is addressed in Chapter V of the doctoral dissertation. The chapter opens with a story about a large European project I am involved in, and also about related events taking place overseas, which triggered a personal reflection on the significance of responsible innovation, circular economy, and on how to design for both. The story is followed by an academic publication, which directly answers the aforementioned research question. From a method standpoint, the publication is based on a rigorous problematization approach, which is functional to develop conceptual contributions within management studies (Alvesson and Sandberg, 2011). Accordingly, the outcome is a conceptual framework that theorizes how the design thinking process may unfold in the context of responsible innovation, which is consequently exemplified through the case of the European project mentioned above (see Chapter V, Figure 2 and Figure 3).

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CHAPTER I

APPLYING SUSTAINABLE DESIGN IDEAS IN BUSINESS PRACTICE

FIRST STORY

"Don't burn them, Franco!" Potato sticks are sizzling in the oil. Standing proud, wearing a pair of blue boxers and a ragged wool jumper, Franco is smoking some rolled tobacco by the window, losing his sight over the earthenware tiles on nearby roofs of the city center in Milan. I watch him closely. This is my task. We live in the same house, and I have to observe everything he does as he gets those potatoes from the supermarket shelf all the way to the kitchen table, passing through the frying pan. I must understand his problems and come up with some kind of solution to make the task easier for him. It is called user-centered design: I have just learned this as a first-year product design student at Politecnico di Milano. When I look at him thinking of his needs, the first thing that comes to mind is a pair of pants and a new jumper, but unfortunately this does not qualify as an acceptable outcome to pass the exam. During the progress meeting, the professor seems to have visionary ideas about what the solution might look like: "A potato cutter" he suggests with the smartest glance he is capable of "Maybe in the shape of a woman's breast to make it pleasurable for Franco to extrude the tubers more quickly!" (Note to the reader: this is not a joke of poor taste; I am reporting what the professor said). Needless to say, my expectations about higher design education are in free fall. The problem is not so much related to that specific exam, or to the competences of the educators, but more to the type of problems I have to spend my time dealing with. Fortunately, in the course there is also another professor, who seems

to have more respect for women and a rather different view on design. During a lecture he says that design is about solving more pressing problems than Franco's struggles with potatoes, such as climate change, plastic waste in the sea, and poverty in less-industrialized countries. "Indeed" he explains "This can done by creating new products in a different way". Listening to him helps me to go back to my studies with renewed motivation. I learn about eco-design, an approach to create products with a lower environmental impact by considering their entire life cycle. For example, in the case of Franco's potato cutter, the life cycle is this: getting petrol and ferrous minerals out of the ground, processing them into high density polyethylene pellets and stainless steel profiles, manufacturing the blades and plastic parts of the final product, getting it into a store where he can buy it, use it and then, when he doesn't need it anymore, throw it in the bin, from where it will most likely end up in a landfill at the outskirts of the city. All these steps have a negative environmental impact, not to mention all the transport needed in between and the waste of potatoes that are now getting burned. By design it is possible to change at least something. If the steel blades can be easily detached from the polyethylene handle, then these components can be recycled and there is no need to get new resources out of the ground. "But there is a problem" says the professor: "If nobody makes sure that the blades and the handle are actually sent to a recycler, making disassembly

possible by design is a waste of time. You need a service for that". Product service system design, that's how he calls it: "It's a mix of products and services that solve problems for people but also for society as a whole, and for the environment". A few years later, at Delft University of Technology, I have the chance to work on many design projects of this kind with different companies. In the center of Baden Württemberg, inside the headquarters of one of the most prestigious automotive manufacturers in the world, my friend Philip is explaining that the car of the future will be a shared commodity, powered by hydrogen fuel cells that will also lighten up the streetlamps in the night. "On top of it all" he concludes, "this car will be controlled like a horse". It seems that he has pushed it a bit too far. In the room there is a handful of old-fashioned German engineers, who do not seem very convinced of our design proposal, as they chuckle behind their prominent mustaches like an army of massive walruses in a suit. Apparently, getting product service systems on the market is an equally massive endeavor. Also in India, it is a tough nut to crack. This time, we are not designing the future of mobility, but a service for leasing cycle rickshaws to the people living in the slums of Varanasi. The idea is allowing them to generate an income as taxi drivers by giving them access to the vehicle and a license in turn of a 3 dollars weekly payment. After 52 weeks they can keep the rickshaw, which becomes a key asset for their family to break through the extreme poverty line. Besides designing a lighter and better

product, my colleagues and I soon realize that this is a business challenge: manufacturing the new rickshaw fast enough to meet demand; making sure that production volumes allow the company to break-even; finding around 1,000 customers in the city maze to collect from each of them 3 dollars every week. These are only some of the issues we are confronted with. The reason why it is so difficult is that product service system design messes with the current way a company operates, which is called their existing business model. At university they told me that business models could be designed too, and that this allows embedding social and environmental criteria right into the objectives and operations of businesses. New ventures are created from scratch and there is room to be flexible about it. But in the case of established companies, a business model that has proven to generate profit is already in place. Therefore, they may be reluctant to take the risk of trying something radically different to accommodate sustainability goals. A good example is the Swedish giant selling furniture all over the world. The project is about reducing the impact of their paper catalogue, which has recently surpassed the Holy Bible in terms of printout numbers: lots of paper, lots of ink, lots of water, lots of energy, transport and waste. However, the company is not keen to shift to a digital catalogue because in the current business model, these prints represent an effective marketing channel to boost product sales. Changing this is not a viable option from a financial standpoint. On the other hand, incremental

improvements are possible. With a multidisciplinary team of innovators, I collaborate on the design of a software to help our Swedish client to identify and select those paper and printing suppliers who operate more sustainably, using certified paper, less energy, water, etc. The number of these suppliers scattered all over the globe is impressive. I begin to understand that sustainability cannot be the property of a single business: it lies in the interactions across multiple firms. Collaboration is essential. European policy makers are trying to stimulate collaboration by using public money to fund circular economy innovation projects involving multiple organizations across different countries. Even my own PhD research is funded by one of these projects: twenty stakeholders are working together to recover raw materials out of industrial wastewater and put them back on the market. Now working inside academia, I learn that some people are beginning to use the expression "innovation ecosystems". It is an analogy with the natural world to indicate that, just like trees, ants, flowers and squirrels living together in the same forest, businesses are interdependent. To foster a rosy future, we must better understand how to design for these manmade innovation ecosystems. As I engage with this type of research too, I start to put all the pieces of the story back together. Design is about helping Franco chopping potatoes. If you care about the planet, it is about making a potato cutter that can be recycled. Beyond that, design can also be used to think about more complicated stuff: product-

service combinations, business models and inovation ecosystems, slowly drifting away from the material world of objects toward intangible interactions, processes and policies. The more I read about this stuff, the more I realize that while keywords proliferate like mushrooms in the woods, the real problem is implementation, a fancy word that ultimately means to quit the talking and getting stuff done.

FIRST SCIENTIFIC PUBLICATION

Implementing sustainable design theory in business practice: A call to action

This article has been published in the Journal of Cleaner Production. Please cite as:

Baldassarre, B., Keskin, D., Diehl, J. C., Bocken, N., and Calabretta, G. (2020). Implementing sustainable design theory in business practice: A call to action. Journal of Cleaner Production, 123113.

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Abstract

The intensification of industrial activity within an unsustainable development paradigm caused an alarming
The intensification of industrial activity within an unsustainable development paradigm caused an alarming environmental crisis intertwined with societal problems on a global scale. Sustainable design theory contains an extensive body of knowledge on how these environmental and societal issues can be addressed by rethinking industrial products, processes and, more broadly, how organizations operate in the context of a more sustainable socio-economic system. Nevertheless, evidence shows that implementing these ideas is a problematic yet under addressed aspect, resulting in a gap between abstract speculations and concrete action. In this study, we focus on this critical gap by looking at how existing theory of sustainable design is implemented in business practice. To this end, we conduct a literature review followed by interviews with twenty international experts, to uncover their knowledge related to relevant project experiences. The outcome is a framework that integrates existing sustainable design theory with important business concepts, clustering it into four literature streams: ecodesign, product service system design, sustainable business model design, and collaborative ecosystem design. These streams correspond to four levels of design for sustainable innovation. The framework also encompasses a set of themes related to the implementation of sustainable design theory in business practice across the aforementioned four levels. Based on this, we outline our contributions to theory and practice, and pinpoint recommendations for academic researchers, industrial designers and business managers who want to leverage their professional position to play an active role in the transition toward sustainable development.

1. BACKGROUND AND RESEARCH QUESTION

The concept of sustainable development is not new. It emerged in the 1960s with the rise of ecological concerns and the fear of resource scarcity (Carson, 1962; Hardin, 1968). The United Nations defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). Sixty years later, these good intentions have not been complemented with sufficient efforts and adequate measures to steer the course of action in the correct direction (Allwood, 2018; Grafton et al., 2019). As a result, we are now facing an alarming environmental crisis that is intertwined with societal problems on a global scale. The climate is changing, bringing along severe consequences, including sea-level rise and more frequent extreme weather events that escalate the risk of food scarcity, massive migratory flows and conflicts around the world, both in developing and industrialized countries (IPCC, 2019). For example in the past Australian summer across 2019 and 2020, the country has been literally "on fire" due to extremely dry conditions, causing 18 million hectares of land burning to ashes, the destruction of over 6000 buildings, the loss of around 1 billion animals, as well as some human fatalities (UNEP, 2020). While natural resources are being depleted (Rockström et al., 2009), Europe is particularly concerned about the dependency of its economy from critical materials imported from overseas (European Commission, 2018). Science policy makers have started to metaphorically compare freshwater to gold (Borgomeo, 2020). In order to address these problems, the United Nations have already drafted an agenda based on specific sustainable development goals (United Nations, 2015). The discipline of design can, and should, play a role in addressing these goals by helping to rethink industrial products, processes and, more broadly, how business takes place around them (Dobers and Strannegård, 2005; Papanek, 1971).

The expression "sustainable design" refers to a rational and structured process to create something new (Simon, 1968) in order to solve sustainability-related problems (Manzini, 2009; Papanek, 1971). Sustainable design emerged in the 1960s along with the concept of sustainable development. Back then, the American visionary architect and philosopher Richard Buckminster Fuller stated that "a comprehensive anticipatory design science" should be adopted to create an "operating manual for spaceship Earth", in order to guide human development while preserving the environment, optimizing the use of resources, and ensure their fair distribution (Fuller, 1957, 1969). In the 1970s Victor Papanek leveraged these ideas in his book Design for the Real World (Papanek, 1971), which can be considered the seed of sustainable design theory (Bhamra and Lofthouse, 2016; Ceschin and Gaziulusoy, 2016). Over time, sustainable design theory has discussed how this creative yet rational process can be applied to address an increasingly broader spectrum of issues, ranging from crafting a pair of shoes that can be recycled (McDonough and Braungart, 2002) to managing the waste streams of a large city (Prendeville, Cherim,

and Bocken, 2018). Recent work by Ceschin and Gaziulusoy (2016; 2020) provides a comprehensive and up to date mapping of this body of knowledge.

Sustainable design theory is functional to advance the understanding of how the sustainability transition may be realized (Gaziulosoy and Oztekin, 2019) by transforming products, people's behaviors, commercial services, cities and eventually the entire socio-economic system (Ceschin and Gaziulusoy, 2016). However, these theoretical speculations on sustainable design will not go to great lengths, unless they are tied to solid business considerations (Baldassarre et al., 2019a; Dobers and Strannegård, 2005). Indeed, evidence shows that sustainable design ideas can be implemented successfully only when they are grounded into the objectives and operations of organizations (Baldassarre et al., 2017; Ceschin, 2013). Although this issue has been identified almost two decades ago (Manzini and Vezzoli, 2003; Tukker, 2004), most ideas still fail to reach the market (Tukker, 2015) and the knowledge gap on how to implement sustainable design theory in business practice remains (Baldassarre et al., 2020; Pigosso et al., 2013; Vezzoli et al., 2015). Addressing this gap is essential to achieve a positive impact on society and the environment that sustainable design theory promises (Tukker, 2004, 2015). Thus, we pose the following research question:

How is sustainable design theory applied in business practice?

In addressing this question, we integrate existing sustainable design theory with complementary business concepts. In this paper, the expression "business concepts" is used to indicate theoretical principles and constructs used in the literature to explain and discuss how business organizations operate. We focused specifically on integrating those business concepts that are relevant from a sustainability standpoint. For example, "green product development" is a set of principles that provide business organizations with normative guidance for the creation of new products with a lower environmental impact (Baumann et al., 2002). Another example is represented by the constructs of "sustainable business model" (Bocken et al., 2014) and "circular innovation ecosystem" (Konietzko et al., 2020), which are used to describe how one or multiple business organizations can achieve competitive advantage while addressing social and/or environmental issues. Consequently, we develop a framework (Fig. 4) that integrates existing sustainable design theory with such business concepts, and clusters it into four literature streams—ecodesign, product service system design, sustainable business model design, collaborative ecosystem design—corresponding to four levels of design for sustainable innovation. In addition, the framework comprises a set of themes—the strategic objective of sustainable design, the perspective and terminology of sustainable designers, the key stakeholders, core activities, and main challenges in the sustainable design process—related to the implementation of sustainable design theory in business practice across the aforementioned four levels. Through this framework, our contribution to sustainable design theory is providing a synthetic

yet insightful overview of research streams at the boundary with business literature, while identifying a set of themes related to its implementation in business practice and highlighting language differences across literature and practice. Relatedly, we put forward three recommendations to inform future work of sustainable design scholars. Furthermore, the framework contributes to business practice by clarifying that implementing sustainable solutions requires operating simultaneously on multiple design levels. Relatedly, we put forward two recommendations for actors in business practice, more specifically for industrial designers and business managers. Altogether, we hope that these contributions may serve as a "call to action" targeted to scholars, designers and managers, for getting intangible ideas implemented into reality, and achieving a tangible impact for a more sustainable development.

The remainder of this paper is structured as follows. In section 2, we explain in detail the research design we used to address the research question. In section 3 and 4, we present the results of our research. In section 5, we answer the research question by introducing our framework (Fig. I) and discussing in detail the contributions of our work to sustainable design theory and business practice. In section 6, we highlight the limitations of our study, indicate directions for future research, and close with some brief, conclusive remarks.

2. RESEARCH DESIGN

To address the research question, we adopted a two-step approach (Fig. 1). Step A consisted of a literature review. The objective of this step was to integrate existing sustainable design theory with business concepts, in order to lay the foundations for further investigating how it can be implemented in business practice. The outcome of the review was a categorization of sustainable design theory into four literature streams, corresponding to four levels of design for sustainable innovation. Step B consisted of an empirical investigation based on expert interviews. Building on the conceptual outcomes of the previous step, the objective of this step was gaining deep insights into how sustainable design theory can be applied in business practice. The outcome was a set of themes, describing how sustainable design theory can be implemented in business practice across the four levels previously identified. Empirical investigations represent an important follow up after a literature review as they ensure that theoretical assumptions on sustainable design remain consistent with real-world developments (Pigosso et al., 2013). The research process within step A and B is visualized below (Fig. 1) and further detailed in the coming paragraphs. Finally, we combined the outcomes of Step A (Fig. 2) and Step B (Fig. 3) resulting into our framework of implementing sustainable design theory in business practice (Fig. 4).

2.1 Step A

Step A of our research process consisted of a literature review, aimed at integrating existing sustainable design theory with business concepts.

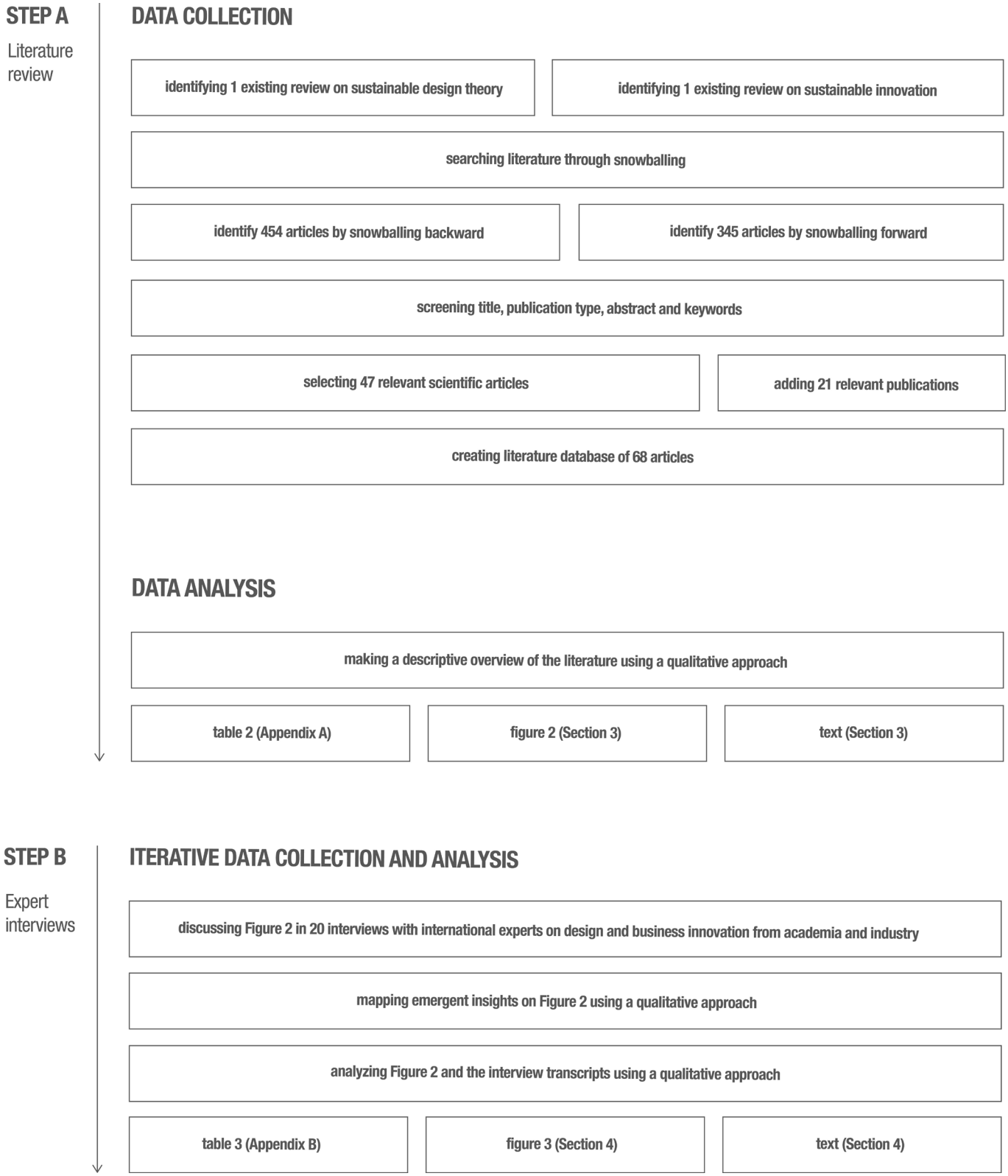

Figure 1. Overview of the research design employed in this research

Data collection

Our data collection process started with the identification of a comprehensive and up to date overview of sustainable design theory. We identified a review on the subject proposed by Ceschin and Gaziulusoy (2016), recently published in Design Studies, the academic journal with the highest impact and reputation in the field of design (Gemser et al., 2012). The authors develop a four-level framework that maps sustainable design approaches from a technical and product-centered focus toward large-scale system-level changes. This work is based on the systematic review paper of Adams et al. (2016), recently published in the International Journal of Management Reviews. The authors develop a three-level framework that categorizes sustainable innovation in terms of operational optimization, organizational transformation and systems building, discussing sustainable design in the broader business context. Together, these two papers provided us with a starting point for identifying and integrating additional literature on sustainable design and business. We opted for this choice—instead of a pool of articles derived from a systematic search—because of our aim to combine the research findings of two broad research fields over several years, which posed objective difficulties in identifying a comprehensive and focused enough pool of relevant and influential articles. Consequently, we decided to start from two literature reviews with high relevance and impact on the research domains on which this paper is focused. Both reviews were recently published in high-quality journals, and they both have a significant impact within their respective domains, with respectively 117 and 205 citations (Scopus search performed on March 1, 2020).

After identifying the two review papers, we leveraged them to engage in an iterative literature search based on a snowballing approach (Wohlin, 2014). Snowballing is useful for gathering comprehensive data on established and emerging concepts within and across research domains (Blomsma and Brennan, 2017; Geissdoerfer et al., 2017). Thus, it was a suitable approach to integrate sustainable design theory with business concepts. In line with this approach, we created a literature database by selecting articles cited by (backward snowballing) and citing (forward snowballing) the two review papers mentioned above. To mitigate the bias during snowballing, two authors engaged in this process independently. They selected the articles separately, and eventually discussed and integrated their individual results first with each other, and then with the other three authors (Silverman, 2013). More specifically, for snowballing backwards two authors independently screened the titles in the reference list of the two review papers (a total of 454 articles) and selected relevant articles. To this end, they first checked the type of the publication and included only the peer-reviewed papers published in scientific journals. Next, they checked the keywords and abstracts of the articles to identify those that are useful for the integration of sustainable design theory with business concepts. Since backward snowballing only allows identifying established concepts, the authors simultaneously engaged in forward snowballing, working independently to identify new concepts

emerging from the two review papers. Accordingly, on Scopus, they identified articles that cite these two papers (in total 345 articles). Similar to backward snowballing, forward snowballing was based on a screening of title, type of publication, keywords and abstract. Throughout this process, articles were selected according to the following four criteria. First, a relevance criterion: selected articles focus explicitly on both sustainable design and business. Second, a content variety criterion: selected articles range in focus from product to systemic innovation—building upon focus areas found in the reviews of Ceschin and Gaziulusoy (2016) and Adams et al. (2016). Third, a pragmatic criterion: selected articles are fairly distributed in number across the range of focus. Fourth, a quality criterion: selected articles are peer-reviewed scientific publications. This resulted in the selection of 47 articles. Finally, all authors, as experts on the investigated subject, were aware of a number of important publications—including scientific and grey literature—that did not emerge from the snowballing process. These were included in the literature database, which resulted in a sample of 68 articles.

Data analysis

After data collection, we used the database of articles to provide a descriptive overview of the identified literature. Using a qualitative approach for data analysis (Silverman, 2013), the first author scanned the articles in the database, in order to identify core concepts in the text across the multiple documents. In this process, he used the frameworks developed by Ceschin and Gaziulusoy (2016) and Adams et al. (2016) as a source of inspiration to structure the emergent concepts. This resulted in a set of written and visual notes (Silverman, 2013) categorizing the articles in the database according to their focus. In order to reduce subjectivity and avoid bias, such written and visual notes were eventually revised in series of face-to-face discussions with all members of the author team and with two independent researchers, who are also experts in the investigated subject (Silverman, 2013).

The outcome of this process is a list in which all the articles in the database are categorized into four clusters corresponding to four literature streams and four levels of design for sustainable innovation: ecodesign, product service system design, sustainable business model design, collaborative ecosystem design. For each article in the list, we include the authors, year of publication, journal and title, indicating as well how we have identified the source (Table 2 in Appendix A). Based on this outcome, in section 3, we present our literature review and a graphic visualization of four levels of design for sustainable innovation (Fig. 2).

2.2 Step B

Step B of our research process consisted of an empirical investigation based on twenty expert interviews, aimed at gaining insight into how sustainable design theory is applied in business practice.

Iterative data collection and analysis

The starting point of our empirical investigation was a qualitative data collection based on individual interviews with 20 international experts. The interviews were conducted with an informal conversation approach (Patton, 2002) leveraging the visual developed in Step A (Fig. 2). The visual was used to facilitate an open and interactive discussion with the experts around the implementation of sustainable design theory in business practice. Specifically, the experts were asked to elaborate upon their knowledge and project experiences on design projects for sustainable innovation across the four levels previously identified. While no specific interview protocol was followed, probing the experts to describe their real experiences was functional to explore the gap between theoretical speculations and their implementation in business practice. Some of the interviews were conducted face-to-face, while others as video calls, by the first author and a research assistant. All interviews were digitally recorded and transcribed by the research assistant. In line with our focus at the boundary between theory and practice, sustainable design and business, respondents included both academics and industry professionals with a different mix of expertise. Despite background and profile differences, all of them have relevant knowledge and real project experiences related to the investigated subject. All experts operate at an international level, working within and across different European countries and types of organizations, including prestigious universities, small and large multinational manufacturing companies, and consultancy firms. Furthermore, attention was paid to ensuring age diversity in the sample of respondents. This was needed to integrate fresh and unbiased insights from the younger experts into the more consolidated ideas of the more senior experts. Table 1 contains the list of all the respondents indicating their profile next to their years of experience.

Data analysis took place iteratively and in parallel with data collection, using a qualitative approach (Silverman, 2013). Specifically, while the interviews took place, written and visual notes were taken to map emerging insights directly upon a printed copy of the visual (Fig. 2). This allowed collecting on the same template multiple layers of data, which were gradually analyzed and integrated into new versions of the visual informing the following interviews. Continuously re-discussing and re-shaping emergent insights with the cumulative views of multiple experts allowed reducing subjectivity in analyzing the qualitative data (Silverman, 2013). The last version of the visual was then used in combination with the transcripts as the input for a second analysis. At this stage the first author went through the transcripts in order to identify and categorize key passages and quotes, making a first thematic categorization of all the findings (Silverman, 2013). In order to break again through subjectivity and avoid bias, this categorization was progressively improved through a series of separate face-to-face discussions with the other authors (Silverman, 2013).

The outcome of this process is a set of five themes related to the implementation of sustainable design theory in business practice across the four levels previously identified: the strategic objective of

Table 1: Profile and experience of the experts selected for the interviews

Expert #	Profile	Experience
Expert 1	Full professor of Sustainable Design	38 years
Expert 2	Full professor of Sustainable Design	27 years
Expert 3	Associate professor of Sustainable Design	23 years
Expert 4	Associate professor of Sustainable Business	15 years
Expert 5	Full professor of Sustainable Business	12 years
Expert 6	Assistant professor and practitioner of Sustainable Design	13 years
Expert 7	Assistant professor and practitioner of Sustainable Business	8 years
Expert 8	Researcher and practitioner of Sustainable Design and Business	8 years
Expert 9	Professor and corporate manager of Sustainable Business	38 years
Expert 10	PhD researcher and consultant of Sustainable Business Model Design	5 years
Expert 11	PhD researcher and practitioner of Sustainable Design and Business	15 years
Expert 12	Postdoctoral researcher and practitioner of Sustainable Business	12 years
Expert 13	Consultant of Sustainable Business and Design	23 years
Expert 14	Consultant and researcher of Sustainable Design and Business	6 years
Expert 15	Designer and corporate management trainee of Sustainable Business	3 years
Expert 16	Corporate designer and strategist of Sustainable Business	6 years
Expert 17	Corporate manager of Sustainable Business	8 years
Expert 18	Product Design manager and lead of Sustainable Business	8 years
Expert 19	Lead Designer and director of Sustainable Business	19 years
Expert 20	Corporate manager and consultant of Sustainable Business	23 years

sustainable design, the perspective and terminology of sustainable designers, the key stakeholders, core activities, and main challenges in the sustainable design process. To illustrate the connection with the respondent's knowledge and project experiences, we include a list with some of the most insightful interview quotes categorized according to the five themes and four levels (Table 3 in Appendix B). In section 4, we present a descriptive text of our empirical findings, based on quotes and the combined inputs of multiple experts.

3. LITERATURE REVIEW

In this section of the paper, we present our literature review aimed at integrating existing sustainable design theory with business concepts. According to the outcomes of our review, the section is divided into four parts, corresponding to four literature streams matching four levels of design for sustainable innovation (Fig. 2).

3.1 Ecodesign

Ecodesign literature discusses strategies, methods and tools for developing sustainable—also referred to

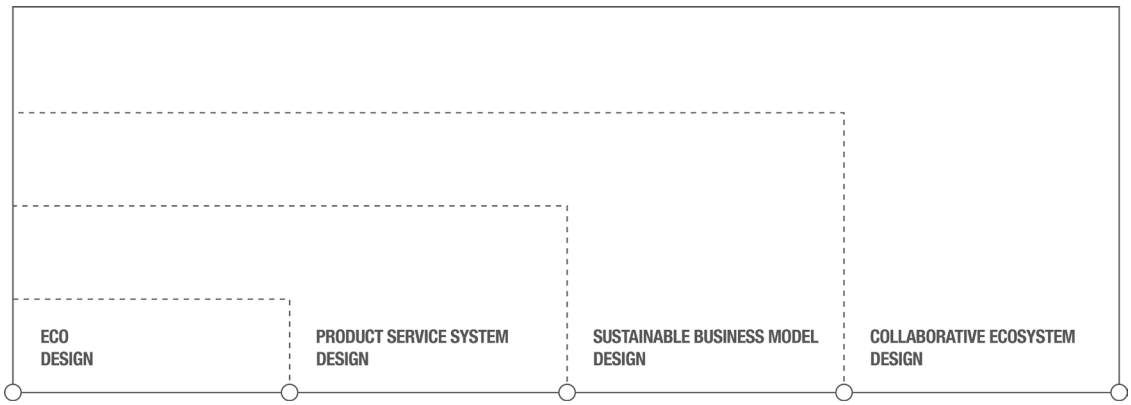

Figure 2. Literature streams matching four levels of design for sustainable innovation. Based on the results of our literature review and inspired by the work of (Adams, Jeanrenaud, Bessant, Denyer, and Overy, 2016; Ceschin and Gaziulusoy, 2016)

as "green"—products, in order to balance economic and environmental benefits (Baumann et al., 2002). Business concepts in ecodesign are thus largely related to product development.

Ecodesign scholars argue that by addressing both ecologic and economic aspects, ecodesign minimizes the negative environmental impact of products, while simultaneously offering financial benefits and other business advantages (Dangelico and Pujari, 2010; Hallstedt, et al., 2013; Huang and Wu, 2010). Indeed, ecodesign gives to the environment the same status as traditional industrial values such as profit, functionality, aesthetics, ergonomics and quality (Brezet and van Hemel, 1997). The intention is eliminating the conflict between environmental criteria and business success (Baumann et al., 2002; Brezet and van Hemel, 1997). Instead of considering environmental responsiveness as a compliance issue—involving expenses, and trade-offs with other corporate goals—ecodesign frames it as a business opportunity (Braungart and McDonough, 2002; Pujari et al., 2003). Such opportunity rests upon the identification of internal and external drivers that could result into win-win situations (Tariq et al., 2017; van Weenen, 1995). This literature specifically highlights the external drivers as particularly important for business to adopt an ecodesign approach. These include restrictive policies and laws punishing environmental harmful behavior. However, in the case of new ventures, internal drivers and the motivation of innovators in developing sustainable products is crucial as well (van Hemel and Cramer, 2002). A central aspect of ecodesign is the concept

of product life cycle. In the ecodesign manual for the United Nations Environment Programme (UNEP), Brezet and van Hemel (1997) introduce important thoughts around product life cycle phases—production, distribution, use and end-of-life. The argument is that adopting environmental criteria in the design of products allows reducing the environmental impact in these phases, and thus along the entire lifecycle (Pigosso et al., 2013). Ecodesign also considers consumer awareness and behavior, and explored consumers' willingness to reduce their environmental impact as a driving force for creating new market opportunities (Aschehoug et al.,, 2012; De Marchi, 2012; De Medeiros et al., 2014). Several scholars argue that there is a lack of integration between ecodesign and the broad context of product development, management, business development, and corporate strategy (Baumann et al., 2002; Pigosso et al., 2013). In particular, the strategic role of ecodesign within companies is underexplored and the connection with business activities is still quite loose (Baumann et al., 2002; Domingo et al., 2015). For example, Baumann et al. (2002) argue that many ecodesign approaches do not provide practical ways on how to implement the concept in business practice. Pujari et al. (2003) conclude that in order to make ecodesign more successful and impactful, it has to be linked and integrated into the overall business strategy of the firm. An analysis of this work shows that in ecodesign literature, important connections between sustainable design theory and business concepts exist (Domingo et al., 2015). However, this often occurs with a narrow focus related to product development (Dyllick and Rost, 2017; McDonough and Braungart, 2002).

In business practice, the implementation of ecodesign ideas typically results in a redesigned product with a life cycle that has a lower environmental impact (Braungart et al., 2007). An example of this is the Aeron Chair by Hermann Miller, which can be fully disassembled and recycled in all its parts.

3.2 Product service system design

Product service system design literature discusses how to develop a mix of tangible products and intangible services jointly capable of fulfilling final customer needs while fostering a positive sustainability impact (Tukker and Tischner, 2006). Business concepts in product service system design are thus related not only to products but also to the services taking place around them.

Product service system design scholars argue that a focus only on products is not sufficient to achieve sustainability goals (Manzini and Vezzoli, 2003; Martinez et al., 2010; Oliva and Kallenberg, 2003). Indeed, they state that sustainable design should take into account not just products but also services (Cook et al., 2006; Goedkoop et al., 1999; Morelli, 2002). These new ideas position sustainable design as a strategic competence for creating new business opportunities and new ways of fulfilling product functions through the design and novel combination of products and services (Dewberry et al., 2013; Tukker and Tischner, 2006). Product service system design rests upon these assumptions. For businesses,

it is an excellent vehicle to enhance competitiveness and foster sustainability simultaneously (Tukker, 2004). From a business perspective, product service systems offer the possibility to find new strategic market opportunities, increase competitiveness, establish a longer and stronger relationship with customers and build up barriers to entry for potential new competitors due to service component of the system, which is hard to copy (Emili et al., 2016). From a sustainability perspective, they can potentially delink profit and production volumes, reduce resource consumption and material use, motivate the inclusion of through-life and end-of-life issues, and lead to enhanced efficiency in use and product longevity (Kristensen and Remmen, 2019). Since firms become responsible not only for production and delivery of products but also for other phases in the life cycle of products, they have more incentives to adopt life-cycle thinking (Baines et al., 2007; Manzini and Vezzoli, 2003; Vezzoli et al., 2015). Compared to a traditional product sales offer, in product service system design, it is in the economic and competitive interest of the producer/provider to foster continuous innovation in reducing the environmental impacts and improving social equity and cohesion (Vezzoli et al., 2015). A central aspect of product service system design is the network of stakeholders that produce and deliver the solution to customers. Consequently, the development of partnerships is crucial, as well as the value co-production process within such a partnership (Cavalieri and Pezzotta, 2012; Ceschin, 2013; Laperche and Picard, 2013; Vezzoli et al., 2015). Design plays an important role in creating new stakeholder configurations and developing an integrated system of products, services and communications (Manzini and Vezzoli, 2003). To this end, design needs to be more business-oriented and at the same time focus on technical details, for example, when discussing the specifics of product or service elements (Ceschin, 2013). An analysis of this work shows that in product service system design literature, sustainable design theory establishes strong connections with broader strategic business concepts (Tukker, 2004). Nevertheless, literature concludes that while product service systems have the potential to enhance competitiveness and contribute to sustainability simultaneously, consumer acceptance and business factors remain under-addressed issues (Tukker, 2015). Successful product service system design thus requires adopting a stronger business perspective and the early involvement with the customer and changes in the organizational structures of the provider (Baines et al., 2007).

In business practice, the implementation of product service system design ideas typically results in a product - service combination, where the environmental impact of a product is potentially lower - since customers pay for using a product instead of buying it - while providing a better solution to people (Tukker, 2004). An example of this is the “OV fiets”, a bike rental service offered by the Dutch Railways. The objective of OV fiets concept is to reduce the use of cars by offering a bike rental scheme that makes public transport more functional for people.

3.3 Sustainable business model design

Sustainable business model design literature discusses how to develop new ways of doing business integrating sustainability into the objectives and operations of organizations (Stubbs and Cocklin, 2008). Business concepts in sustainable business model design are thus related not only to products and services but also to the overall business strategy around them.

Sustainable business model design scholars argue that the business model concept can be leveraged to make design more strategic (Baldassarre et al., 2017; Esslinger, 2011; Rocha et al., 2019). Indeed, sustainable business modeling requires firms redefining the purpose of their business and operating differently, for example by reporting financial, environmental, and social outcomes, by taking a stakeholder view of the firm, by including society and the environment as stakeholders, and by taking a leading role in sustainability (Birkin et al., 2009; Stubbs and Cocklin, 2008). Design is a central aspect of sustainable business model innovation. The word design is mentioned repeatedly in some key publications as a strategic process for the creation of sustainable business models (Bocken et al., 2013; Boons and Lüdeke-Freund, 2013; Lüdeke-Freund et al., 2016). Boons and Lüdeke-Freund (2013) state that the design of sustainable business models is a key challenge of sustainable business model innovation. Bocken and colleagues explain that there are several archetypes of sustainable business models and that the "product service system" is one of them, thus reinforcing the connection with earlier literature on sustainable design and broadening the theoretical domain (Bocken, Short, Rana, and Evans, 2014). Esslinger (2011) argues that designers are especially well suited to implement and promote sustainable business models because they are able to connect human needs and dreams with new opportunities and inspirations from science, technology, and business. Keskin et al. (2013) study the design and innovation processes for sustainability in new ventures. There are multiple tools and methods to support the design of sustainable business models (Baldassarre et al., 2020; Bocken et al., 2013; Joyce and Paquin, 2016; Lüdeke-Freund et al., 2016). Their aim is to implement the design of sustainable business models in practice (Baldassarre et al., 2020; Joyce and Paquin, 2016). Circular Economy is a recent theme in business model research, referring to an industrial economy that is restorative and regenerative by intention and design, fostering sustainability by converting waste into a resource (Geissdoerfer et al., 2017). Some scholars focus on the design of sustainable business models from this circular angle (Guldmann and Huulgaard, 2020; Henry et al., 2020; Sumter et al., 2018). For example, Sumter et al. (2020) look at the case of refurbished strollers, and the role of design in driving circular business model innovation. Recent work by Henry et al. (2020) specifically identifies the 'design-based model' as a type of circular business model focused on innovating through new technology to reduce material use. An analysis of this work shows that in sustainable business model design literature, sustainable design theory is inextricably intertwined with business concepts, and especially with entrepreneurship, using design almost as a synonym of this word (Keskin et al., 2013; Klewitz and Hansen,

2014).

In business practice, the implementation of sustainable business model design ideas typically results in a (new) organization or a corporate venture driven by a social and environmental purpose (Keskin et al., 2013). An example of this is Fairphone, a social enterprise that emerged from a social movement with the core mission of developing and selling smartphones with a minimum environmental impact and a fair supply chain.

3.4 Collaborative ecosystem design

Collaborative ecosystem design literature discusses how to develop new interactions across firms in order to reshape entire markets and industries toward a sustainability transition (Talmar et al., 2018). Business concepts in collaborative ecosystem design are thus not anymore related to single firms, but rather to the wider industries and markets in which they operate.

Sustainable ecosystem design scholars argue for the need to build on theories of system innovation and transitions, which call for a systemic change on an economic, institutional, socio-cultural, organizational and technological level (Gaziulusoy et al., 2013; Joore and Brezet, 2015). Geels (2005) introduces the concept of transitions as a transformation of the system across the above-mentioned levels. Loorbach and Wijsman (2013) integrate literature on corporate sustainability and transition management, exploring the role of business in transitions. They suggest that a system perspective can help firms in analyzing their societal context (e.g. mobility system or energy system) and, in turn, determining innovation opportunities and alternative business models while remaining competitive within current markets (Loorbach and Wijsman, 2013). In that respect, they coined the term 'ambidextrous management' as an approach to mediate the long-term goals required by system innovation with short-term business goals linked to existing business models (Loorbach, van Bake, Whiteman, and Rotmans, 2010). Gaziulusoy and Brezet (2015) build onto this work from a design perspective. They integrate insights from sustainability science and system innovations with the sustainable design theory. They suggest that firms can address wider-scale changes by adopting a systemic and long-term perspective and by interpreting strategically the insights emerging from this perspective. Within this process, they emphasize the role of learning-oriented networking with universities, other firms and government (Gaziulusoy and Brezet, 2015).

Indeed, the transition to new societal or economic systems, such as a circular economy, requires the intentional design of new products and services, and experimentation with new business models to deliver them (Baldassarre, et al., 2019b; Bocken et al., 2019). For these new business models to work in practice and enable the changes at a system level, it is essential to establish a collaborative capacity across organizations (Brown et al., 2019). Brown et al. (2019) explore the creation of circular-oriented innovation and highlight the interdependence within diverse networks of actors, as well as collaboration across organizations

and sectors as critical factors for the success of sustainable business models at the system level. On these theoretical grounds, the term ecosystem emerges as a new lens to frame such collaborations as macro business models in which multiple organizations jointly deliver a value proposition connected to environmental gains (Brehmer et al., 2018; Hellström et al., 2015; Heuer, 2011; Zucchella and Previtali, 2019). For instance, Zuchella and Previtali (2019) emphasize the crucial role of a focal actor as the ecosystem orchestrator in engaging other actors in the implementation of circular business models by building a common vision and trust and facilitating relations and forms of cooperation. Building on Jacobiedes et al. (2018), Konietzko et al. (2020) propose design principles for circular ecosystem innovation, which prescribe how firms should collaborate and experiment via a structured trial-and-error process. An analysis of this work shows that in collaborative ecosystem design literature, sustainable design theory connects with business concepts beyond a firm centric approach, in order to support the creation of coalitions of organizations working together in the transition toward sustainable development (Manzini, 2017).

In business practice, the implementation of collaborative ecosystem design ideas typically results in a coalition of organizations collaborating to drive the sustainable transformation of an economic sector (Konietzko et al., 2020). An example of this is the EU Horizon 2020 "Zero Brine" Project (www.zerobrine.eu), in which an international consortium formed by over 20 partners is collaborating to redesign the value and supply chain of water and minerals in the process industry.

4. EMPIRICAL INVESTIGATION

This section of the paper covers our empirical investigation aimed at gaining insight into how sustainable design theory is applied in business practice. According to the outcomes of the investigation, this section is divided into five sub-sections associated with five themes that emerged through twenty interviews with international experts. These themes provide a coherent structure to describe the knowledge and experiences of the experts working on sustainable innovation projects across the four levels of design previously identified (Fig. 2). An overarching finding is that when implementing theory into practice, the way of thinking and language related to these levels differs between academic research and business practice. Some of the experts who are closer to business practice explained that from the perspective of a company, theoretical differences between the four levels may be complex to grasp and not particularly relevant. For example, when trying to go beyond the product focus of ecodesign, a firm might not see any concrete difference between engaging in product service system design or sustainable business model design. What instead matters from a business practice perspective is the output of the design process, namely: a sustainable product, a sustainable product and service design, an entirely sustainable organization and a collaboration across multiple organizations driven by sustainability.

	SUSTAINABLE PRODUCT DESIGN	SUSTAINABLE PRODUCT & SERVICE DESIGN	SUSTAINABLE ORGANIZATION DESIGN	SUSTAINABLE COLLABORATION DESIGN
Strategic objective of sustainable design	Pushing an organization to think beyond the "form and function" of their product, changing its life cycle (production, distribution, use, end of life), in order to reduce its environmental footprint while making profit	Pushing an organization to think beyond the life cycle of its product, changing tangible and intangible stakeholder exchanges (e.g. knowledge, materials, energy, money, etc.), in order to foster a positive social and environmental impact while making profit	Pushing an organization to think beyond products and services, (re)defining its purpose, how it functions from an economic and operational standpoint, in order to pursue sustainability goals while making profit	Pushing multiple organizations to think beyond their individual business, collectively (re)defining (un)sustainable market practices, in order to facilitate the transformation of existing sectors while making profit together
Perspective and terminology of sustainable designers	- Department centric (one department) - Engineering terminology	- Cross functional (multiple departments) - Commercial terminology	- Firm centric (the entire organization) - Strategy terminology	- Cross organizational (multiple organizations) - Policy terminology
Key stakeholders involved in the sustainable design process	- R&D - CSR - Marketing - Suppliers - ...	- Users - Operations - Logistics - External partners - ...	- CEO / upper management - Finance - HR - Shareholders / investors - ...	- Public officers - Civil society - Business representatives - Legal experts - ...
Core activities in the sustainable design process	- Life cycle analysis - Product development - ...	- Stakeholder analysis - Service development - Experimentation - ...	- Business modeling / case - Financial accounting - Risk assessement - ...	- Industry / sector analysis - Strategic foresight - Transformational leadership ...
Main challenges in the sustainable design process	Reducing resource and energy use, toxicity and carbon emissions	Transforming existing supply chains and assessing impact of alternative solutions	Managing stake / shareholders, and ensuring financial viability while scaling up	Creating policy frameworks and gaining stakeholder committment over time

Figure 3. Themes and insights describing the implementation of sustainable design in business practice. Based on the results of our empirical investigation.

Consequently, we discuss our empirical findings by adopting the terminology from the perspective of the business practice. In other words, we renamed the four design levels as illustrated in Fig. 3 and present our interview insights categorized according to these levels and the five themes that differentiate them.

4.1 Strategic objective of sustainable design

In business practice, the strategic objective of sustainable design refers to the scope of the design process when integrating environmental and/or social concerns into the objectives of organizations.

Implementing sustainable product design (ecodesign in academic literature) requires a major focus on reducing the life cycle impact of products while increasing their efficiency and quality and reducing cost for the organization that manufactures them (Expert 1, 2, 8, 9, 11, 19). Expert 1 explicitly mentioned that in the projects where he was involved "ecodesign was an approach to focus on the life cycle of the product". Expert 9 clarified that the company he had worked with for multiple years, "embraced ecodesign as an important contributor to the efficiency and quality of its operations". Indeed, at a product level, the strategic objective of sustainable design is pushing an organization to think beyond the "form and function" of their product, changing its life cycle (production, distribution, use, and end-of-life), in order to reduce its environmental footprint while making profit.

Implementing sustainable product and service design is about the exchanges of an organization with other stakeholders, and on how these affect the environmental and social impact across the supply chain (Expert 2, 3, 6, 7, 18, 19). For example, Expert 18 explained that when his/her company started a project about selling a sustainable product as a service, they "focused a lot on the materials that were used in that product but also on the entire supply chain […] and the specific impact in the community". This example illustrates that at this level, the strategic objective of sustainable design is pushing an organization to think beyond the life cycle of its product, changing tangible and intangible stakeholder exchanges (e.g. knowledge, materials, energy, money, etc.), in order to foster a positive social and environmental impact while making profit.

Implementing sustainable organization design entails questioning the purpose and reason of being of an organization, rethinking its core goals, underlying processes and how it creates value out of social and environmental issues (Expert 5, 8, 14, 16, 17, 18, 20). Expert 20 made this very clear: "And of course, we do projects like that […] where we redesign the business model and you've got a shift toward an [economic] value focus [while solving sustainability problems]". Consequently, at this level, the strategic objective of sustainable design is pushing an organization to think beyond products and services, (re)defining its purpose, how it functions from an economic and operational standpoint, in order to pursue sustainability goals while making profit.

Implementing sustainable collaboration design entails broadening the scope beyond single business models in order to transform the entire socio-technical system, entire industries and/or market sectors through a collective conversation of all the parties involved (Expert 3, 5, 6) aimed at creating innovation ecosystems (Expert 10, 20). Expert 10 explained this ecosystem concept providing the example of a project

where multiple organizations "worked together for a while on a completely redesigned mobility system for the city". Additionally, Expert 20 clarified that in his experience, this type of project "only works when they [the organizations] collaborate, when they have a clear joint goal and mutual benefits" (Expert 20). At this level, the strategic objective of sustainable design entails pushing multiple organizations to think beyond their individual business, collectively (re)defining (un) sustainable market practices, in order to facilitate the transformation of existing sectors while making profit together.

4.2 Perspective and terminology of sustainable designers

In business practice, the perspective and terminology of sustainable designers respectively refer to the point of view from which designers may frame and address simultaneously sustainability and business problems to the terminology they use to communicate with different stakeholders while doing this.

Sustainable product designers often operate in Research and Development (RandD) departments. From that perspective, they strive to change the way products are made in order to reduce their life cycle impact (Expert 2, 9, 17, 19, 20). This is clearly reflected by the case of Expert 14, who explained: "When I was working [as an industrial designer] for those two multinational companies I was into an engineering context". Relatedly, Expert 9 recalled on his experiences in the company he worked with, saying that within sustainable product design and development "environmental requirements had to be communicated with a factory language" (Expert 9). Thus, at this level, the perspective of designers is department centric. This perspective is intertwined with a specific terminology. Indeed, within the RandD department, designers must be able to explain to engineers how products can be developed more sustainably (Expert 1, 9). To this end, they use an engineering terminology.

Sustainable product and service designers must understand how different people across departments in their organization look at sustainability issues (Expert 6, 9, 19). Expert 6 commented upon the importance of "thinking about this from a design perspective". Relatedly, Expert 9 stated that: "You need a cross functional view to bring this [sustainable design] safely across the borders of departments". These instances show that at this level, the perspective of designers is cross functional. In other words, the designer has to work from the perspective of multiple departments, aiming to change not only how products are made but also how they are delivered to customers (Expert 9, 19). This effort entails talking with operations and logistics (Expert 14, 19, 20). This requires commercial terminology.

Sustainable organization designers are able to use the business model framework in order to take the perspective of the entire organization on sustainable innovation (Expert 7, 14, 16, 17). This is illustrated very clearly by the experience of Expert 17: "Since I am working with business models […] and the sustainability strategy […] I use the perspective of the

entire organizations […] And it is a semantic language thing […] knowing how to talk to different people. Personally, I talk very differently to a [product] designer than I speak to a financial controller [in my company]". At this level the perspective of designers becomes firm centric. In this regard, Expert 14 mentioned that in one of the projects he had worked on, "it was clear that the managers [of the client organization] wanted to talk about alternatives to fossil fuels in their business model". These examples show that when the goal is the transformation of a business model, it is important to understand and talk with the strategy function (Expert 4, 20). To this end, a strategy terminology is required, in order to effectively communicate design ideas to the upper management and the CEO.

Sustainable collaboration designers must work from many different perspectives because all the companies operating in a certain market or industry have different priorities and issues to deal with (Expert 1, 10). Expert 10 stated that "in the end, it's just a matter of perspective", and that "a systemic view, is what is unique in ecosystem [collaborative] innovation". As the collaboration emerges over time from the interactions and negotiations of the stakeholders involved, the designer can facilitate this process by bridging perspectives and outlining a shared vision (Expert 1, 3, 20). Expert 1 exemplified this using the metaphor of a "spider in the web, connecting the points of view between industry, public sector and civil society". Consequently, at this level, the perspective is cross organizational. Since in Europe such collaborations are often funded by Circular Economy project calls as part of current policy frameworks (Expert 8, 11), it is important to be able to understand the related terminology of decision-makers (Expert 1, 10). This is apparent in the case of Expert 19, who explained: "[As a designer] I do think I have influence by inspiring and explaining our innovation philosophy to our compliance department so they can translate again, to the policy makers". Thus, designers operating at this level must be familiar with a policy terminology.

4.3 Key stakeholders involved in the sustainable design process

In business practice, the key stakeholders involved in the sustainable design process refer to all those parties who need to be directly involved and/or come to play a crucial role when the integration of environmental and/or social concerns into business objectives takes place.

Product design is typically a task of the RandD department, where designers, engineers and in some cases scientists collaborate. Expert 2 explained that in the projects he was involved, "there were designers and engineers working on [sustainable] products". When integrating environmental criteria in the design of products, the RandD department is (often) informed by the Corporate Social Responsibility (CSR) - or sustainability function - of the organization (Expert 9, 16, 19). Furthermore, redesigning products in order to make them sustainable normally entails changing some of their components, materials and/or production processes, requiring interactions with

the related suppliers (Expert 8, 11, 18). Finally, making sure that the sustainability aspects are properly conveyed to consumers is the task of the marketing function (Expert 9, 13). These instances are exemplified by the case of Expert 9 who recalled that in the company he worked with, "after the environmental department […] they decided to establish in their own development department an environmental strategy […] A green marketing function was needed". The project experiences of Expert 8 highlight the importance of suppliers: "Suppliers were also involved [in sustainable product design]". Thus, at this level, the key stakeholders who are most likely involved in the design process are the RandD, CSR and marketing functions of the organization, as well as suppliers to a limited extent.

Implementing services around sustainable products requires the involvement of the operation and logistic functions, which make sure that such services can be delivered as planned (Expert 16, 17, 19). The importance of this aspect was especially stressed by Expert 19, who explained: "When we design our services, we have to understand our users, but also, we involve the service department right from the start, we work closely together with operations and logistics, marketing and sales […] explaining what the design is about […] and with external business partners". Indeed, sustainable service delivery often requires multilateral cooperation with external partners beyond just suppliers (Expert 14), and ultimately users as well play an active role in the delivery system when they experience the service (Expert 14, 16, 19). At this level the key stakeholders that are most likely involved in the design process, next to those previously mentioned, are operations, logistics, users and external partners in different degrees depending on the circumstances.

Integrating sustainability aspects in the business model of an organization requires the commitment of the upper management and the CEO (Expert 9, 16, 17). The finance function must be involved to assess whether the transformation is viable from a revenue perspective (Expert 16, 20). Assessing the financial aspects is essential to get the buy-in of shareholders and/or investors, who could otherwise oppose the initiative (Expert 19). The case of expert 17 exemplify these instances: "I work on the sustainability strategy of the company […] and new business models […] So I work mostly with the CEO, with the brand managers and other departments […] and also externally of course, both with academics and with startups and interesting people and so on". Furthermore, Expert 20 stressed the importance of "the people aspect […] the roles of people". Indeed, transforming a business model toward sustainability requires putting together a team with the right mix of interdisciplinary competences, calling for a role of the Human Resources (HR) department (Expert 16, 20). Consequently, at this level, the additional key stakeholders that are most likely be involved in the process are the upper management, finance, HR and shareholders.

When multiple organizations carry out together collaborative innovation projects, for example in the context of a Circular Economy, the representatives of

each business, often at the upper management level, are involved in the effort (Expert 16, 18, 20). As Expert 16 explained, in such projects "every company has to be represented […] you need delegates from every organization". Legal experts are also needed, in order to make sure that collaboration takes place within clear agreements and establishes regulations (Expert 7, 13, 20). As Expert 18 explained, it is important to involve "different stakeholder types" including "civil society organizations, NGOs, companies, and sometimes also public institutions". Expert 19 elaborated further on the need to consider policy issue thus interacting with stakeholders from latter category: "The European Union, we sometimes have meetings with them […] discussing future policies with policy makers". Thus, at this level, the type of stakeholders involved in the design process diversifies to include legal experts, representatives of business working collaboratively, and also public officers, who can drive top-down change, and civil society, who can drive bottom-up change (Expert 1, 17, 19).

4.4 Core activities in the sustainable design process

The core activities in the sustainable design process are those that need to be performed to integrate environmental and/or social aspects in the development of innovation outputs.

Implementing sustainable product design primarily requires understanding the life cycle of the product to assess its environmental impact (Expert 1, 2, 8). Expert 2 recalled the importance of this activity by recalling one of his experiences: "And then [product] designers said: if we want to make it more sustainable we need to analyze the whole life cycle". After the analysis of the life cycle, it becomes possible to set clear design objectives (e.g. reparability) and criteria (e.g. modularity) to lower the environmental impact of the related product, which is subsequently developed (Expert 8, 9, 14, 19). Expert 19 elaborated explicitly upon this aspect: "I tried to set up guidelines for the product developers […] stuff like modularity and reparability […] to implement products to last longer". Therefore, at this level, the core activities in the sustainable design process are life cycle analysis and product development.

Implementing sustainable product and service design with a sustainability mindset entails considering social aspects, stakeholders and user interactions around the product life cycle (Expert 14, 19). While developing services, it is essential to identify the key stakeholders involved and analyze what they exchange with each other and what do they want to achieve (Expert 6, 10, 14, 15). Expert 15 mentioned the importance of going beyond life cycle analysis and performing a stakeholder analysis when designing services: "We do life cycle analysis […] And we do stakeholder analysis when we design services. We started with plastic cups at festivals […] We contacted all the festival organizers and producers, we involved recycling agencies, cup producers, and we started to bring them together just to clarify the problem for everyone". Moreover, implementing new services requires a trial and error approach based on experimentation, such as demonstrations and pilots

(Expert 7, 12, 18). At this level, the core activities are stakeholder analysis, service development and experimentation. These activities may occur next to those mentioned in the previous level.

Implementing sustainable organization design requires writing a business case to keep track of viability (Expert 16, 20). Expert 16 referred to the company he works with to stress the importance of this and closely related activities: "We have this kind of value proposition design process in the company, which works on those activities […] estimating the size of the market, the willingness to pay, how much financial resources are available, calculating profit and loss and writing a business case". Indeed, financial accounting (e.g. forecasting a profit and loss statement) is also an essential activity to assess viability when introducing a sustainable business model (Expert 14, 19, 20), as well as the risk entailed with undertaking this effort (Expert 20). Consequently, at this level, additional core activities must include business modeling and writing a business case, financial accounting and risk assessment. These activities may occur next to those mentioned in the previous level.

Implementing sustainable collaboration design requires the analysis of the entire industry and/or economic sector (e.g. the automotive industry/mobility sector) that has to be transformed (Expert 5,17). Expert 17 explained that in this context "it's not just about doing an industry analysis […] It's about talking to leaders and changing the future […]". Next to understanding who are the players involved in a certain industry and what are the power plays taking place, strategic foresight is needed to see how they can be disrupted in the long run (Expert 5, 17). Often analysis and foresight need to go beyond a single industry, since sustainably transforming business ecosystems entails synergies across industries and national states across different regions of the globe (Expert 14, 17). To this end, transformational leadership is required from key players active in the public and public sectors, who can together accelerate the change (Expert 12, 17). Again Expert 17 mentioned this activity in his/her working experiences: "How can we integrate directly with the [directives of the] European Union? What is the future of optimization and work in Southeast Asia? How can we meet with the prime minister of [that Asian country]?" These instances show that at this level, the innovation process often includes as core activities industry and sector analysis, strategic foresight and transformational leadership. These activities may occur next to those mentioned in the previous level.

4.5 Main challenges in the sustainable design process

In business practice, the main challenges in the sustainable design process refer to those aspects that prove to be particularly problematic when integrating environmental and/or social goals in the development of innovation outputs.

Implementing sustainable product design is ultimately about reducing the life cycle impact, normally associated with a single product (Expert 2, 8, 9, 11). Thus, at this level, the main challenges relate to

technical issues, specifically reducing material use, energy flows, toxicity and carbon emissions. Expert 11 explicitly elaborated upon the difficulty to get implement new sustainable product designs due to such challenges: "Reduction of emissions, reductions of toxicity, reduction of resource use […] these were the challenges in the project […] And it was quite drastic: 50% less. Yeah, I'd still like to see that implemented".
However, reducing material and energy flows has a limited impact if the broader context is unsustainable (Expert 8). In fact, if materials are not sourced responsibly and if the energy used throughout various phases of the life cycle comes from fossil fuels, a product cannot be sustainable (Expert 2, 18).

Sustainable product and service design is very challenging to implement. Expert 2 stated that: "Designing services [next to products] allows for more radical sustainability changes but also poses new problems". Expert 12 elaborated further on the matter in relation to a project that he was involved in: "We were trying to implement a [service] solution to inform customers about the impact of their mobile phone. Bringing it to market in different countries was the main challenge I encountered [in the project]". Indeed, delivering product-service combinations on the market most likely requires changing current ways of operating of companies and even entire supply chains (Expert 2, 6, 12, 19).
Furthermore, impact assessment beyond a focal product becomes extremely difficult (Expert 10, 14). When more radical transformations take place, unexpected rebound effects might occur (Expert 6, 19, 20). Consequently, at this level, the main challenges are transforming supply chains and assessing the impact of product-service combinations.

Sustainable organization design allows pushing forward even more radical changes, but the new business models required to this end are difficult to implement because they must be financially viable and scalable (Expert 7, 20). Expert 20 was very clear on this aspect: "When we design these [sustainable] business models we must also consider [financial] viability […] And then, can the organization scale it up?" Given that shareholders and external partners are often affected by the introduction and provision of a sustainable business model, managing their wishes and expectations also becomes a major challenge (Expert 4, 13, 17, 19). Expert 13 and Expert 19 were also clear on this challenge, respectively stating that "with new business ideas, stakeholder management is always difficult" and that the need to "generate shareholder value, it's often a barrier to [sustainable] innovation". Thus, at this level, the main challenges relate to financial and organizational aspects, specifically ensuring financial viability, scaling up, and managing stakeholders and shareholders in the process.

Implementing sustainable collaboration design is very challenging (Expert 10, 12) because it requires creating consortiums and/or coalitions of organizations (Expert 8, 10). Expert 5 explained that when multiple organizations are involved "business models are just part of the game. You also need someone who defines the rules of the

game […], policy comes into play. […] There must be interventions and frameworks that help the disruption of existing industry structure". A strong commitment is also required in terms of time and effort from collaborating organizations, both upfront when applying for funding and eventually to turn a temporary endeavor into a running business (Expert 1, 13, 19). Consequently, at this level, the main challenges relate to political and legal aspects, creating policy frameworks, gaining stakeholder commitment and turning a multi-stakeholder temporary project into a stable and cohesive business entity.

5. DISCUSSION

This section is divided into three sub-sections. First, we present the framework about implementing sustainable design theory in business practice. Second, we discuss our contributions to sustainable design theory, putting forward three recommendations for future research. Third, we discuss our contribution to business practice, putting forward two recommendations.

5.1 Framework for implementing sustainable design theory in business practice

This research addresses the question of how sustainable design theory is applied in business practice. We hereby propose a framework that provides an answer to this question through an insightful overview (Fig. 4) combining the outcome of our literature review (Fig. 2) and empirical investigation (Fig. 3)

The top part of the framework proposes an integration of existing sustainable design theory (c.f. Ceschin and Gaziulusoy, 2016) with business concepts (e.g. Adams et al., 2016; Baumann et al., 2002; Boons and Lüdeke-Freund, 2013; Konietzko et al., 2020). Here, we cluster these combined theoretical insights according to four literature streams, corresponding to four levels of design for sustainable innovation: ecodesign, product service system design, sustainable business model design, collaborative ecosystem design. Ecodesign requires developing of products with a life cycle that has a lower environmental impact (Brezet and van Hemel, 1997). Product service system design entails developing of product-service combinations that reduce the environmental impact of resource use by providing access instead of ownership along with a superior functional solution (Tukker, 2004). Sustainable business model design is about reshaping existing organizations or creating new ventures driven by a social and/or environmental purpose (Keskin et al., 2013). Collaborative ecosystem design relates to a systemic effort aimed at the creation of coalitions of collaborating organizations, working together to drive the sustainable transformation or entire markets and economic sectors (Konietzko et al., 2020).

The middle part of the framework visualizes the gap that is present between sustainable design ideas proposed by theory and their concrete implementation in business practice (Baldassarre et al., 2020; Vezzoli et al., 2015). This gap between theory and practice,

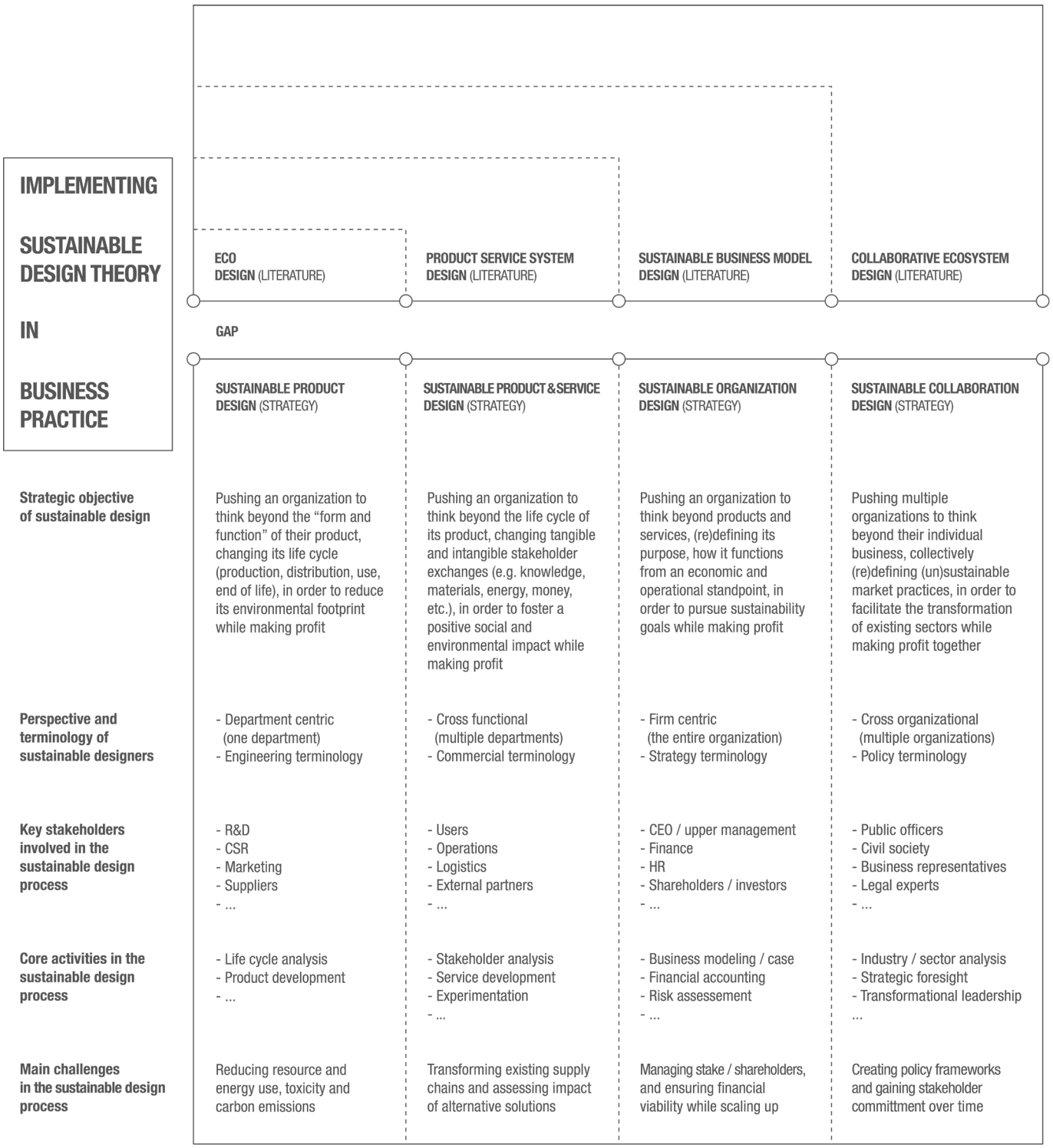

Figure 4. Framework visualizing the gap between sustainable design theory and its application in business practice. Insights are categorized according to four levels of sustainable design based on a literature review (top part/vertical columns) and five themes that emerged from expert interviews (bottom part/horizontal rows). Inspired by the work of (Adams et al., 2016; Ceschin and Gaziulusoy, 2016)

already identified by researchers almost twenty years ago (Manzini and Vezzoli, 2003; Tukker, 2004), must be addressed if the desired environmental and social impacts of sustainable design are to be achieved (Tukker, 2004, 2015).

To this end, in the bottom part of the framework, we propose a set of themes related to how sustainable design theory is applied across the four levels of design, which in business practice correspond to a specific strategy output. These themes are based on the knowledge and real project experiences of the experts. The first theme describes the strategic objective of sustainable design, which is about pushing organizations to change their innovation strategy with a different range of scope across the four levels of our framework, from rethinking products to shaping new systemic collaborations with other players across industries. The second theme describes the perspective and terminology of sustainable designers, which varies across the four levels of the framework from department centric to cross organizational, with a jargon shift from engineering to policy-related. The third, fourth and fifth themes describe respectively the key stakeholders, core activities and main challenges in the sustainable design process, which tend to increase in terms of number and complexity across the four levels of the framework.

5.2 Contributions to sustainable design theory

The first part of our contribution to sustainable design theory lies in integrating the body of knowledge with business concepts derived from reviewing extant theoretical (e.g. Baumann et al., 2002; Bocken et al., 2014) as well as empirical literature (e.g. Baldassarre et al., 2017; Konietzko et al., 2020; Manzini and Vezzoli, 2003). This integration is essential to advance sustainable design theory. Indeed, sustainable design emerged with the objective of aligning environmental and social benefits with economic ones (Brezet and van Hemel, 1997). Therefore, strategic business considerations should be central to it (Dobers and Strannegård, 2005; Manzini and Vezzoli, 2003). Accordingly, in this piece of work, we connect research on sustainable design with (sustainable) business research, providing a synthetic yet insightful overview of research streams at the boundary between these spaces (top part of Fig. 4).

First recommendation: We encourage sustainable design scholars to incorporate more prominently the study of (sustainable) business literature into their research: by better understanding business concepts, and formulating their messages accordingly, they might ultimately increase the relevance of their work and disseminate it outside of the "sustainable design niche".

The second and main part of our contribution to sustainable design theory is uncovering a set of themes related to its implementation in business practice, based on the knowledge and real project experiences of multiple experts. These insights are relevant to contribute in addressing a longstanding gap of knowledge around the implementation of sustainable design theory (Baldassarre et al., 2020;

Manzini and Vezzoli, 2003), which is critical to achieve impact (Tukker, 2004, 2015). Indeed, filling this knowledge gap is not an easy task because in business practice theory is confronted with multiple and diverse issues (Vezzoli et al., 2015). Nevertheless, with this research, we contribute to addressing this complex and multifaceted problem by identifying and describing some of its underlying variables (bottom part of Fig. 4). For example, we describe who are the key stakeholders and which core activities have to be considered when attempting to translate theory into practice.

Second recommendation: We encourage sustainable design scholars to increase research efforts around the gap of knowledge concerning the implementation of theory in business practice: by diving deeper into this complex and multifaceted problem, it is possible to break it down into its underlying variables, resulting into smaller and more manageable subjects to focus on.

An additional theoretical contribution to sustainable design is stressing that the way of thinking and related language of researchers and practitioners working in this space is quite different. Our empirical data indicate that while researchers often think and talk in terms of literature streams, practitioners do so in terms of innovation strategy and outputs. Considering that the overarching goal of sustainable innovation research is ultimately supporting practice in becoming more environmentally and socially responsible (Ehrenfeld and Gertler, 1997), the aforementioned issue becomes rather problematic if it results in raising a communication barrier between academia and industry. Logically follows the importance of developing a common language, a subject already addressed by former research (Bocken et al., 2014; Lüdeke-Freund and Dembek, 2017). To this end, the value of our framework lies in representing a visual support to see these language differences and overcome the related barrier (different naming of the four levels in the top and bottom part of Fig. 4).

Third recommendation: We encourage sustainable design scholars to acknowledge that in business practice theoretical ideas are often reframed in terms of innovation strategy outputs, using a different language: by adopting such language in their conceptual work, they might ultimately be able to better convey their message outside academia and increase the real impact of their work.

5.3 Contributions to business practice

Our contribution to business practice is clarifying the crucial role of operating simultaneously on multiple levels to implement innovation ideas that are truly sustainable. In other words, businesses should not only transform the way they make their products, but simultaneously redesign the service exchanges taking place around these products, the wider business models encompassing these services, and also reconsider the way they interact with other actors to shape markets and industrial sectors. Despite in the literature the discussion about the higher levels of sustainable business model and ecosystem innovation is ongoing (Bocken et al., 2014; Konietzko et al.,

2020)—and that some new ventures are engaging with these forms of radical innovation (Hockerts and Wüstenhagen, 2010)—in practice most large incumbent firms still operate at the lower levels of product and process optimization, driven by eco-efficiency compliance (Linder and Williander, 2017; van Tulder et al., 2013). Besides visualizing these levels of change next to each other, the framework developed in this study captures the broad spectrum of objectives, perspectives, stakeholders, activities and challenges that are present across them. Such information is particularly relevant for industrial designers and business managers who want to play a role in the transition toward sustainable development.

Industrial designers have been traditionally concerned with technical and aesthetic matters (Dell'Era and Verganti, 2010). However, the need for sustainable innovation poses new environmental and societal challenges, which are complex and interdisciplinary (George, Howard-Grenville, Joshi, and Tihanyi, 2016). As general specialists, designers can give a significant contribution to solving such challenges (Manzini, 2009, 2016, 2017) and foster innovation across the four levels of the framework. Yet, doing this requires going out of the comfort zone and learning to do something new (Joore and Brezet, 2015; Manzini, 2009).

Fourth recommendation: We encourage industrial designers to leverage their general specialism to foster sustainable innovation on multiple levels, from rethinking products and services, to disrupting the business model of organizations and transforming entire industrial sectors: by daring to have broader strategic objectives, learning to work from new perspectives, becoming proficient with new terminologies across disciplines, executing new key activities and dealing with new challenges, they may ultimately become active agents of change in the transition toward sustainable development.

Business managers can use their influence inside the organization they work for, in order to elevate design above a minor function concerned solely with technicalities and aesthetics in product development (Micheli et al., 2018). Specifically, designers may play a role at a strategic level by integrating the criteria of desirability (i.e. what people need and want), feasibility (i.e. what is technically achievable), viability (i.e. what is financially possible) and sustainability (i.e. what is economically, socially and environmentally acceptable) when innovating (Baldassarre et al., 2020). Recent research on this subject shows that designers' ways of "thinking and doing" can indeed be leveraged to innovate at the higher levels of our framework (Baldassarre et al., 2019b; Joore and Brezet, 2015). For example, designers can facilitate participatory workshops to foster interdisciplinary dialogue and processes (Bocken et al., 2019), envision and communicate future sustainable scenarios (Gaziulusoy and Ryan, 2017), conceive and test marketing campaigns through digital platforms and prototype beyond focal products entire value propositions, service exchanges and business models (Baldassarre et al., 2020; Schuit et al., 2017).

Fifth recommendation: We encourage business managers to acknowledge that industrial designers are not just product makers: by using their influence inside the organization to employ designers' ways of "thinking and doing" at a more strategic level, they will ultimately be able to realize superior innovation outcomes that are desirable, feasible, viable and sustainable.

6. CONCLUSION

In this paper, we focus on the implementation of sustainable design theory in business practice. This is essential for translating intangible speculations into reality, and achieving a positive, tangible, impact on society and the environment. Former research has already highlighted the need to focus on this important, yet problematic aspect. Our intention is to contribute to this effort while laying the foundations for future research and practice in this direction. To this end, we propose a framework and five recommendations for academic researchers, industrial designers and business managers who want to leverage their professional position to play an active role in the transition toward sustainable development.

Building on our work, future research may also address the limitations of this study. The first limitation relates to our data collection. In our literature review, the included articles were not selected with a systematic approach through a keyword-based search on scientific databases. Conversely, it was initially collected from two existing literature reviews and subsequently expanded through backward and forward snowballing. In our literature search, we included articles found through the reference list of these reviews, and articles citing them found on Scopus. Despite our literature search might have been biased, our data is derived by a large number of relevant publications, which were selected with clear criteria as part of a structured process and provide adequate grounding for our findings. Furthermore, our empirical data was collected with a qualitative approach. Thus, our framework is still an exploratory outcome and further research should validate its comprehensiveness and deepen our understanding of the themes. Nevertheless, the collected data is based on 20 expert interviews with relevant and diverse background knowledge and experience on the investigated subject. As such they provide a broad overview of multiple relevant aspects, which is relevant to inform future research.

The second limitation relates to the qualitative approach that we used to interpret our literature and empirical data. Even though we conducted this analysis in a structured way and employed different measures to mitigate subjectivity, we do not exclude that different interpretations of our data may be possible. Nevertheless, our interpretation remains valuable to inform and guide future research efforts exploring the implementation of sustainable design theory in business practice.

To conclude, this paper represents a call to action related to the implementation of sustainable design theory in business practice. We suggest that future

research around sustainable design theory may build onto this call to action by focusing further implementation issues while addressing the above-mentioned limitations. A potential follow-up of this study may be to leverage the framework, related concepts and keywords as a starting point for a more systematic literature review on the subject. Another future research avenue may be to conduct a follow-up of our empirical investigation, using our results as the starting point for a survey with a larger number of experts or to set up more focused longitudinal case studies on how certain companies or industries have been going through the different phases of sustainable design.

ACKNOWLEDGEMENTS

The authors would like to acknowledge financial support through the ZERO BRINE project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390. The authors would also like to thank the research assistant Celia de Vries for her valuable support in conducting and transcribing the expert interviews.

APPENDIX A

Table 2: Database of articles selected in our literature review

Legend

Rev1: articles identified from the sustainable design review of Ceschin and Gaziulusoy (2016)
Rev2 = articles identified from the sustainable innovation review of Adams et al. (2016)
Back. = articles identified snowballing backward (cited by the two reviews above)
Forw. = articles identified snowballing forward (citing the two reviews above)
Extra (+) = articles we added based on our own knowledge on the subject

	Authors	Year	Outlet	Title	Rev1	Rev2	Extra
Eco/green product design	Aschehoug et al.	2012	Journal of Cleaner Production	Environmental information from stakeholders supporting product development		Back.	
	Baumann et al.	2002	Journal of Cleaner Production	Mapping the green product development field: engineering, policy and business perspectives		Back.	
	Braungart and McDonough	2002	Corporate Environmental Strategy	Design for the Triple Top Line			+
	Braungart et al.	2007	Journal of Cleaner Production	Cradle-to-cradle design: creating healthy emissions - a strategy for eco-effective product and system design	Back.		
	Brezet and van Hemel	1997	UNEP report	Ecodesign: A promising approach to sustainable production and consumption			+
	Dangelico and Pujari	2010	Journal of Business Ethics	Mainstreaming Green Product Innovation: Why and How Companies Integrate Environmental Sustainability		Back.	
	De Marchi	2012	Research Policy	Environmental innovation and RandD cooperation: Empirical evidence from Spanish manufacturing firms		Back.	
	De Medeiros et al.	2014	Journal of Cleaner Production	Success factors for environmentally sustainable product innovation: a systematic literature review		Back.	
	Domingo et al.	2015	Journal of Industrial and Production Engineering	The importance of understanding the business context when planning eco-design activities			+
	Dyllick and Rost	2017	Journal of Cleaner Production	Towards true product sustainability		Forw.	
	Hallstedt et al.	2013	Journal of Cleaner Production	Key elements for implementing a strategic sustainability perspective in the product innovation process		Back.	
	Huang and Wu	2010	Management Decision	The effects of organizational factors on green new product success		Back.	
	Pigosso et al.	2013	Journal of Cleaner Production	Ecodesign maturity model: a management framework to support ecodesign implementation into manufacturing companies	Back.		
	Pujari et al.	2003	Journal of Business Research	Green and competitive: Influences on environmental new product development performance		Back.	
	Tariq et al.	2017	Technology in Society	Drivers and consequences of green product and process innovation: A systematic review, conceptual framework, and future outlook		Forw.	
	van Hemel and Cramer	2002	Journal of Cleaner Production	Barriers and stimuli for ecodesign in SMEs			+
	van Weenen	1995	Journal of Cleaner Production	Towards sustainable product development			+
	Baines et al.	2007	Journal of Engineering Manufacture	State-of-the-art in product-service systems	Back.		
	Cavalieri and Pezzotta	2012	Computers in Industry	Product–Service Systems Engineering: State of the art and research challenges	Back.		

Product service system design	Ceschin	2013	Journal of Cleaner Production	Critical factors for implementing and diffusing sustainable product-Service systems: Insights from innovation studies and companies' experiences	Back.	Back.	
	Cook et al.	2006	Journal of Cleaner Production	The transfer and application of Product Service Systems: from academia to UK manufacturing firms	Back.		
	Dewberry et al.	2013	Design Journal	Critical reflections on designing product service systems	Back.		
	Emili et al.	2016	Energy for Sustainable Development	Product-Service System applied to Distributed Renewable Energy: A classification system, 15 archetypal models and a strategic design tool	Back.		
	Goedkoop et al.	1999	Report for Dutch ministries of environment and economic affairs	Product service systems, ecological and economic basics			+
	Kristensen and Remmen	2019	Journal of Cleaner Production	A framework for sustainable value propositions in product-service systems	Forw.	Forw.	
	Laperche and Picard	2013	Journal of Cleaner Production	Environmental constraints, Product-Service Systems development and impacts on innovation management: Learning from manufacturing firms in the French context			+
	Manzini and Vezzoli	2003	Journal of Cleaner Production	A strategic design approach to develop sustainable product service systems: Examples taken from the 'environmentally friendly innovation' Italian prize	Back.		
	Martinez et al.	2010	Journal of Manufacturing Technology Management	Challenges in transforming manufacturing organizations into product-service providers	Back.		
	Mont	2002	Journal of Cleaner Production	Clarifying the concept of product–service system	Back.		
	Oliva and Kallenberg	2003	International Journal of Service Industry Management	Managing the transition from products to services	Back.		
	Tukker	2015	Journal of Cleaner Production	Product services for a resource-efficient and circular economy e a review	Back.		
	Tukker	2004	Business Strategy and the Environment	Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet	Back.	Back.	
	Tukker and Tischner	2006	Journal of Cleaner Production	Product-services as a research field: past, present and future. Reflections from a decade of research	Back.		
	Vezzoli et al.	2015	Journal of Cleaner Production	New design challenges to widely implement 'Sustainable Product Service Systems'	Back.		
Sustainable business model design	Baldassarre et al.	2020	Journal of Cleaner Production	Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots		Forw.	
	Baldassarre et al.	2017	Journal of Cleaner Production	Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design			+
	Birkin et al.	2009	Business Strategy and the Environment	A New Business Model for Sustainable Development: an Exploratory Study Using the Theory of Constraints in Nordic Organizations		Back.	
	Bocken et al.	2013	Corporate Governance	A value mapping tool for sustainable business modelling	Back.		
	Bocken et al.	2014	Journal of Cleaner Production	A literature and practice review to develop sustainable business model archetypes		Back.	
	Boons and Lüdeke-Freund	2013	Journal of Cleaner Production	Business models for sustainable innovation: state-of-the-art and steps towards a research agenda		Back.	
	Esslinger	2011	Journal of Product Innovation Management	Sustainable Design: Beyond the Innovation-Driven Business Model		Back.	
	Geissdoerfer et al.	2017	Journal of Cleaner Production	The Circular Economy – A new sustainability paradigm?			+
	Guldmann and Huulgaard	2020	Journal of Cleaner Production	Barriers to circular business model innovation: A multiple-case study		Forw.	
	Henry et al.	2020	Journal of Cleaner Production	A typology of circular start-ups: An Analysis of 128 circular business models		Forw.	

	Joyce and Paquin	2016	Journal of Cleaner Production	The triple layered business model canvas: A tool to design more sustainable business models			+
	Keskin et al.	2013	Journal of Cleaner Production	Innovation process of new ventures driven by sustainability		Back.	
	Klewitz and Hansen	2014	Journal of Cleaner Production	Sustainability-oriented innovation of SMEs: a systematic review	Back.		
	Lüdeke-Freund et al.	2015	Network for business sustainability report	Business models for shared value			+
	Rocha et al.	2019	Journal of Cleaner Production	Design for sustainability models: A multi perspective review	Forw.		
	Stubbs and Cocklin	2008	Organization and Environment	Conceptualizing a "Sustainability Business Model"		Back.	
	Sumter et al.	2018	Sustainability	The Role of Product Design in Creating Circular Business Models: A Case Study on the Lease and Refurbishment of Baby Strollers	Forw.		
Collaborative ecosystem design	Baldassarre et al.	2019	Journal of Cleaner Production	Industrial Symbiosis: towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives			+
	Bocken et al.	2019	Journal of Cleaner Production	Sustainable business model experimentation by understanding ecologies of business models			+
	Brehmer et al.	2018	Journal of Cleaner Production	Sustainable business models as boundary-spanning systems of value transfers			+
	Brown et al.	2019	Sustainability	Why Do Companies Pursue Collaborative Circular Oriented Innovation?	Forw.	Forw.	
	Gaziulusoy et al.	2013	Journal of Cleaner Production	System innovation for sustainability: a systemic double-flow scenario method for companies		Back.	
	Gaziulusoy and Brezet	2015	Journal of Cleaner Production	Design for system innovations and transitions: a conceptual framework integrating insights from sustainability science and theories of system innovations and transitions	Back.		
	Geels	2005	Technological Forecasting and Social Change	Processes and patterns in transitions and system innovations: Refining the co-evolutionary multi-level perspective	Back.		
	Hellström et al.	2015	Journal of Cleaner Production	Collaboration mechanisms for business models in distributed energy ecosystems			+
	Heuer	2011	Business Strategy and the Environment	Ecosystem cross-sector collaboration: Conceptualizing an adaptive approach to sustainability governance			+
	Jacobides et al.	2018	Strategic Management Journal	Towards a theory of ecosystems			+
	Joore and Brezet	2015	Journal of Cleaner Production	A Multilevel Design Model: the mutual relationship between product-service system development and societal change processes			+
	Konietzko et al.	2020	Journal of Cleaner Production	Circular ecosystem innovation: An initial set of principles	Forw.	Forw.	
	Loorbach et al.	2010	Business Strategy and the Environment	Business strategies for transitions towards sustainable systems		Back.	
	Loorbach and Wijsman	2013	Journal of Cleaner Production	Business transition management: exploring a new role for business in sustainability transitions	Back.		
	Manzini	2017	Strategic Design Research Journal	Designing coalitions: Design for social forms in a fluid world			+
	Talmar et al.	2018	Long Range Planning	Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model			+
	Zucchella and Previtali	2019	Business Strategy and the Environment	Circular business models for sustainable development: A "waste is food" restorative ecosystem			+

APPENDIX B

Table 3: categorization of interview insights and illustrative quotes

Level of design	**Illustrative quotes**	**Emergent topic**
Ecodesign (literature stream) - Sustainable product design (strategy output)	*"[In the projects] eco design was an approach to focus on the life cycle of the product"* (Expert 1). *"[The company] embraced it as an important contributor to the efficiency and quality of its operations"* (Expert 9).	*Strategic objective of sustainable design*
Product service system design (literature stream) - Sustainable product and service design (strategy output)	*"And then we started this project about selling the product as a service. […] And we focused a lot on the materials that were used in that product but also on the entire supply chain […] and the specific impact in the community" (Expert 18).*	
Sustainable business model design (literature stream) - Sustainable organization design (strategy output)	*"And of course, we do projects like that […] where we redesign the business model and you've got a shift toward an [economic] value focus [while solving sustainability problems]"* (Expert 20).	
Collaborative ecosystem design (literature stream) - Sustainable collaboration design (strategy output)	*"All these organizations have been working together for a while on a completely redesigned mobility system for the city"* (Expert 10). *"But, this only works when they collaborate, when they have a clear joint goal and mutual benefits"* (Expert 20).	
Ecodesign (literature stream) - Sustainable product design (strategy output)	*"When I was working [as an industrial designer] for those two multinational companies I was into an engineering context"* (Expert 14). *"Environmental requirements had to be communicated with a factory language"* (Expert 9).	*Perspective and terminology of sustainable designers*
Product service system design (literature stream) - Sustainable product and service design (strategy output)	*"You are designing the product, the services and their interrelationships […] I am thinking about this from a design perspective […]"* (Expert 6). *"You need a cross functional view to bring this [sustainable design] safely across the borders of departments"* (Expert 9).	
Sustainable business model design (literature stream) - Sustainable organization design (strategy output)	"*It was clear that the managers [of the client organization] wanted to talk about alternatives to fossil fuels in their business model"* (Expert 14). *"Since I am working with business models […] and the sustainability strategy […] I use the perspective of the entire organizations […] And it is a semantic language thing […] knowing how to talk to different people. Personally, I talk very differently to a [product] designer than I speak to a financial controller [in my company]"* (Expert 17).	
Collaborative ecosystem design (literature stream) - Sustainable collaboration design (strategy output)	*"A systemic view, this is what is unique in the ecosystem innovation projects […] In the end it's just a matter of perspective, that's the main point I think"* (Expert 10). *"And the designer must be like the spider in the web, connecting the points of view between industry, public sector and civil society"* (Expert 1). *"[As a designer] I do think I have influence by inspiring and explaining our innovation philosophy to our compliance department so they can translate again, to the policy makers"* (Expert 19).	
Ecodesign (literature stream) - Sustainable product design (strategy output)	*"There were designers and engineers working on [sustainable] products"* (Expert 2). "*After the environmental department […] they decided to establish in their own development department an environmental strategy […] A green marketing function was needed" (*Expert 9). *"Suppliers were also involved [in the sustainable design process]"* (Expert 8).	
Product service system design (literature stream) - Sustainable product and service design (strategy output)	*"When we design our services, we have to understand our users but also, we involve the service department right from the start, we work closely together with operations and logistics, marketing and sales […] explaining what the design is about […] and with external business partners"* (Expert 19).	

Sustainable business model design (literature stream) - Sustainable organization design (strategy output)	*"I work on the sustainability strategy of the company […] and new business models […] So I work mostly with the CEO, with the brand managers and other departments […] and also externally of course, both with academics and with startups and interesting people and so on"* (Expert 17). *"I think it shouldn't be underestimated, the people aspect […] the roles of people […] Do you have all the capabilities to bring this alive?*" (Expert 20).	
Collaborative ecosystem design (literature stream) - Sustainable collaboration design (strategy output)	*"To design [business collaborations] every company has to be represented […] you need delegates from every organization"* (Expert 16). *"But it's different stakeholder types. It is civil society organizations, NGOs, companies, and sometimes also public institutions* (Expert 18). *"And also the European Union, we sometimes have meetings with them […] discussing future policies with policy makers*" (Expert 19).	
Ecodesign (literature stream) - Sustainable product design (strategy output)	*"[…] And then [product] designers said: if we want to make it more sustainable we need to analyze the whole life cycle"* (Expert 2). *"I tried to set up guidelines for the product developers […] stuff like modularity and reparability […] to implement products to last longer"* (Expert 19). *"The engineers stayed overnight and next day came up with a design with 50 joints only. Soon after it was reduced to 30"* (Expert 9).	*Core activities in the sustainable design process*
Product service system design (literature stream) - Sustainable product and service design (strategy output)	*"We do life cycle analysis […] And we do stakeholder analysis when we design services. We started with plastic cups at festivals […] We contacted all the festival organizers and producers, we involved recycling agencies, cup producers, and we started to bring them together just to clarify the problem for everyone"* (Expert 15).	
Sustainable business model design (literature stream) - Sustainable organization design (strategy output)	*"We have this kind of value proposition design process in the company, which works on those activities […] estimating the size of the market, the willingness to pay, how much financial resources are available, calculating profit and loss and writing a business case"* (Expert 16).	
Collaborative ecosystem design (literature stream) - Sustainable collaboration design (strategy output)	*"It's not just about doing an industry analysis […] It's about talking to leaders and changing the future […] How can we integrate directly with the [directives of the] European Union? What is the future of optimization and work in Southeast Asia? How can we meet with the prime minister of [that Asian country]?"* (Expert 17).	
Ecodesign (literature stream) - Sustainable product design (strategy output)	*Reduction of emissions, reductions of toxicity, reduction of resource use […] these were the challenges in the [sustainable product design] project […] And it was quite drastic: 50% less. Yeah, I'd still like to see that implemented* (Expert 11).	*Main challenges in the sustainable design process*
Product service system design (literature stream) - Sustainable product and service design (strategy output)	*"Designing services [next to products] allows for more radical sustainability changes but also poses new problems"* (Expert 2). *"We were trying to implement a [service] solution to inform customers about the impact of their mobile phone. Bringing it to market in different countries was the main challenge I encountered [in the project]"* (Expert 12).	
Sustainable business model design (literature stream) - Sustainable organization design (strategy output)	*"When we design these [sustainable] business models we must also consider [financial] viability […] And then, can the organization scale it up?"* (Expert 20). *"We must generate shareholder value, and that's often a barrier to [sustainable] innovation"* (Expert 19). *"With new business ideas, stakeholder management is always difficult"* (Expert 13).	
Collaborative ecosystem design (literature stream) - Sustainable collaboration design (strategy output)	*"But business models are just part of the game. [When many organizations are involved] you also need someone who defines the rules of the game […], policy comes into play. […] There must be interventions and frameworks that help the disruption of existing industry structure"* (Expert 5).	

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CHAPTER II

DESIGNING A NEW BUSINESS DRIVEN BY SUSTAINABILITY OBJECTIVES

SECOND STORY

"You forgot again to pay the energy bill!" Sebba is frustrated, complaining with his strong Italian accent. This startup story does not begin in a garage of the Silicon Valley, but in the living room of a student house in the province of South Holland. He enters the main room where Caballino is baking olive bread and Nicolone is chilling on the couch wrapped into his favorite fleece blanket, pretending to make progress on his master thesis about the European market of wind energy. To show some fake interest in my friend's complaint, I stop playing the guitar and pick up the white envelope on the table. To be honest, I've always considered going through the energy bill as pleasant as studying mathematics on a Sunday afternoon. You open that envelope, and you are suddenly confronted with text and numbers less understandable than Sumerian clay tablets covered in cuneiform symbols from 6,000 years ago. The problem is serious: while buildings are responsible for about 1/3 of the total energy consumption on our planet, most people don't have a clue of how much energy they use when they are indoors, and for what purpose. And so they waste it. How can this energy waste problem, as well as other sustainability related issues, be used as the starting point for some kind of profitable business innovation? This is a question I had been asking myself many times during my studies. And so I decide to use my graduation project as a good excuse to find out, while gaining some more hands-on working experience. Through the faculty, I get involved in a project aiming to reduce energy consumption in

large office buildings by changing the behavior of the occupants. Here's an example to put things a bit into perspective. A building of 20 floors hosting 1,000 office workers from Monday to Friday from 8.00 to 17.00 consumes a big deal of energy for heating, cooling, ventilation, lighting, and for powering all sort of electronic devices. Without getting into too much detail, up to 20% of this energy, and around € 80,000 in terms of energy bill, could be saved every year if people at work started to do simple actions such as turning off the light when they go home, or avoiding to open the window during summer, when the air conditioner blows like the wind over the East Siberian taiga. My task in the project is designing a digital service to encourage this kind of behavior. On top of that, I also have to design a new business, a startup, which could develop and sell this service. I do not have much of a clue on where to start, and so I do what my supervisors Tomasz and Giulia prescribe: read. I read many books, reports, and academic articles, and watch online videos on energy consumption, behavioral change, corporate sustainability and entrepreneurship. One of these books about business venturing is titled "the four steps to epiphany", written by a guy called Steve Blank. The book opens with some lines that resonate with me, more than anything else because as a kid I had been watching Star Wars with my older sisters over and over again. The book says: "From Moses and the Burning Bush to Luke Skywalker meeting Obi Wan Kenobi, the journey always begins with a hero who hears a calling to a quest. At

the outset of the voyage, the path is unclear, and the end is not in sight […] Most entrepreneurs travel down the startup path without a roadmap and believe that no model or template could apply to their new venture. They are wrong. For the path of a startup is well worn, and well understood. The secret is that no one has written it down". Going through the pages, the main message is clear: "If you want to start a business, stop reading, close your laptop. Instead, get out of the building and talk to people".
I start to do this. I talk to academics, innovators, managers of various organizations and many office workers. And by doing so, I understand more. I understand that the money spent on the energy bill is pennies from the perspective of a big company. Multinationals do not care about this huge energy waste for financial reasons. The issue is more related to their image: they don't want to look irresponsible before the eyes of millions of people who are becoming every day more aware of the negative impact of business on the environment. This growing awareness may result in losing customers, thus less profit. Also, they don't want to look bad in front of their employees, especially the younger ones with higher education, who tend to be more aware about the environmental crisis and not so keen to work for companies ignoring it. Therefore, the solution that most multinationals found is—instead of trying to reduce energy consumption—donating tens of millions to charity every year. It is called CSR, acronym for corporate social responsibility. Now, I am not saying this to blame the companies,

like my beloved old uncle would do, arguing behind one of his socialist books. I am aware that companies are part of a complex system where everyone is responsible, including myself when I forget to turn off the toilet light every single day. But at the same time, looking at the bigger picture, it is impossible to ignore that recklessly wasting energy that contributes to climate change while donating money to WWF in order to save the polar bears from the Arctic meltdown is a rather curious way to act. I spent quite some time thinking about the problem from this new perspective, especially in the evening time watching BBC's "frozen planet" documentaries. While the legendary Sir David Attenborough eloquently narrates about the polar bears' struggles for survival, and Sebba is snoring on the couch after a second round of "sleepy time" herbal infusion, I have an idea: why not empower the employees of these multinationals to donate some of the CSR budget every time they do an energy-saving action? My assumption is that having a tangible proof that they can make an impact through the donation should motivate them to save energy as well. The only way to find out if it works is testing the concept. Using a web-based platform, I create a low-fidelity digital prototype of a smartphone app that allows office workers to donate when they turn off the light by scanning a QR code placed next to the switch. As they do it, a picture with a polar bear pops up and says: "THANKS". This is going to be the name of the new startup. Office workers seem to like it. I talk to a few CSR managers, who are also positive about

the idea and open for a pilot. At the same time, my supervisors agree that this is enough for me to graduate. But the work with THANKS is just beginning. Together with my old friend, latin lover and Spanish king of innovation, Diego Mazo Rosete, we raise some funding to keep the ball rolling. Vittorio and Karel use their computer magic to build a new prototype that allows to donate money using the personal badge of each employee, and to collect data about his or her actions. A cool professor from the United States helps us to shape up the business plan: "I like how you guys think" he says with a cowboy accent "one day, you are going to walk away with those 10 million dollars in your pocket". But in order to do this, we know that we must iterate. More talking with CSR managers and office workers, to better understand what sort of value they expect from our solution. More thinking about what the real problem is, based on the inputs they provide. And more testing with new versions of the prototype, to achieve a sustainability impact and, at the same time, generate economic value. Over and over: talking-thinking-testing. This is how you design a startup driven by sustainability objectives.

SECOND SCIENTIFIC PUBLICATION

Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design

This article has been published in the Journal of Cleaner Production. Please cite as:

Baldassarre, B., Calabretta, G., Bocken, N. M. P., and Jaskiewicz, T. (2017). Bridging sustainable business model innovation and user-driven innovation: A process for sustainable value proposition design. Journal of Cleaner Production, 147, 175-186.

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Abstract

With an increasing population, a growing middle class and increased resource use, our current ways of living and doing business are unsustainable. Next to the implementation of innovative technology, sustainable development based on innovative business models, better understating of customer needs and behavioural change are crucial. This research aims at combining principles from both sustainable business model innovation and user-driven innovation to develop more successful, radical and user-centred sustainable value propositions. Sustainable business model innovation entails developing value propositions that create value for multiple stakeholders at the same time, including customers, shareholders, suppliers and partners as well as the environment and society. User-driven innovation allows developing solutions that are meaningful for people and profitable for business by involving potential customers, users and/or other stakeholders in an experimental and iterative design process. The study adopts a research-through-design methodology, a qualitative research approach that uses design practice to inform research. To this end, a design project in the framework of the Climate-KIC (the largest European partnership addressing the challenge of climate change) was investigated. As a result, this paper proposes a process for sustainable value proposition design which adopts a thorough, dynamic and iterative perspective (talking to stakeholders, thinking about the problem, testing the product/service) that leads to an actual sustainable value proposition and to a superior problem-solution fit. In practice, managers are provided with an initial methodological framework for mapping and understanding the stakeholders in a broad sense (including and especially users), identifying their needs and interests, and progressively combining them into a more meaningful and enriching value proposition.

1. INTRODUCTION

The combination of a growing global population and increasing overall material consumption has implications for a finite planet: signs of unwanted impacts (e.g. climate change reducing crop yields; IPCC, 2014) and of irreversible changes (e.g. the increased rate of species extinction) are growing alarmingly (Royal Society, 2012). This means that our current consumption and production patterns are unsustainable. In this scenario, sustainable development—namely, innovation and development patterns that meet current human needs without compromising future generations' ability to meet their own (Brundtland, 1987)—becomes necessary, and companies can play a substantial role (Loorbach and Wijsman, 2013). Although companies attempt to embrace these sustainable patterns, they still use traditional innovation routines aiming prevalently (if not exclusively) at business growth and financial objectives (Ehrenfeld, 2009). Furthermore, companies' innovation efforts primarily focus on improving existing technologies and production systems through increased energy and resource efficiency, but not on other key drivers of successful sustainable innovation like combining customer benefits and technological efficiency in sustainable offerings (Keskin et al., 2013) and altering consumption patterns towards more sustainable behaviours and interactions with products (Daae and Boks, 2015). As a consequence, sustainable development might lead to incremental improvement, but not to the degree of change that would be required to address global environmental challenges.

A fundamental shift towards a deeper integration of environmental and social needs within business activities and innovation practices seems necessary (Boons et al., 2013).

To this purpose, sustainable business model innovation is an emerging research stream that attempts to strengthen companies' ability to pursue sustainable development by integrating sustainability objectives into business models, and thus concurrently achieving profit and a positive impact on society and/or the environment (Schaltegger et al., 2015; Stubbs and Cocklin, 2008; Tyl et al., 2015). Focusing on the business model for achieving sustainable development offers opportunities for more thorough, long term and radical solutions, as modifying the business model might have implications for all the activities, processes and resources through which a company creates, delivers, captures and exchanges value (Teece, 2010). Hence, a sustainable business model has the potential of going beyond incremental innovation and/or the improvement of operational and technological efficiency. The core of a sustainable business model is a sustainable value proposition; namely, a value proposition that allows simultaneous value creation for multiple stakeholders, including customers, shareholders, suppliers and partners as well as the environment and society (Bocken et al., 2014; Donaldson and Preston, 1995; Tyl et al., 2015). Despite the relevance of this research stream, few tools have been developed to support practitioners in the creation of value propositions for sustainable business models (Geissdoerfer et al., 2016).

Such tools are either too complex, or prevalently conceptual, or fall short in supporting sustainable

entrepreneurial practice (Bocken et al., 2013). This paper attempts to address this gap by proposing and exemplifying a hands-on process for sustainable value proposition design. Particularly, the process is derived by integrating sustainable business model innovation practices with user-driven innovation practices.

User-driven innovation posits that innovation is driven by users' needs, ideas and opinions, and is the result of a more or less close collaboration with users (Baldwin and von Hippel, 2011). User-driven innovation practices can benefit sustainable business model innovation in two ways. First, developing a sustainable value proposition is a long and challenging process that may require several product-market iterations, based on designing prototypes and interacting with external stakeholders to progressively find an overlap between sustainability and economic objectives (Keskin et al., 2013; Keskin, 2015). User-driven innovation also stresses the importance of creativity and prototyping when innovating, in order to derive meaningful solutions for end-users (Brown and Katz, 2011; Ries, 2011). Furthermore, the practice of iteration is central in user-driven innovation; specifically, the practice of developing and testing solutions early to validate business viability gradually and up front, thus saving significant time and resources in the subsequent development process (Blank, 2013; Ries, 2011). Second, by integrating a user focus, tools for sustainable business model innovation can support companies in overcoming the pitfall of directing their sustainable development efforts exclusively on technological advancements and production efficiency. Instead, their focus is shifted to concurrently pursuing behavioural change—i.e. altering consumption patterns towards more sustainable behaviours and interactions with products (Daae and Boks, 2015)—as a way of achieving sustainable and performance objectives (Tukker et al., 2008). Based on the above, this paper's research question can be summarized as follows:

How to design a new sustainable business model by integrating the needs of external stakeholders and users?

The research question is addressed through a qualitative research approach—a research-through-design methodology (Stappers, 2007; Zimmerman and Forlizzi, 2008; Zimmerman et al., 2010)—in the context of sustainable innovation for energy efficiency. Particularly, a sustainable innovation project aimed at developing a value proposition to trigger energy saving behaviour in commercial office buildings is used to implement the method. This project was part of the Building Technology Accelerator (BTA) project of the Climate-KIC (Jaskiewicz and Keyson, 2015). The Climate-KIC is Europe's largest innovation partnership addressing the challenge of climate change. This project represents an appropriate empirical context because energy consumption in the building sector is a persistent sustainability challenge that would benefit from more innovative solutions (Heck and Tai, 2013) and a greater focus on buildings' occupiers and their behaviours (Berkhout et al., 2000; Hens et al., 2010). By developing a value proposition that combines technological advancements with a

deep understanding of user needs in order to induce behavioural change, the study also contributes to research on excessive energy consumption. Specifically, this would be a situation in which the demand for energy outpaces the sustainable generative capacity of the ecosystem, leading to scarcity in supply and concurrent environmental degradation (Holdren, 1990). Reducing energy consumption is a priority (Bertoldi et al., 2012; US Energy Information Administration, 2014). Despite the important role that technology plays in increasing energy efficiency, the diffusion of innovative technology-driven solutions remains minor compared to overall needs (Heck and Tai, 2013). Furthermore, recent studies have demonstrated that more energy efficient buildings and products do not automatically guarantee energy savings in practice if individual behaviours fail to take advantage of their improved characteristics (Berkhout et al., 2000; Hens et al., 2010). Adopting a user-driven approach might help in addressing the energy efficiency challenge.

Based on the project's development process and results, the empirical findings are combined with theoretical underpinnings to propose an iterative process for sustainable value proposition design. The paper is organized as follows. First, there is a literature review on sustainable business model innovation and user-driven innovation, linking these to the empirical problem and research objective. Subsequently, there is an introduction to the research-through-design methodology. The findings are then presented, which correspond to the results of the design project. Next, the empirical findings are reconnected with the literature followed by a proposed process for designing a sustainable value proposition. Finally, there is a discussion of the theoretical and practical implications of this study, the limitations of the research and directions for further research.

2. LITERATURE REVIEW

As stated in the research question, this paper aims at showing that by following the principles of sustainable business model innovation and user-driven innovation, the behaviours and needs of customers and stakeholders can be better understood and new, more innovative solutions to environmental challenges can be reached. Such principles are briefly reviewed in the following paragraphs.

2.1 Sustainable business model innovation

A business model describes the design or architecture of how value is created, delivered and captured by an organization (Teece, 2010). According the Richardson (2008), a business model consists of a value proposition (i.e., the products and/or services that a firm offers to deliver value to its customers), a value creation and delivery system (i.e., the system of activities, processes, capabilities and resources through which the firm delivers the value proposition to its customers and achieves competitive advantage); and value capture (i.e., the way in which the firm generates revenues and profits from the delivery of the value proposition). Business model innovation is about creating new value propositions, and the related

value delivery and value capture systems, in order to generate superior economic value (Richardson, 2008). Business model innovation refers to both the transition from one business model to another within established companies (e.g. after mergers and acquisitions), and the creation of entirely new business models in new ventures (e.g. Chesbrough, 2007; Giesen et al., 2007; Mitchell and Coles, 2004; Ostelwalder and Pigneur, 2013).

Relatedly, sustainable business model innovation aims at benefitting society and/or the environment by also generating economic value (Schaltegger et al., 2015). The core of a sustainable business model is a sustainable value proposition; namely, a value proposition that allows multiple-stakeholder value creation by considering the needs of customers, shareholders, suppliers and partners as well as the environment and society (Bocken et al., 2013; Donaldson and Preston, 1995; Tyl et al., 2015). Conceptualizing a sustainable value proposition is a critical task in sustainable business model innovation, because it requires understanding and managing several needs and objectives across a network of multiple stakeholders in order to create shared value (Allee, 2000; Bocken et al., 2013; Porter and Kramer, 2011). The criticality lies in the fact that sustainable development (both in research and practice) has given limited attention to understanding customer needs and in integrating them with technological innovations in order to generate value (Keskin et al., 2013). Furthermore, a holistic view of the value proposition is required, where the benefits and costs of the customers need to be combined not only with those of the firm, but also of a broader range of stakeholders, including investors and shareholders, employees, suppliers, the environment and society (Bocken et al. 2013). Ultimately a sustainable value proposition results from combining three interrelated building blocks: generating shared value for a network of stakeholders, addressing a sustainability problem, and developing a product/service that tackles this problem by taking the stakeholders into account (Figure 1).

Despite the complexity, few tools have been developed to support practitioners in the creation of value propositions for sustainable business models (Bocken et al., 2013). Furthermore, existing tools are either complex, rather conceptual, or fall short in supporting sustainable entrepreneurial practice (Bocken et al., 2013). Improving the process of developing a sustainable value proposition would also offer a better input for existing tools that focus on developing the entire business model (including the value creation and value capture systems) – e.g., Strongly Sustainable Business Model Framework (Upward and Jones, 2015) and the Triple-layer Canvas by Joyce et al. (2015).

The Value Mapping Tool (Bocken et al., 2013; Bocken et al., 2015) was created as an attempt to provide entrepreneurial practice with a structured approach for supporting the conceptualization of sustainable value. It is a network-centric tool that enables the mapping of four key aspects of a sustainable value proposition (i.e. value captured, value destroyed, value missed and value opportunities) across a set of stakeholders. The tool

Figure 1. Sustainable Value Proposition Framework (based on and adapted from Bocken et al., 2013; Osterwalder et al., 2015)

allows an initial identification and understanding of different stakeholders' needs and objectives (including society and the environment), which is a fundamental first step in the development of a sustainable value proposition. However, developing a sustainable value proposition further is a long process that may require several product-market iterations, based on designing prototypes and interacting with stakeholders, in order to find an overlap between sustainability objectives and economic value (Keskin et al., 2013; Keskin, 2015). Accordingly, this study argues that the Value Mapping Tool and, more generally, literature on sustainable business model innovation would benefit by being integrated with principles from user-driven innovation—an approach to innovation that stresses the importance of creativity, experimentation and iteration as a way to address user needs while at the same time creating profitable business opportunities (Blank, 2013; Brown and Katz, 2011; Liedtka and Ogilvie, 2012; Ries, 2011).

2.2 User-driven innovation

User-driven innovation identifies business opportunities and develops new concepts by involving different groups of customers and/or potential users (Baldwin and von Hippel, 2011). Within user-driven innovation, design thinking is gaining popularity as an approach for doing business innovation (Liedtka and Ogilvie, 2012). Design thinking is defined as a user-centred innovation approach based on problem solving and a process of repeated iterations between the three creative phases of inspiration, ideation and implementation (Brown and Katz, 2011). Central to design thinking and relevant to sustainable business model innovation are practices such as problem reframing, knowledge brokering and co-creation of solutions (Calabretta and Gemser, 2015). Problem reframing implies changing the perspective on the problem in order to foresee alternative solutions (Dorst, 2011). Knowledge brokering refers to the use of information and expertise from prior and/or unrelated projects (e.g. in other markets and industries) in order to address the current project in a creative manner (Calabretta and Gemser, 2015). Co-creation is based on involving relevant stakeholders throughout an innovation project to ensure that their different and divergent needs are taken into account and addressed (Schneider and Stickdorn, 2011).

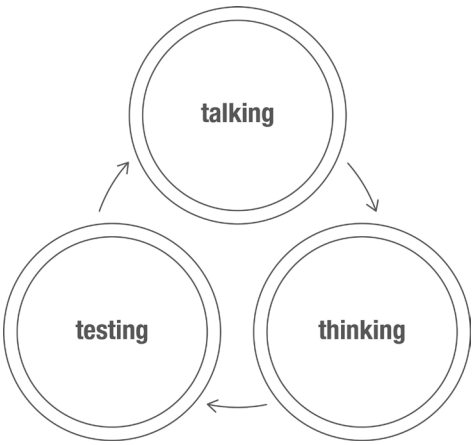

Figure 2. User-driven iterative process for developing value propositions (based on Brown and Katz, 2011; Ries, 2011)

Another stream within user-driven innovation that is relevant to this paper is the lean startup movement, which focuses specifically on how entrepreneurs can start new ventures (Ries, 2011). Similar to design thinking, this approach is also user-centred and iterative. Lean startup is grounded in the customer development philosophy, which argues that, in contrast with traditional new product development approaches, most startups do not fail because they lack a product but because they lack customers (Blank, 2013). Achieving product-market fit is the foremost challenge of entrepreneurship and can be achieved by treating business ideas as hypotheses to be quickly tested in front of potential customers. Lean startup builds on these ideas and integrates them with the lean manufacturing principles developed by Toyota in the early seventies (Womack, 2003). Lean startup is based on an iterative customer feedback loop of three steps: Build, Measure, Learn (Ries, 2011). Build involves creating a Minimum Viable Product (MVP); namely, the simplest possible prototype, which is to be tested with customers as early, quickly and cheaply as possible. Measure involves using specific metrics to evaluate customer feedback about the MVP. Learn refers to the collection of learnings validated by user feedback, which should then be integrated into the MVP itself to start a new lean development cycle. A MVP can also be sees as a bundle of features embedding assumptions that have to be tested (Ries, 2011).

The common denominator of design thinking and lean startup is the use of creativity and experimentation-pursuing innovation. Solutions are developed iteratively, and with the involvement of potential users, in order to validate their business viability and customer desirability gradually and up front. This saves significant time and resources in the product

development process (Blank, 2013; Brown and Katz, 2011; Ries, 2011). Ultimately, the two processes can be framed together as an iterative three-step process based on (1) talking to users, customers and stakeholders; (2) thinking about potential solutions; and (3) testing these solutions early on moving towards problem-solution fit (Figure 2).

This paper leverages principles from both sustainable business model innovation and user-driven innovation to advance business practices in sustainable innovation in general, and to address the challenge of energy efficiency in particular. The focus is on developing a process for sustainable value proposition design by combining the sustainable value proposition framework (Figure 1) and the user-driven iterative process for developing value propositions (Figure 2). Through the empirical study, the paper aims at contributing to academic research on sustainable business model innovation by integrating it with principles from user-driven innovation and ultimately proposing an iterative process for sustainable value proposition design.

3. METHODS

3.1 Research approach

Research-through-design is an iterative qualitative research approach that uses design practice to inform research (Stappers, 2007; Zimmerman and Forlizzi, 2008; Zimmerman et al., 2010). Methods, processes and artefacts derived from a design project are employed to develop conceptual frameworks, processes and guiding principles. The research-through-design process is an iterative spiral of generative and evaluative cycles converging towards a design objective (Stappers, 2007). In this process, knowledge is gradually gathered, integrated and contextualized. This method was selected because it allows building tangible solutions and knowledge simultaneously. In this paper, it is relevant for advancing theoretical research in the domain of sustainable business model innovation while simultaneously addressing the empirical problem of energy efficiency in the building sector.
In line with this methodological approach and the research question, a design project within the Building Technology Accelerator (BTA) flagship project (Jaskiewicz and Keyson, 2015) was selected. This project is part of the Climate-KIC, Europe's largest innovation partnership addressing the challenge of climate change. The objective of the design project was to develop a value proposition to trigger energy saving behaviour in commercial office buildings. The project provided a suitable empirical context for the research because it required the design of a value proposition and a business model for a service addressing a sustainability problem while creating shared value for a network of stakeholders: corporate clients and office workers (users). Thus, it offered an appropriate endeavour for observing how the principles of sustainable business model innovation and user-driven innovation interact. Furthermore, reducing energy consumption in the building sector is a priority (Bertoldi et al., 2012; US Energy Information Administration, 2014); consequently, the project also offers a good context for studying how

combining sustainable business model innovation and user-driven innovation can contribute to addressing the energy efficiency challenge.

3.2 Research process

The research process (Figure 3) followed to implement the methodology is based on the research-through-design principles described in the previous section (i.e., iterative spiral of generative and evaluative cycles, the use of design artefacts and outcomes to generate knowledge).

The starting point of the research process is the empirical problem of energy efficiency in the building sector. According to the sustainable business model innovation approach, this sustainability problem should be addressed by concurrently creating economic, societal and environmental values. Based on theoretical and market knowledge, the initial sustainable value proposition was defined as follows: providing an alternative energy awareness program

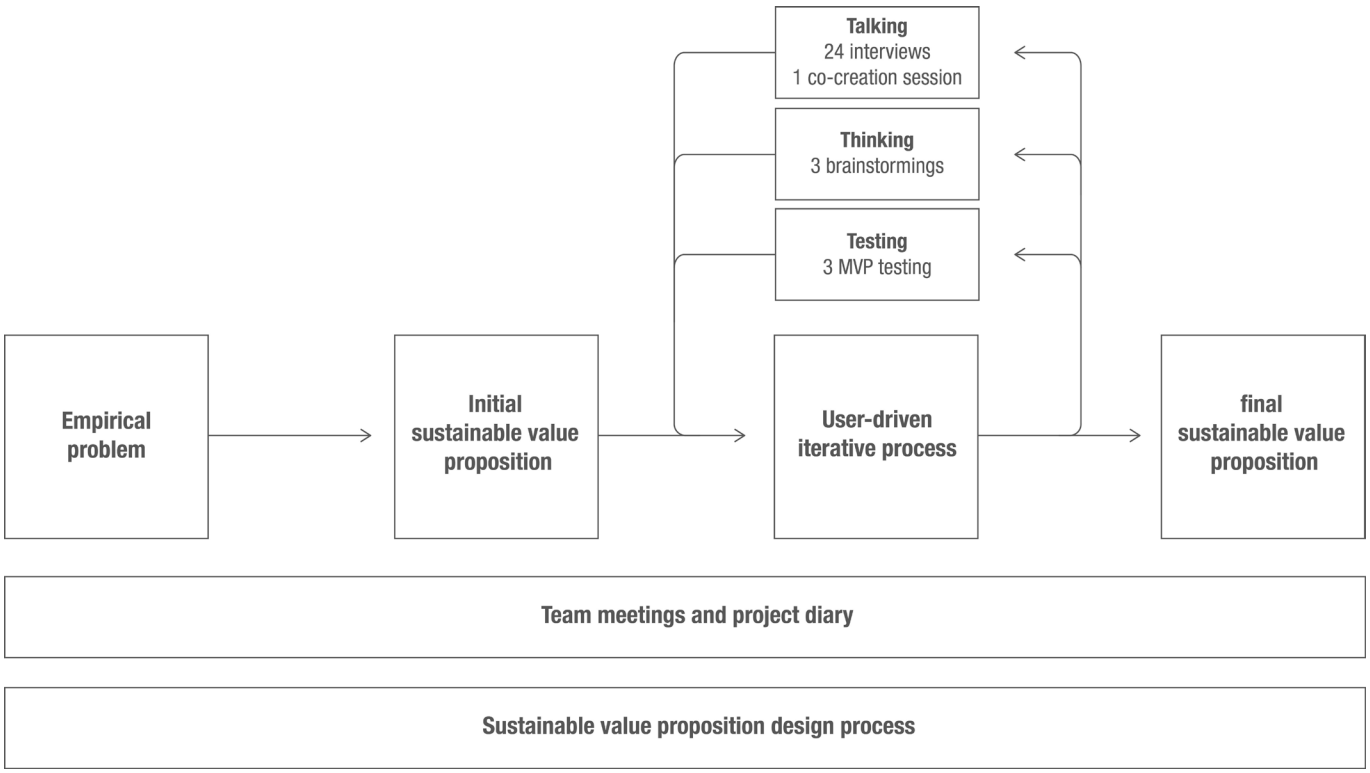

Figure 3. Methodology to design a sustainable value proposition for energy efficiency in commercial office buildings, and to extrapolate a conceptual process for Sustainable Value Proposition Design (based on Brown and Katz, 2011; Ries, 2011; Stappers, 2007)

to corporate clients who want to reduce energy consumption in their office buildings with a cost-effective solution (unlike complex and expensive technology-based interventions). During the project, this initial value proposition was developed further by iterating the three steps of the user-driven process: talking, thinking, testing.

The talking phase aimed at involving relevant stakeholders in the identification and discussion of core elements of the proposition. To this purpose, qualitative field research was used. The first author started with interviewing a potential client who was the energy manager of an international company. The interview was conducted with an informal conversational approach and audio recorded (Patton, 2002). The conversation topics focused on understanding the importance of energy efficiency in a building for a company, and the current and desired solutions for pursuing energy efficiency. Afterwards, a group of potential end-users (ten office workers from a Dutch company) were involved in the process through a co-creation session (Calabretta and Gemser, 2015; Sanders and Stappers, 2012). Participants were given stickers and drawing material and were asked to associate energy saving behaviours to desired rewards. Subsequently, the participants were asked to generate ideas for energy saving office products or services on the basis of the rewarding mechanism that they valued most. The co-creation session was video recorded. Both the interview and the co-creation session have been transcribed for data analysis.

In line with the guidelines of qualitative data analysis methodology, the analysis of the transcribed material was coded by following several steps (Eisenhardt, 1989; Miles and Huberman, 1994). First, in line with the research questions, the first author analysed the interview and the co-creation session separately, and selected quotes exemplifying key drivers of energy saving behaviours and key elements to be included in a value proposition for triggering such energy saving behaviours in office buildings. Based on the selected quotes, the first author completed an initial list of the main themes, which was then discussed and iterated with the second and the fourth author in two sessions. During these sessions, the 'analysis on the wall' approach was used as an appropriate technique for capturing the richness of the data set, and as suggested by the research-through-design methodology (Sanders and Stappers, 2012). The most relevant findings of the talking phase were visualized into a set of insightful infographics (Charmaz and Belgrave, 2002; Dunleavy, 2015; Stappers, 2007).

The thinking phase aimed at using the previously collected insights for ideation; the infographics were used for this purpose. During this phase, additional market and literature research on the topics that emerged from the previous phase was performed. The authors also brokered knowledge from a former project, in which one of the team members had been involved, to shape the development of the value proposition (Calabretta and Gemser, 2015). As a result, the problem was reframed and a new version of the value proposition was crafted accordingly (Dorst, 2011). Finally, the authors engaged in a series of brainstorming sessions with different (potential)

stakeholders. The resulting ideas were clustered by using the 'analysis on the wall' approach (Sanders and Stappers, 2012), and subsequently channelled into a service concept based on the value proposition.

The testing phase aimed at early testing of the value proposition with relevant stakeholders (Ries, 2011). A Minimum Viable Product of the service concept was built using an existing instant messaging application as the enabling platform. The objective was to simulate the interaction with the service concept with ten office workers over the course of five days. The results of the user test were measured quantitatively with a specific metric to assess the robustness of the value proposition (Ries, 2011).

The testing phase flowed into a first iteration of the user-driven process aiming to further develop the value proposition towards a better problem-solution fit. A new talking phase consisted of ten follow-up individual interviews with test participants, which aimed at a qualitative assessment of the concept and underlying value proposition that they had been testing. The interviews have been transcribed and analysed with the same coding process described in the first talking phase. In addition, another potential client (the Sustainability Manager of an international company) was also interviewed. A new thinking phase involved a team brainstorming session to refine the value proposition according to the new feedback obtained from the stakeholders (Ries, 2011). Finally, a new version of the MVP was built and tested again with ten office workers as participants over the course of ten days.

The first iteration flowed into a second iteration, including a new talking phase with twelve additional interviews (ten follow-up interviews with the participants of the latest MVP testing, one interview with another potential client—the Sustainability Manager of another international company—and one interview with a potential partner, the president of a foundation engaged in social and environmental initiatives); a new thinking phase, with an additional team brainstorming session to integrate the new feedback into a new value proposition; and a new testing phase, where a new version of the MVP was built and tested again with four office workers for twenty days. The positive outcome of the second iteration provided the necessary validated learning for the definition of a preliminary business model around the value proposition (Blank, 2013), which, however, falls outside the scope of this research. Table 1 summarizes, describes and categorizes the stakeholders involved in the data collection. Each relevant stakeholder is included: the office workers are used as a proxy for "society", the company stakeholder represents "economy", and partners from environmental organisations were used as a proxy for "environment".

Finally, during the course of the project, regular team meetings took place to discuss the adopted methodology and the emerging outcomes. The project development process, as well as the outcomes of the meetings, were documented in a visual project diary providing a rich set of qualitative data. Upon project completion, such data have been analysed and reconnected with theory from the literature review

Table 1: Stakeholders involved to design the value proposition for energy saving behaviour in commercial office buildings (based on Allee, 2000; Bocken et al., 2013; Donaldson and Preston, 1995; Porter and Kramer, 2011)

	Trigger energy saving in office buildings		
	Society	**Economy**	**Environment**
Stakeholders	Office workers (end users)	Companies (clients)	Environmental organizations (partners)
Research activities	3 MVP tests with 24 participants	3 interviews with company managers	1 former project 1 manager interview

to conceptualize the iterative process for Sustainable Value Proposition Design.

4. FINDINGS

This section reports the empirical findings on how a sustainable value proposition for energy efficient behaviours in commercial office buildings can be designed by combining the sustainable business model innovation approach with practices from user-driven innovation. Particularly, the focus is on how the value proposition evolves and improves through the different practices. Subsequently, in the discussion section, these findings are used to extrapolate a process that brings together the two innovation approaches and serves the hands-on needs of practitioners engaged in the development of sustainable value propositions. The findings are structured according to the three steps of the user-driven design process (i.e. talking, thinking, testing) and their iterations.

4.1 Talking

The design process of the sustainable value proposition started with a talking phase, in which relevant stakeholders were involved in the identification and discussion of core elements of the proposition. This phase was supported by two main practices, namely a conversational interview with a stakeholder and a co-creation session.

The interview with the potential client confirmed interest in the core of the value proposition: reducing energy consumption in the office building through a cost-effective solution based on behavioural change. Since every office building is different, the energy saving actions should be tailored on the characteristics of the building. Furthermore, it was discovered that the main interest of the company is not cutting costs on the utility bills but improving the public image and engaging the employees through corporate sustainability. For this reason, the company makes corporate donations to support environmental

projects. It was concluded that corporate sustainability, entailing public image and employee engagement should be a central aspect of the value proposition.

The results of the co-creation sessions with end-users highlighted a paradoxical situation: many office workers liked the idea of being sustainable and working for a sustainable company but at the same time found it hard to maintain their behaviour afterwards. Office workers are focused on their daily tasks; they do not know exactly what to do to save energy, they do not feel individually responsible for energy consumption and forget about it. However, they also think it is very important to protect the natural environment. When probed, some of them explained that seeing images of climate change consequences on the natural world could be a way to remind and motivate them to save energy. Thus, it was concluded that the value proposition has to recall specific energy saving actions and establish a connection with their environmental impacts, giving office workers tangible proof that their individual behaviours make a difference, but without intruding into their daily working routine.

4.2 Thinking

The talking phase was followed by a thinking phase, in which the conclusions from the interview and the co-creation session were iterated with market and research knowledge, and subsequently integrated into the problem definition, providing the foundations to design the core elements of the value proposition. This phase was supported by three main practices, namely problem reframing, knowledge brokering and brainstorming.

The talking phase highlighted that the potential client is not interested in energy saving primarily from a financial perspective, but rather in the competitive advantage deriving from being a sustainable firm. To explore and validate this finding, the authors engaged in a brief literature review focused on corporate sustainability drivers. The literature confirmed that, for most companies, energy costs are not a primary concern and the business case for energy efficiency should tap into the sources of value creation of sustainability more than into cost reduction motivators (Berns et al., 2009; Holmberg and Roth, 2005; Prindle, 2010; Sullivan, 2009). Particularly, the business case for corporate donations is improved public image and employee engagement through sustainability (CECP, 2014). Based on these notions, the problem frame was broadened from energy efficiency to providing a solution for corporate sustainability.

At this stage, knowledge brokering also played an important role. One of the researchers had worked in a design project where the client was an environmental organization and provided the following two insights. First, the environmental organization required innovative solutions for triggering people into donations through digital media; thus, the digital media element was brought into the scene. Support for using digital media for influencing sustainable behaviour was also found in the literature, indicating

that technological aids can play an important role in reducing overall energy consumption, but are largely absent from current initiatives (Bin, 2012; Lopes et al., 2012). Furthermore, research has proved that energy displays are very effective in stimulating people to use less energy in domestic environments (Darby, 2006; Barbu et al., 2013). As a second relevant insight, many environmental organizations receive annual funding from large companies that do this as part of their Corporate Social Responsibility (CSR) strategy. This new knowledge led to the decision to include donations in the value proposition and to position environmental organizations into the stakeholder network (next to corporate clients and office workers). This decision is also grounded in the literature, according to which, for pursuing successful sustainable innovation, the value proposition should be grounded within the cultural references and positive associations already present in the cultural context of the user (Santamaria et al., 2016); that is, donations to environmental organizations in the context of the project investigated in this study.

As a result, the aim of the project became to combine individual energy saving behaviour with corporate donations to environmental organizations as a unique corporate sustainability effort. Literature on behavioural change was again used to consider the triggering mechanism. According to studies, energy awareness programs for office workers represent a cost-effective solution for favouring conservative energy behaviours in office buildings (Nguyen and Aiello, 2013). However, they are largely absent from current practices (Bin, 2012), or they are structured as one-way communication means (e.g. posters, stickers), which remind employees of the importance of energy saving behaviours but do not engage them (Prindle, 2010). In most cases, such solutions fail to attract the end-users: office workers are not intrinsically motivated to save energy at the workplace because they do not profit directly from it (Siero et al., 1996). Furthermore, workers may not only be unaware of how much energy they use, but they may also feel that their individual behaviours do not significantly impact energy consumption (Barbu et al., 2013). Therefore, engaging energy consumption feedback mechanisms emerges as a most effective strategy for reductions. Appealing visuals increase the feedback effectiveness (Darby, 2010), while gamification and goal setting favour long term engagement (Knol, 2011).

Based on this knowledge, a brainstorming session was used to detail some desirable features of the value proposition and embed them into a service concept called THANKS. The core idea is to trigger office workers into saving energy by empowering them to make a donation with corporate money to an environmental organization of their choice. The money is drawn from the Corporate Social Responsibility (CSR) budget, which is already allocated for company donations. In this way, a clear connection between simple daily actions and a tangible impact on the natural environment is established; that is, a clear feedback mechanism with engaging goals is created. As shown in Figure 4, THANKS creates shared value for the stakeholders in the network as laid out in Table 1. Environmental

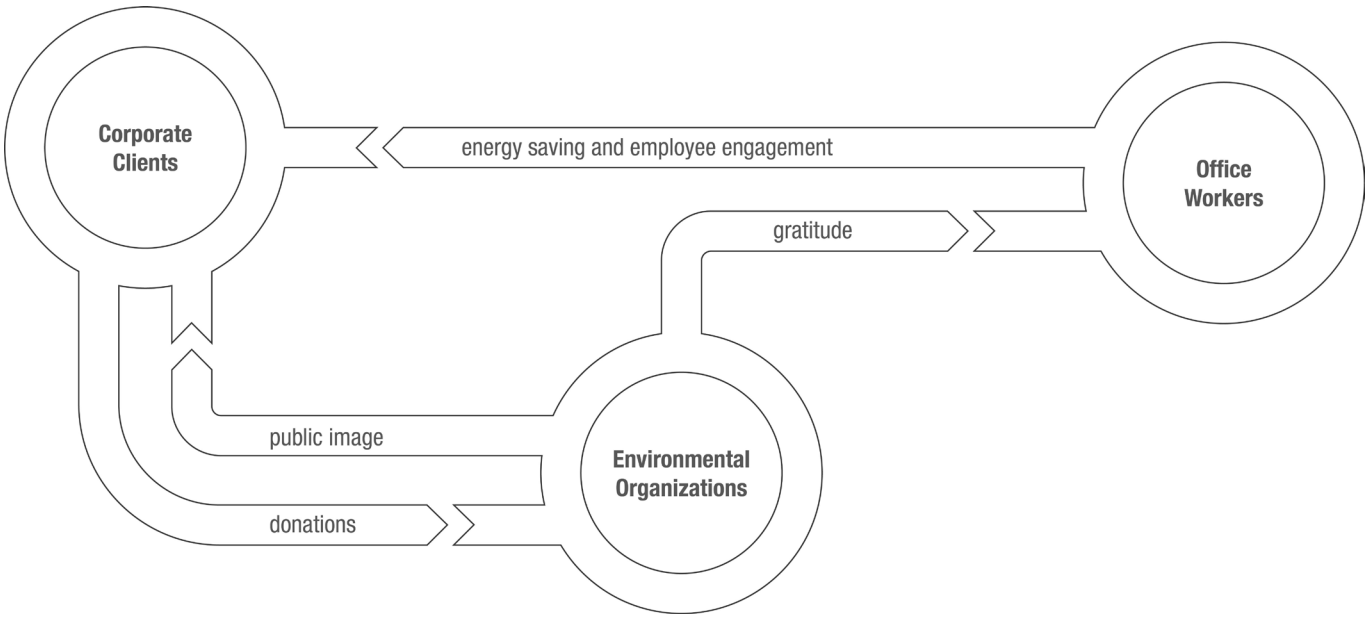

Figure 4. Sustainable value proposition addressing the empirical problem of energy efficiency in commercial office buildings

organizations receive donations from the company and increase their public awareness. Corporate clients gain competitive advantage by improving their public image and engaging their employees while also reducing energy costs on the utility bills. Office workers earn the gratitude of environmental organizations for their support—the office workers' gain is intangible yet significant.

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Office workers earn the gratitude of environmental organizations for their support—the office workers' gain is intangible yet significant.

4.3 Testing

The thinking phase was followed by a testing phase, in which a Minimum Viable Product of the service concept was built to validate the value proposition with relevant stakeholders. This phase was supported by three main practices, namely assumption definition, feature testing and evaluation of the results.

During the thinking phase, energy saving actions and donations to environmental organizations were combined as a unique corporate sustainability effort. The results of the MVP testing gave a preliminary validation of the concept. This process was based on the three practices. First the combination of energy saving actions and donations was defined as an assumption to be tested. Secondly, this assumption was embedded into a bundle of specific, tangible features. Office workers were sent a daily message containing the following features: an energy saving reminder (e.g. 'Turn off the computer at the end of the working day') and a link to an update related to the activities of an environmental organization. By reading and replying with the word 'donate' to the message, they could donate 1 euro to the environmental organization. Finally, results were evaluated with a quantitative parameter. The ten participants donated 32 out of a maximum of 50 euros over the five days of the experiment. The conclusion was that office workers become engaged by feeling empowered when enabled and prompted to donate corporate money to environmental organizations.

4.4 First iteration

The testing phase naturally flowed into a first iteration of the user-driven process aimed at further developing the value proposition. During this iteration, follow-up interviews (talking) with participants from the MVP testing revealed that the service concept has an effect on energy efficient behaviours: office workers reported increased awareness and attention in this regard during the course of the experiment. However, they complained about being unable to choose the organization receiving the donation, and especially about the message not reminding them about energy saving in the right place and at the right time. In parallel, the findings of the interview (talking) with the potential client pointed out that the most relevant element of the value proposition is employee engagement.

These findings fuelled a team brainstorming session (thinking) to plan further testing. The team decided to run a second test with a new MVP focusing on employee engagement as a main aspect of the value proposition. Consequently, it was decided to allow office workers to choose the organizations receiving the donations. The results of the new MVP testing reinforced the findings of the first one. By scanning energy saving reminders next to QR codes placed in strategic locations (e.g. on the personal computer), office workers could donate money to an organization of their choice. The ten participants donated 87 out

of a maximum of 100 euros during the ten days of the experiment. The conclusion was that employee engagement is indeed a fundamental aspect of the value proposition from a client's perspective, and that allowing office workers to choose the receiver of the donations may have a positive effect on it.

4.5 Second iteration

The first iteration was followed by a second one, which started with follow-up interviews (talking) with the participants of the latest MVP testing. They confirmed that allowing office workers to choose the receiver of the donation had a positive effect on their engagement. However, some of the participants complained that, after a while, scanning the QR codes did not feel as a tangible donation experience and that interest could wear off over time. This was also due to the lack of feedback about the overall impact of positive behaviour at the end of the experiment. In parallel, the interviews with the potential client and the potential partner (talking) revealed significant interest in running a small-scale pilot of the service, which gave a positive indication on the business viability of the value proposition.

Based on these findings, the team conducted another brainstorming session on how to proceed (thinking). It was decided to build a new MVP that would provide office workers with a more tangible donation experience as well as feedback about positive behaviours. By putting physical tokens of different colours associated to different energy saving actions inside a piggy bank with three separate slots placed on their desk, office workers could choose to donate money to three different environmental organizations. By counting the tokens of different colours at the end of the experiment, the participants could receive feedback on how many times they performed a certain energy saving action and the related environmental impact (e.g. kWh saved by shutting down the computer overnight for multiple days and avoided CO2 emissions). Participants could also be informed about how much money they donated to each environmental organization. The four participants donated 68 out of 100 Euros during the twenty days of the experiment.

In conclusion, the experience of a physical donation, the possibility to choose the receiver of the donations, and the provision of feedback about positive behaviour are all key aspects of the value proposition, thus allowing office workers to engage with energy saving over longer periods.

The positive outcome of the second iteration facilitated the definition of a preliminary business model around the value proposition, and the impetus towards a small-scale commercial pilot with a potential company client. These activities, however, fall outside the scope of this research.

5. DISCUSSION

The sustainable business model innovation approach aims at achieving sustainability objectives by generating economic value. In this context, the

development of a sustainable value proposition—that is, an offering addressing a sustainability problem, creating shared value for a network of stakeholders—is central. User-driven innovation is an approach to business innovation that can help overcome some key challenges in the development of sustainable value propositions. This paper explored the connections between these two approaches through a project aimed at developing a sustainable value proposition for increasing energy efficiency in office buildings through behavioural change.

Following the user-driven innovation approach, the sustainable value proposition was designed by talking with relevant stakeholders, thinking about potential solutions and testing such solutions early on to iterate towards a problem-solution fit. The outcome is a sustainable value proposition, which combines energy saving behaviours with donations to environmental organizations as a unique corporate sustainability effort. THANKS is an innovative solution that leverages on business incentives (increasing employee engagement and improving public image) and behavioural changes (empowering and engaging employees to make a positive impact at the workplace and giving them feedback about the effects of their behaviour) so as to deliver superior value for multiple stakeholders, including environmental organizations (who receive donations from companies while engaging office workers with their causes and promoting pro-environmental behaviours).

The empirical findings can be reconnected with the literature on sustainable business model innovation and user-driven innovation to derive a process for sustainable value proposition design (Figure 5). The upper half of the circle represents the sustainable value proposition and its three building blocks. The lower half represents the design process based on user-driven innovation. The core idea of this process is that a sustainable value proposition (and its three building blocks) can be designed through an iterative process involving three activities.

The first activity combines the first building block of the sustainable value proposition with the first step of the user-driven process: talking to the network of stakeholders. The findings suggest that companies developing sustainable value propositions should identify relevant stakeholders (including users), and discuss the core elements of the value proposition with them to discover novel and multiple perspectives on the sustainability problem as well as unexpected connections with other types of problems and with other stakeholders. Going a step further, companies could use this activity to reconfigure the network of stakeholders according to the context. Adding stakeholders generates additional and unexpected opportunities for shared value creation inside a broader network of interactions. Based on the literature review and the analysis of our design process, we maintain that this objective can be addressed through two practices: conversational interviews and co-creation sessions.
In the context of this study, the combination of conversational interviews (Fontane and Frey, 2000) and co-creation sessions with different stakeholders allows to gain a multifaceted stakeholder perspective

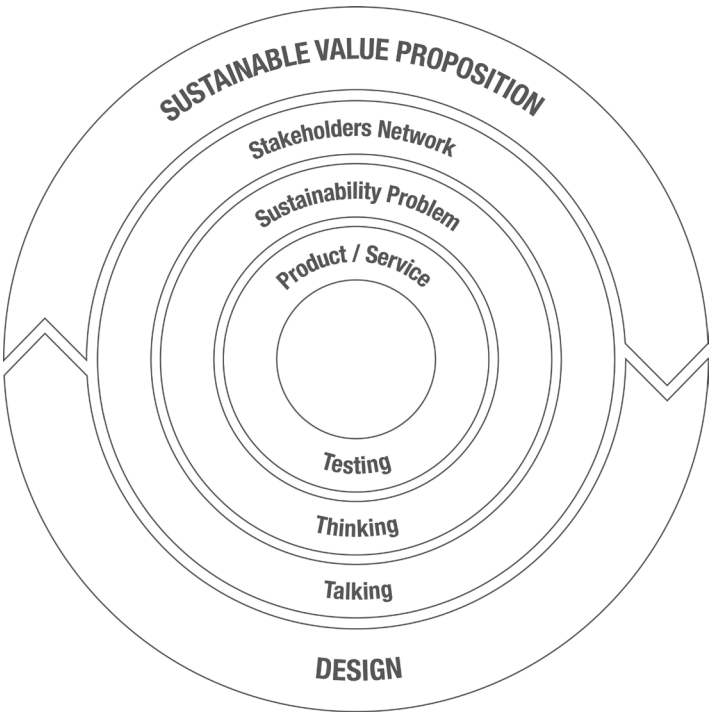

Figure 5. Process for sustainable value proposition design

and consequently identify a stakeholder network. In line with the literature, the latter is in the first place a relational and conversational challenge, because it requires understanding and mediating several needs and objectives across a network of multiple stakeholders in order to create shared value (Allee, 2000; Bocken et al., 2013; Porter and Kramer, 2011). According to our findings, conversational interviews emerge as a particularly suitable practice to his end. Furthermore, the stakeholder network should not only include potential clients for the envisioned value proposition but also the end-users and all other parties that may be relevant for the sustainability problem (Allee, 2000; Donaldson and Preston, 1995; Porter and Kramer, 2011). In fact, adopting a multifaceted stakeholder perspective—instead of a simple customer centric—allows the discovery of opportunities for shared value creation that would otherwise be missed (Bocken et al., 2013). In this project, corporate social responsibility, public image and employee engagement emerged as value drivers for companies and as areas of opportunity to be considered in the ensuing stages. Furthermore, by talking about the sustainable value proposition with the initial set of stakeholders (i.e. corporate clients and office workers), it was discovered that environmental

organizations could play a role, and it was decided to include them in the network.

The second activity combines the second building block of the sustainable value proposition with the second step of the user-driven process: thinking about the sustainability problem. The empirical data suggest that companies should refine (or redefine) the sustainability problem according to stakeholder feedback, and consequently conceptualize a related product/service idea that creates shared value for the network stakeholders. By combining the literature review and the empirical findings, we propose that this objective can be addressed through the following interrelated practices: problem reframing, knowledge brokering, brainstorming.
In the context of this study, reframing (Dorst, 2011) is based on combining the sustainability problem with other stakeholder needs and goals, merging information coming from different parties into a unique and broader problem definition that can be addressed by an innovative solution. In this project, the initial problem frame was centred on energy efficiency. Subsequently, through discussions and iterations with a broader spectrum of stakeholders and through knowledge brokering (Calabretta and Gemser, 2015) from a former project, the problem frame was broadened to corporate sustainability. Finally, brainstorming allowed to conceive a product/service concept combining energy saving actions with corporate donations to create additional value through improved public image and employee engagement.

The third activity combines the third building block of the sustainable value proposition with the third step of the user-driven process: testing the product/service. We argue that companies developing a sustainable value proposition should create a MVP of the product/service idea, and quickly verifying whether its features effectively deliver the intended value across the network of stakeholders. The practices that enable this activity include assumption definition, feature testing, and evaluation of the results.
In the context of this study testing is done in line with the lean startup approach to achieve problem-solution fit (Ries, 2011). Assumptions to be tested are defined up front. Consequently assumptions are embedded into specific product/service features to be tested in front of stakeholders (Blank, 2013; Osterwalder et al., 2015; Ries, 2011). Finally, results are measured with specific parameters (Ries, 2011). These three practices lie at the core of building the MVP (Blank, 2013; Osterwalder et al., 2015; Ries, 2011). Our first MVP was developed to test the feature of a text message reminding office workers to save energy and empowering them to donate corporate money to an environmental organization. The amount of donated money was used as a parameter for the test performance. The outcome of this activity is a Minimum Viable Product and validated learning about the sustainable value proposition.

In the context of this study iteration of the three activities aims to the further development of the value proposition towards problem-solution fit. Iteration should be continued until sufficient validated learning allows the definition of a preliminary business model (Blank, 2013). This involves repeating the three

activities and related practices described above: talking again to the stakeholders in order to redefine the problem and finally updating the MVP for further validation. During the iterations of this project, employee engagement emerged as a prominent element of the sustainable value proposition when approaching a potential client, and QR codes as a way to improve the user interaction with the service. The three activities and their iterations are summarized in Table 2, including their objective, underlying practices and outcome accompanied by an example from the empirical context.

Table 2. Actions, outcomes and practical examples from the design project related to the three activities, and their iterations supporting the process for sustainable value proposition design

	Talking	**Thinking**	**Testing**	**Iterations**
Objective	Identifying relevant stakeholders (including users) and discussing the value proposition with them to discover different perspectives on the sustainability problem as well as connections with other problems and stakeholders	Redefining the sustainability problem using stakeholder feedback and knowledge brokering to conceptualize a product/service to address the problem while creating shared value for the stakeholders	Creating a prototype of the product/service idea, and verify if its features deliver effectively shared value across the network of stakeholders	Iterating the development of the sustainable value proposition towards problem-solution fit by talking to stakeholders, redefining the problem and finally testing the updated solution
Practices	Conversational interviews, co-creation sessions	Problem reframing, knowledge brokering, brainstorming	Assumption definition, feature testing, evaluation of the results	Iterating the practices
Outcome	A stakeholders' network as a system of needs and goals related to the sustainability problem	A broader problem frame and a product/service concept to address it	A Minimum Viable Product and validated learning about the sustainable value proposition	An updated version of the Minimum Viable Product and additional validated learning to define a preliminary business model
Example	Environmental organizations are introduced into the stakeholders' network next to corporate clients and office workers	The frame is broadened from corporate energy efficiency to corporate sustainability and THANKS is conceptualized	A message is designed to test if office workers are engaged with energy saving and corporate donations	Employee engagement is highlighted as a core element of the sustainable value proposition, and a more tangible donation experience is introduced to improve the user interaction with the service

6. CONCLUSION

This paper focuses on combining sustainable business model innovation with user-driven innovation for

addressing the challenges of sustainable development through the design of sustainable value propositions that combine economic and environmental objectives. By addressing this topic, the paper contributes in different ways to theory and practice.

First, the paper contributes to academic research on sustainable business model innovation. This approach maintains that business model innovation driven by profit is an effective way to address sustainability objectives (Schaltegger et al., 2015). Central to this approach is the creation of sustainable value propositions, which address sustainability problems through products or services providing shared value for a network of stakeholders (Bocken et al., 2013). Developing a sustainable value proposition is a long process that may require several product-market iterations (Keskin at al., 2013; Keskin, 2015). In this regard, the paper argues that the sustainable business model innovation approach would benefit by being integrated with principles from user-driven innovation, an approach to business innovation based on deep user understanding, experimentation and iteration (Blank, 2013; Brown and Katz, 2011; Karpen et al., forthcoming; Ries, 2011). Particularly, by gaining a deep understanding of the users, the development of sustainable value proposition can be steered towards directions that are more desirable for the users themselves and that are able to influence their behaviours in a virtuous manner (Boons et al., 2013; Santamaria et al., 2016). Furthermore, iterating the value proposition with an extended range of stakeholders creates larger acceptance, commitment and support for sustainable innovations that are not merely incremental or aimed at technological efficiency (Geissdoerfer et al., 2016).

The paper consequently shows how the two approaches can be combined into practice through a process for sustainable value proposition design. While there are many tools supporting practitioners in the development of conventional value propositions, this is not the case for tools integrating sustainability considerations (Bocken et al., 2013). The process depicted in this paper aims at filling this gap. Particularly, one of the few tools that support practitioners in the development of sustainable value propositions allows an initial identification and understanding of different stakeholders' needs and objectives, which is indeed a fundamental first step (Bocken et al., 2013). The process for sustainable value proposition design proposed in this paper goes a step further, adopting a dynamic and iterative perspective (talking to stakeholders, thinking about the problem, testing the product/service) that leads to an actual sustainable value proposition and to a superior problem-solution fit. In this way, managers are provided with an initial methodological framework for mapping and understanding the stakeholders in a broad sense, identifying their needs and interests, and progressively combining them into a more meaningful and enriching value proposition, which is also financially viable and sustainable.

Furthermore, the paper contributes to the literature in energy efficiency by combining technological advancements with a deep understanding of human needs in order to induce behavioural change (Barbu

et al., 2013). By analysing the specific context of commercial office buildings, a value proposition for energy efficiency centred on behavioural change was conceptualized. Current solutions to energy efficiency through behavioural change are based on energy awareness programs, which strive to engage office workers and do not tap sufficiently into corporate strategic objectives (Prindle, 2010). Unlike current solutions, the value proposition developed through the approach proposed in this paper leverages on business incentives and behavioural science to deliver superior value for multiple stakeholders (corporate clients, office workers and environmental organizations). While gaining a deep understanding of human behaviour is required for triggering energy saving behaviours, methods adopting this approach in the domain of energy consumption are currently lacking or very complex (Heiskanen, 2013). This paper proposes a process to understand user needs and influence their behaviours by involving them in the development of the value proposition.

User-driven innovation emerged as a suitable approach for addressing the energy efficiency challenge in combination with the sustainable business model innovation. Other researchers could explore if the same combination could effectively be used for other sustainability challenges. For instance, sustainable innovation to overcome pollution and resource depletion also clashes against resistance to change and the intricate and contrasting interests of several stakeholders. Using this study's process for sustainable value proposition design could promote behavioural change as an innovation direction to address those challenges. Furthermore, testing the process proposed in this paper in different contexts could validate and further improve the process itself, thus contributing to overcoming one of the main limitations of this study: the reliance on a single project.

This study is an exploratory endeavour, based on a single project focusing on a specific type of sustainability problem. This limitation affects the generalizability of the findings, as some context-specific factors might have steered the project in a certain direction and/or interacted with the interventions of the researchers. For instance, the list of practices that we associate to each stage of the process is an exploratory attempt to guide practitioners in the development of a sustainable value proposition, but is certainly not exhaustive. We expect further research to support and extend that list, and even to identify new practices and methods to support each step. Additionally, another challenge during our empirical investigation was the lack of direct contact with all types of stakeholders that might be relevant in the development of a successful value proposition (e.g., business managers/developers, governmental institutions). Additional case studies where all stakeholders are involved could provide further validation and generalizability to our findings. Furthermore, future work should focus on testing the validity of the process in relation to different sustainability problems, and consequently integrate additional findings into the theoretical foundations of the process itself.

Overall, the sustainable value proposition design process proposed by this paper offers more solidity and innovative drive to sustainability objectives by framing them into the structure of a value proposition that delivers shared value to all stakeholders. Furthermore, the process allows to define up front the value proposition in close contact with prospective customers, business stakeholders and environmental stakeholders. In this way, if the value proposition falls short in delivering the intended value, adjustments can be made according to stakeholder feedback. On the contrary, as the value proposition succeeds, key connections for the future business are also being established at an early stage. This approach can save significant time and resources on product and business development when starting a new venture, and can potentially reduce the innovation perceived risks and the success odds. While THANKS—the value proposition developed in the project used for this study—is about to be introduced into the market, that only represents anecdotal and preliminary evidence for the impact of sustainable value proposition design on sustainable innovation performance indicators. Further research could adopt a more longitudinal approach by following similar projects for longer periods of time, thus yielding additional support—and even improvement—to the model.

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CHAPTER III

HELPING ORGANIZATIONS TO IMPLEMENT SUSTAINABLE BUSINESS DESIGN

THIRD STORY

"Prepare for starboard tack!" The German Seawolf, master of execution and process optimization, handles flawlessly the jib sheet, while the Chill Officer stands fearless on deck holding tight on the rum bottle, scanning the horizon with attentive eye, ready to warn his Captain at the first sight of peril, and to promptly refill everyone's cup whenever the level gets too low. The morale of the crew is high, even though this time we did not set sails in the turquoise waters of the Mediterranean. With 20 knots of breeze right in our face, we are cruising upwind inside a giant brownish pond in the middle of the Dutch flatlands, cove of cunning spice traders and seasoned buccaneers who seek shelter from the storms of the North Sea. Leaving from Amsterdam, our destination is the province of Friesland, where a sustainable innovation event will soon take place in the context of a summer music festival. Using the power of the wind is a sustainable way to get there, but also slow. Instead of a car ride of two hours, it takes us three days until we finally reach our destination and drop the anchor in the muddy harbor of Leeuwarden, surrounded by grazing cows, swarms of mosquitoes and scorched by the July sun, which due to climate change is beating on our necks harder than expected for these northern, and usually gloomy latitudes. We are academics in disguise, operating under a pirate flag that towers on the mast of our vessel like a dreadful menace to our enemies. Stepping on the land, the Seawolf goes by the name of Jan Konietzko, while most people know the Chill Officer as Phil Duncan Brown.

Concerning myself, the Captain, I was baptized three decades ago with the name of Brian Rashid Antonio Giuseppe Pablo Baldassarre, a ridiculous homage from my old man to western and eastern cultures, as well as to both my grandparents, and to the Spanish priest who celebrated the function in the Vatican city according to the strictest of catholic traditions. The mission of our improbable trio is protecting trees, rivers and the penguins of the southern hemisphere from the private interests, in a world where society and the environment are being crushed under the iron fist of a ruthless economic logic driven by free market capitalism. First signs of trouble related to our ways of doing business after the industrial revolution, were spotted back in the 1960s. But since then, we have not been able to go much beyond "flower power" and doing some talking about this problem. I remember my old grandpa—may he rest in peace—who served as a doctor against totalitarian regimes during World War II, and always used to say that the revolution must be started from within the current system. That's exactly why we sailed here: to support a new generation of businesses, startups built by young entrepreneurs and university students driven by the ambition to solve environmental and social problems through innovation. The innovation event lasts ten days and many startups showed up. They are developing new products and services with the aim of testing them at the music festival, while also making a positive impact. For example, Solar Solutions is integrating photovoltaic panels into benches and lockers,

in order to allow festival visitors to charge their mobile devices with the power of the sun. Proper Plates is launching a new dishwashing service to prevent the use of disposables and reduce the amount of plastic waste. But the Bakers Best guys are definitely our favorites: they are making gin out of leftover bread loafs collected from local bakeries, bringing the "waste equals food" principle to a whole new level. It was after drinking recycled bread that the idea of Circular Strategies came about. To be more accurate, Phil the Chill Officer had always struggled to contain his wild entrepreneurial spirit inside the glass walls of the doctoral study room in the north wing on the fourth floor of the faculty of Industrial Design Engineering, at the Delft University of Technology. By the coffee machine, he often dropped casual ideas about doing something real with the outcomes of our miserable scribblings, and certainly found a receptive audience in the Seawolf and myself. We knew that in order to translate our speculations into action we had to engage with businesses, with real organizations. And so, with the help of our professors, we started to reach out. As we collaborated with startups open to try new things right away, we also realized that it is with the larger, and slower, multinational companies where the biggest potential to change the status quo lies. The key to reach them is finding those people who are also trying to join the revolution, to change the organization, from within. We connected to some of these people and worked with them as well. Beyond that, we got involved into

cross-organizational partnerships and international consortia operating collaboratively to shift from a linear to a circular economy, where the flow of resources is turned into a closed loop by changing how products are made, as well as the way companies operate and interact with each other. Building on the experience of our shared supervisor Nancy, we realized that a pragmatic approach to catalyze these changes would be condensing the heavy baggage of academic thinking into tools, a sophisticated name commonly used to indicate some kind of paper support, for example a poster template, to put questions in boxes and facilitate discussion around them. After all, the starting point for any kind of change is always asking the right questions. For example in 1789: "Why does the Sun King Luis XIV gets to wear such a cool wig while we spend our days working the land?" And then boom: French Revolution! Therefore, we developed tools, and combined them into a workshop methodology based on three steps. The first step is helping organizations to get together, understand what a circular economy means, and generate ideas on what they could do to shift toward it. The Seawolf developed and optimized a card deck for this purpose. The second step, based on the Chill Officer's expertise around cross-organizational collaboration, is supported by a poster template that allows uncovering the priorities and concerns of the parties involved. Finally, the third step, supported by a tool that I developed, is helping such parties to find out whether the circular business idea they had in mind can

work for real, by planning and executing a demonstration. This is what we do at Circular Strategies, when we are not otherwise busy sailing and drinking rum. (Please be aware that in this pirate story, all references to drinking rum have been included for purely narrative reasons. By no means were we at any point in time working in an altered state of mind and consuming alcoholic beverages while steering our mighty vessel, since that is dangerous and against the current laws).

THIRD SCIENTIFIC PUBLICATION

Addressing the design-implementation gap of sustainable business models by prototyping: A tool for planning and executing small-scale pilots

This article has been published in the Journal of Cleaner Production. Please cite as:
Baldassarre, B., Konietzko, J., Brown, P., Calabretta, G., Bocken, N., Karpen, I. O., and Hultink, E. J. (2020). Addressing the design-implementation gap of sustainable business models by prototyping: a tool for planning and executing small-scale pilots. Journal of Cleaner Production, 255, 120295.

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Abstract
Next to the redesign of industrial products and processes, sustainable business model innovation is a strategic approach to integrate environmental and social concerns into the objectives and operations of organizations. One of the major challenges of this approach is that many promising business model ideas fail to reach the market, which is needed to achieve impact. In the literature, the issue is referred to as a "design-implementation gap." This paper explores how that critical gap may be bridged. In doing so, we contribute to sustainable business model innovation theory and practice. We contribute to theory by connecting sustainable business model innovation with business experimentation and strategic design, two innovation approaches that leverage prototyping as a way to iteratively implement business ideas early on. Using a design science research methodology, we combine theoretical insights from these three literatures into a tool for setting up small-scale pilots of sustainable business models. We apply, evaluate, and improve our tool through a rigorous process by working with nine startups and one multinational company. As a result, we provide normative theory in terms of the sustainable business model innovation process, explaining that piloting a prototype forces organizations to simultaneously consider the desirability (i.e., what users want), feasibility (i.e., what is technically achievable), viability (i.e., what is financially possible), and sustainability (i.e., what is economically, socially and environmentally acceptable) of a new business model. Doing so early on is functional to bridge the design-implementation gap of sustainable business models. We contribute to practice with the tool itself, which organizations can use to translate sustainable business model ideas defined "on paper" into small-scale pilots as a first implementation step. We encourage future research building on the limitations of this exploratory study by working with a larger sample of companies through longitudinal case studies, to further explain how these pilots can be executed successfully.

1. INTRODUCTION

Alongside important work on cleaner production and the related redesign of industrial products and processes, sustainable business model innovation (SBMI) is an approach that takes a strategic viewpoint on how environmental and social concerns can be integrated into the objectives and operations of organizations (Abdelkafi and Täuscher, 2016; Bocken et al., 2014; Stubbs and Cocklin, 2008). For example, new business models based on service provision instead of product sales (e.g., a car-sharing service instead of selling cars) have the potential to reduce the impact of organizations up to 90% across different sustainability categories, ranging from energy consumption to waste management (Tukker, 2004; Tukker and Tischner, 2006).

SBMI has accordingly emerged as a research field of high relevance for cleaner production (Lüdeke-Freund and Dembek, 2017). To this end, SBMI research places a prominent focus on developing actionable knowledge for business (Bocken et al., 2013; Lüdeke-Freund et al., 2016). Former work conceptualized sustainable business models (SBMs) (Stubbs and Cocklin, 2008) and identified different categories (Bocken et al., 2014; Lüdeke-Freund et al., 2019) across industrial sectors (Yang et al., 2017; Yip and Bocken, 2018; Zhao et al., 2018). Furthermore, it explained how negative environmental and social impacts may be turned into business opportunities, thus into positive sources of value (e.g., turning waste into a resource) (Bocken et al., 2013; Yang et al., 2017).

To facilitate the development of sustainable business practices, there has been recent emphasis on tools for performing SBMI (Breuer et al., 2018). Most of these tools – such as the "triple layered business model canvas" (Joyce and Paquin, 2016) and the "flourishing business model canvas" (Upward and Jones, 2016) – focus on how to ideate new SBMs and not on their implementation (Bocken et al., 2019). Importantly, this results in a design-implementation gap in SBMI, which must be bridged to get SBMs to market and achieve impact (Geissdoerfer et al., 2018). Some SBMI researchers have started to address this issue by establishing connections with business experimentation (Antikainen et al., 2017; Weissbrod and Bocken, 2017) and strategic design (Baldassarre et al., 2019; Geissdoerfer et al., 2016).

Business experimentation and strategic design are two different approaches proposing an iterative process that covers the spectrum of innovation efforts from idea generation to market launch (Calabretta et al., 2017; Chesbrough, 2010). So far, work at the intersection between SBMI, business experimentation, and strategic design demonstrates the relevance of performing specific practices for implementing SBMs (Bocken, Boons and Baldassarre, 2019; Bocken, Schuit and Kraaijenhagen, 2018). However, despite its relevance for bridging the design-implementation gap of SBMs, research connecting SBMI with business experimentation and strategic design is still limited (Breuer et al., 2018). Indeed, the main focus of SBMI research has been conceptualizing SBMs rather than exploring how to perform them in practice (Weissbrod

and Bocken, 2017); as a result, they are rarely implemented (Ritala et al., 2018). Consequently, we pose the following research question:

How to support business organizations in bridging the design-implementation gap through a tool for sustainable business modeling?

Given the scant research on this topic, our study is exploratory. Our exploration first integrates SBMI, business experimentation, and strategic design knowledge. Through a literature review and synthesis, we contextualize the design-implementation gap of SBMs and explain how a prototyping expertise derived from business experimentation and strategic design can be leveraged to address it. Consequently, through a design science research approach (Peffers et al., 2007), we develop a prototype-driven tool for setting up small-scale pilots, which is a first crucial step into the implementation of SBMs. Then, we iteratively apply, evaluate, and improve the tool by working in business practice. Finally, we delineate our contributions to theory and practice; in particular, offering normative theory and managerial guidance based on our empirical study on how to prototype towards the implementation of SBMs and the related tool to support organizations.

2. LITERATURE REVIEW

2.1 Sustainable business model innovation

SBMI is an emerging research field, which provides an effective lens to investigate and communicate sustainable innovation with practitioners (Lüdeke-Freund and Dembek, 2017).

The origins of SBMI are rooted in the business model framework, which organizations can use to plan and execute their strategy (Teece, 2010; Zott and Amit, 2010). The framework is based on a value proposition (i.e., what the organization offers and to whom), value creation and delivery (i.e., how the organization generates the offering and reaches customers), and a value capture element (i.e., how the organization covers costs and generates revenue) (Richardson, 2008). SBMI leverages this framework to embed sustainability into the strategy of firms (Boons and Lüdeke-Freund, 2013). While, in a broader context, sustainability refers to a state of human development that meets present needs without compromising the future (Brundtland, 1987), in our business context, we refer to it more narrowly as embedding a multi-stakeholder perspective, triple-bottom-line (people-planet-profit) thinking, and impact assessment orientation into business objectives and operations (Elkington, 1998; Stubbs and Cocklin, 2008). Recent work conceptualized SBMs ("a value proposition that provides economic, environmental and social value; a supply chain and a customer interface that allows stakeholders and customers to act responsibly; a financial model that reflects an appropriate distribution of costs and benefits across stakeholders") (Boons and Lüdeke-Freund, 2013) and brought together disparate sustainable innovation approaches (e.g., PSS, social enterprises, the blue economy, green product development) under the common framework

of SBM archetypes (Bocken et al., 2014).

The SBMI field is currently in a consolidation phase and new reviews are contributing to defining its scope and boundaries (Lüdeke-Freund and Dembek, 2017). In parallel, several tools have been conceptualized to support organizations performing SBMI (Breuer et al., 2018). However, SBMI researchers have realized that SBMI lacks a process dimension needed to advance toward the implementation of SBMs (Baldassarre et al., 2017; Weissbrod and Bocken, 2017). Thus, they have started connecting to business experimentation and strategic design theory by following two directions. The first direction leverages the iterative process dimension of business experimentation and strategic design, arguing that it is needed to gradually integrate stakeholder objectives with sustainability concerns, stepping toward the implementation of SBM ideas (Geissdoerfer et al., 2016; Weissbrod and Bocken, 2017). The second direction zooms into this process dimension, and explains how each step can be supported by specific practices including (but not limited to) conversational interviews, booklet interviews, ethnography observations, brainstorming, co-creation sessions, A/B testing, and prototyping (Bocken, Boons, et al., 2019).

2.2 Business experimentation

Business experimentation is a broad concept that advocates a shift from a linear innovation process toward a faster and less risky process in which new business ideas are developed gradually and more flexibly in iterative cycles (Chesbrough, 2010; Sarasvathy, 2001).

The origins of business experimentation can be traced back to innovation and entrepreneurship theory (Schumpeter, 1934). More specifically, it is possible to identify two theoretical roots. The first root is effectuation, an entrepreneurship theory that advocates taking "a set of means as given and focus on selecting between possible effects that can be created with that set of means" (Sarasvathy, 2001). Effectuation theory explains that this frame of thinking and acting is particularly suitable when operating in high uncertainty conditions, and therefore can support the creation of new ventures (Sarasvathy, 2001). Effectuation is about using available knowledge, means, and resources within iterative business innovation processes based on design experiments and stakeholder interactions (Keskin, 2015; Sarasvathy, 2001). The second root is the business model concept framed as a strategic architecture (Chesbrough, 2010; Teece, 2010). In line with effectuation, but in contrast with conventional business strategies that emphasize analysis, this stream of literature argues that new business opportunities can be discovered through a different approach based on trial and error, which is explicitly defined as business experimentation (McGrath, 2010). This literature also explains how the business model framework facilitates experimentation by allowing to "construct maps of business models, to clarify the processes underlying them, which then allows them to become a source of experiments considering alternate combinations of the processes" (Chesbrough, 2010). More recently, these perspectives have been

combined with some of Toyota's manufacturing principles from the 1970s and 1980s, resulting in the lean startup movement, which has been successful in disseminating these ideas (Ries, 2011; Womack and Daniel, 1997). Lean startup maintains that most new ventures do not fail because they lack a product but because they lack customers (Blank, 2006). Consequently, the foremost challenge of entrepreneurship is achieving a good product-market-fit by treating business ideas as hypotheses to be tested in front of potential customers as quickly and cheaply as possible (Ries, 2017).

Implementation knowledge

The concept of business experimentation is intertwined with early business model implementation. The lean startup movement puts a major focus on this aspect by proposing an actionable framework to set up small-scale pilots based on three iterative steps, called the build-measure-learn loop (Ries, 2011). The "build" step is about creating a minimum viable product (MVP), defined as the simplest version of a product that can be sold to consumers. The "measure" step assesses how the product performs on the market. Finally, the "learn" step integrates the learning collected in the previous two steps into the next version of the MVP. The steps are iterated until the MVP fits the needs of a solid customer base, and sales can be scaled up. Within this framework, several practices and methods can be employed. The most central one is prototyping, which is essential for the creation of MVPs, and physical or digital artifacts (e.g., a landing page for a web-based service) to be tested with consumers on the market (Ries, 2011). A/B testing is a method to evaluate two (or multiple) prototypes simultaneously (Blank, 2012; Ries, 2011). The key method for evaluation is defining key performance indicators or metrics, and then using them to quantitatively measure product performance (Ries, 2011).

2.3 Strategic design

Strategic design is an innovation approach that leverages design principles, practices, methods, and tools in the context of strategy and innovation management (Calabretta et al., 2016; Liedtka and Ogilvie, 2012). Compared to product design, strategic design deals more with long-term, systemic initiatives that typically require significant organizational commitments and investments, seeking to achieve competitive edge and shape markets.

The origins of strategic design connect to design literature as a rational process to solve complex problems (Buchanan, 1992; Simon, 1973). These ideas have recently been leveraged into a business context, focusing the design process beyond a product scope to business and organizational challenges, in order to innovate experimentally across three spaces: inspiration, ideation, and implementation (Brown, 2008). As this discussion gained momentum, questions arose around how to actually apply these ideas in business practice (Rylander, 2009). In response, academic research clarified that design is not only an abstract process but also "a practice," meaning the way in which designers think and act (Dorst, 2011; Kimbell, 2012). This conception of

design-as-a-practice allows shifting the discussion on the design process away from "what it is" toward defining "how" organizations can actually use it to achieve a competitive advantage, which leverages design up to a strategic rather than purely tactical level, hence the emergence of strategic design (see Baldassarre, Calabretta, Bocken, Diehl and Keskin, 2019; Calabretta et al., 2016). According to strategic design, specific design principles, practices, methods, and tools can be leveraged to balance desirability (i.e., what customers want, the value proposition of a business model), feasibility (i.e., what is technically achievable, the value creation and delivery system of a business model), and viability (i.e., what is financially possible, the value capture system of a business model) (Brown, 2008; Calabretta et al., 2016), while considering systemic conditions and implications of the design. Balancing desirability, feasibility, and viability in view of systems is key to effectively implementing new products, services, and the business models around them (Calabretta et al., 2016; Karpen et al., 2017).

Implementation knowledge

Strategic design supports the implementation of new business model ideas through a set of practices that allow making them tangible and testable early on in the innovation process (Calabretta et al., 2016). Specifically, prototyping can be used not only to present and test concepts in the development stage of innovation, but also to inspire stakeholders and to convince them to embrace an innovation and commit to introducing it in the market. By going beyond the traditional application of a prototyping logic to physical objects to test desirability of a new product, strategic design proposes innovative prototyping methods and tools to simulate also the intangible components of a new business model in order to test innovation feasibility and viability (Calabretta et al., 2016; Stickdorn et al., 2011). The service blueprint is an example of a tool that allows the prototyping of intangible service components and financial transactions of a new business model by defining a sequence of actions that organizations must perform to execute the business idea as part of a small-scale pilot or a full-scale implementation. Finally, implementation by strategic design is also supported by the definition of key performance indicators and iterative business casing, needed for assessing the feasibility and viability of the innovation early on (Azabagic and Karpen, 2016).

2.4 Research gap

SBMI is characterized by a design-implementation gap that hinders the diffusion of new SBMs in practice (Geissdoerfer et al., 2018; Tukker, 2015). The design-implementation gap refers to the fact that new SBM ideas are not implemented on the market (Geissdoerfer et al., 2018; Ritala et al., 2018), and often fail when they are (Tukker, 2015). To start addressing this gap, recent SBMI research established a connection between business experimentation (Weissbrod and Bocken, 2017) and strategic design (Baldassarre et al., 2019). So far, this body of work has demonstrated that framing SBMI as an iterative process, where sustainability objectives are gradually integrated with stakeholder priorities, allows shaping

the design of new SBMs in a way that is functional to implementation (Baldassarre et al., 2017). Furthermore, research has shown how each step of this process can be supported by multiple business experimentation and strategic design practices (Bocken et al., 2019).

Prototyping is mentioned as a practice for executing pilots, simulating early on the implementation of SBMs in a real-world context (Bocken et al., 2018). However, despite its potential for bridging the design-implementation gap, the application of this practice remains largely unexplored. To our knowledge, few SBMI studies (e.g., Baldassarre et al., 2017; Geissdoerfer et al., 2016) have focused on prototyping, specifically looking at how this practice can be used to get a conceptual SBM defined "on paper" to actually unfold in "the reality of practice." On the other hand, our literature review on business experimentation and strategic design highlights important knowledge on how to prototype toward business model implementation (Calabretta et al., 2016; Ries, 2011).

Therefore, the aim of this paper is to transfer relevant prototyping expertise from business experimentation and strategic design into the SBMI field, exploring how the design-implementation gap of SBMs may be addressed. To this end, we develop a tool to set up small-scale pilots for new SBMs. The tool allows applying a prototyping logic beyond a focal product to the intangible components of an SBM, including service elements, stakeholder interactions, monetary transactions, and sustainability impact. Materializing these aspects in a small-scale pilot allows validating the desirability, sustainability, technical feasibility, and financial viability of a new SBM, which is essential to advancing toward its full-scale implementation.

The choice of developing a tool is justified by the intention of producing a tangible output to support SBMI practice (Bocken et al., 2019). SBMI research is placing an increasing focus on the development of tools (Lüdeke-Freund et al., 2016). A recent review has categorized them according to their purpose: ideating, implementing, and evaluating SBMs (Bocken et al., 2019). A deeper analysis shows that while most of these tools fit into multiple categories at the same time, with a prominent focus on ideation, none of them focuses on how to bridge the design-implementation gap (Bocken et al., 2019). Consequently, we aim to expand this body of knowledge by proposing a tool for implementing existing SBMs concepts within small-scale pilots.

Figure 1 shows the design-implementation gap in SBMI innovation literature and practice, and how this gap may be addressed by infusing prototyping expertise from business experimentation and strategic design into a tool for setting up small-scale SBM pilots.

3. METHODOLOGY

This study uses a design science research (DSR) methodology (Peffers et al., 2007). DSR comes

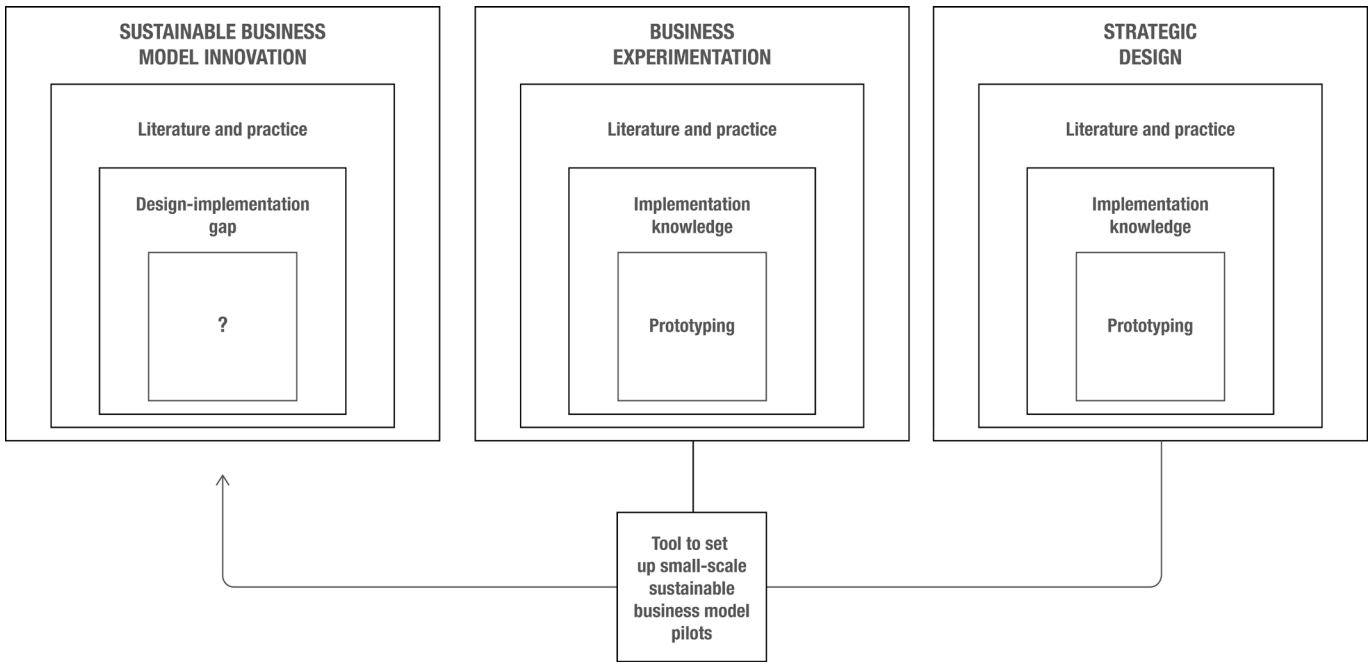

Figure 1. Visual representation of the design-implementation gap of SBMI and explanation of how this research aims to address it

from the field of information systems, but more recently it was applied in entrepreneurship (Romme and Reymen, 2018), management (Van Aken and Romme, 2009), and service design research (Grenha Teixeira et al., 2017), in order to structure a solid scientific inquiry around innovation efforts and tools. DSR generates scientific knowledge about a theoretical issue by creating and evaluating an artifact through empirical work (Peffers et al., 2007). Artifacts include tools to address organizational and innovation challenges (Peffers et al., 2007); thus, this method is suitable for our research. DSR provides a meta-methodological process, within which several other research techniques are deployed (Collatto et al., 2018). In line with Peffers et al. (2007), our DSR process is visualized in Figure 2 and further explained in the paragraphs below.

3.1 Problem definition

The research process starts with a problem definition based on a theoretical investigation summarized in the literature review of this paper and substantiated by the experience of the authors working in SBMI practice. Specifically, the problem definition relates to the design-implementation gap of SBMs. Our literature review on business experimentation and strategic design shows that prototyping is often mentioned as

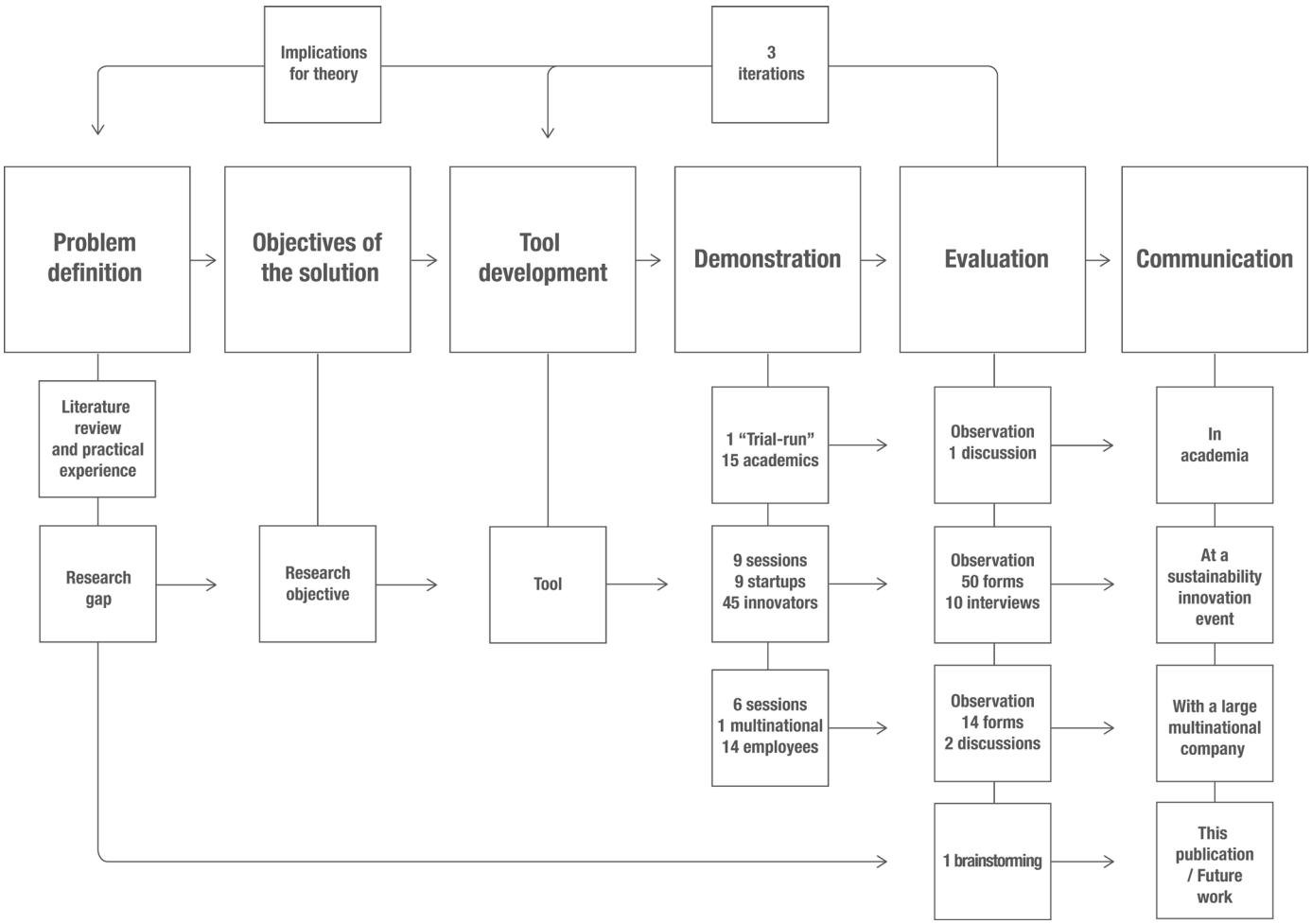

Figure 2. Overview of the design science research process applied in this research (based on Grenha Teixeira et al., 2017; Peffers et al., 2007)

a way to implement new business models. However, the full potential of this practice remains, to date, largely unexplored both conceptually and empirically in SBMI.

3.2 Objectives of the solution

The objective of this paper is to address the design-implementation gap of SBMs by leveraging prototyping expertise found in business

experimentation and strategic design. We pursue this intent via an exploratory objective:

Explore how the practice of prototyping may be leveraged to set up small-scale pilots and address the design-implementation gap of sustainable business models.

3.3 Tool development

The objective is addressed by developing a tool to set up small-scale SBM pilots by means of prototyping. Tool development is iterative. Section 4.1 presents the initial version of the tool (Figure 3), explaining how theoretical knowledge from SBMI, business experimentation, and strategic design is combined into it. Section 4.2 describes the first iteration, based on a practical demonstration and follow-up evaluation. Section 4.3 presents the second iteration. Here, an improved version of the tool (Figure 4) is applied in an empirical demonstration and then evaluated. Section 4.4 illustrates the third iteration. Specific details about the content of the pilots within this iteration cannot be shared for confidentiality reasons. Finally, Section 4.5 summarizes the improvement points identified in the previous iterations and presents the final version of the tool (Figure 5).

3.4 Demonstration

The tool was applied in three practical demonstrations. Each demonstration was based upon a mix of qualitative (Corbin and Strauss, 2008; Sanders and Stappers, 2012) and action research techniques (Swann, 2002). The tool was introduced to research subjects through a thirty-minute presentation. Consequently, it was applied in a set of workshop sessions, where the subjects (in groups) used the tool to plan an SBM pilot. Each session was audio and/or video recorded. The researchers led the sessions and took written notes.

The first demonstration was a trial run at the Delft University of Technology. Research subjects were 15 academics with relevant knowledge and experience in the SBMI field. They were split into three groups and worked for one hour on fictional assignments for testing the tool while collecting expert feedback on it.

The second demonstration was a ten-day sustainability innovation event, where nine early-stage startups were coached by experts to set up a small-scale pilot, implementing new business models addressing sustainability challenges related to a nearby music festival. Sustainability challenges included sustainable food supply, sustainable energy supply, sustainable water supply, and waste management. In this instance, nine workshop sessions of two hours were conducted, in which the nine startups translated initial business ideas into a plan for a small-scale SBM pilot addressing the sustainability challenges. Subsequently, these pilots were also executed. Research subjects were the nine startups, each led by a novice entrepreneur with one year's experience, supported by four master students from different Dutch universities. Each startup had at its disposal prototyping facilities and a 500 Euro budget for prototyping. The nine startups, their initial

business ideas, and relationships to the sustainability challenges of the festival are listed below.

- Biopack: supporting the music festival in producing less waste, by using food-packaging products made from biodegradable cellulose.
- Vegart: supporting the music festival in providing visitors a sustainable food option, based on an organic chia pudding made from natural ingredients as an alternative to meat.
- Bakers' Best: supporting the music festival in providing visitors a sustainable drink option, based on the Genever drink made from leftover loaves of bread.
- Studio Marc: supporting the music festival in sourcing water sustainably, by using a plant-based water-filtration system.
- Zzinga: supporting the music festival in providing visitors with a sustainable drink option, based on honey wine harvested from sustainable bee keeping.
- Solar Solutions: supporting the music festival in producing renewable energy, by using an off-grid solar system integrated with furniture to charge mobile devices.
- and Cricket: supporting the music festival in providing visitors a sustainable food option, based on deep-fried finger food made from insects as an alternative to meat.
- Proper Plates: supporting the music festival in producing less waste, by providing a dishwashing service to eliminate disposables.
- Kapitein Flotsam: supporting the music festival in reducing littering and pollution, by providing visitors with an ashtray designed to prevent cigarettes butts from being thrown on the ground.

The third demonstration was a collaboration with a consultancy and a large multinational company as a client. The focus was on supporting the company to set up small-scale pilots to implement and test a new SBM for providing customers with electronic products as a service. Specifically, the aim was extending the service lifetime of an electronic product for personal care through multiple use cycles and refurbishment, thereby reducing environmental impact while generating economic value from waste. Two half-day workshops were conducted. Various alternatives of small-scale pilots for the product were collectively defined and discussed. Research subjects were 14 employees from the sustainability, design, marketing, and operation departments. They worked in six small groups in collaboration with the researchers and three consultants for a total of six sessions.

3.5 Evaluation

Each demonstration was followed by an evaluation comparing the objective of the tool with the actual results from using it (Peffers et al., 2007). In line with DSR, our evaluation was based on the following framework: explicating the goals of the evaluation, choosing an evaluation strategy, determining the evaluation criteria, and planning the evaluation episodes (Venable et al., 2016). The goal of the evaluation was assessing whether the tool can actually help organizations in setting up small-scale SBM

pilots. Our evaluation strategy was to assess the objective results achieved by organizations using the tool as well as their subjective perceptions about it.

There are two criteria for the objective evaluation: first, whether organizations are able to plan a pilot using the tool; and second, whether they can execute such a pilot. To this end, we conducted one evaluation episode after each demonstration, consisting of directly observing if these criteria were met. The subjective evaluation was essential to collecting feedback for improving the tool as well as to verify potential adoption. In line with literature about the factors influencing the adoption of tools to address organizational challenges, our subjective evaluation was based on two criteria: if organizations find the tool useful; and if they find it easy to use (Davis et al., 1989; Legris et al., 2003). To this end, we conducted various evaluation episodes. After the first demonstration, we discussed the results with the fifteen academics. After the second demonstration, we handed out a form to the 45 people involved in the startup challenges, where they could score the usefulness and ease of use on separate scales ranging from 1 to 7, and then provide comments about it. Furthermore, we conducted ten interviews with the young entrepreneurs leading the startups. After the third demonstration, we discussed the results with the 14 employees and gave them the same feedback forms used in the second evaluation. All interviews and discussions were audio recorded and supported by note taking.

In a final evaluation round, the researchers reflected on their experiences, observations, and notes taken throughout the process (Corbin and Strauss, 2008; Miles et al., 2013), to draw implications for SBMI theory by connecting the outcomes with the literature and the research question.

3.6 Communication

Communication about research outcomes, during and after the research process, is a core part of DSR. During the research process, the tool was discussed with several academics and business practitioners. After the research process, communication is represented by this article and by future SBMI projects that we plan to conduct around the tool.

4. TOOL DEVELOPMENT, DEMONSTRATION, AND EVALUATION

4.1 Initial tool

The backbone of the tool is based on the business model canvas (Osterwalder and Pigneur, 2010), a tool for generating business model ideas. The canvas allows to ideate and map the building blocks of the business model, which can be clustered into core elements: value proposition (product/service, customer segments); value creation and delivery (key partners, key activities, key resources, customer relationship, channels); and value capture (costs, revenue streams) (Osterwalder and Pigneur, 2010). Our tool differs from the business model canvas in terms of its purpose, which is not supporting ideation

but rather planning and executing small-scale pilots of new business models driven by sustainability. The tool thus takes an existing SBM idea as the starting point, allowing to zoom into the details and specifications needed to implement a pilot. To this end, we integrate the original tool with SBMI, business experimentation, and strategic design theory. From a practical perspective, the tool also significantly differs from the business canvas model by way of its layout and content fields. Specifically, next to the core elements present in the business model canvas, it incorporates sustainability elements, while aiding users in critical reflection about pilot testing and respective success criteria. Given its focus, we call our tool sustainable business model (SBM) Pilot Canvas.

SBMI theory is leveraged by integrating three sustainability aspects into the process of setting up a small-scale pilot. First, triple-bottom-line thinking, which refers to conceiving the value proposition of the business model pilot not only in economic terms but also in social and environmental ones (Elkington, 1998; Joyce and Paquin, 2016). Second, sustainability impact assessment, which relates to measuring quantitatively the social and/or environmental value generated by the pilot (Baldassarre et al., 2019; Manninen et al., 2018). Third, a multi-stakeholder perspective, which refers to an active effort to conceive the pilot beyond a traditional firm-centric perspective, taking into consideration the priorities of different stakeholders, their roles in creating and delivering value, as well as how benefits, costs, and profits are shared across them (Bocken et al., 2013; Stubbs and Cocklin, 2008). This is a fundamental aspect of SBMI because sustainability is a system property that can only be achieved through the collaboration of multiple stakeholders (Adams et al., 2016; Stubbs and Cocklin, 2008).

Business experimentation and strategic design theory are integrated as follows. First, effectual reasoning, which refers to an approach to set up the pilot in high uncertainty conditions by leveraging current means, knowledge, and stakeholder contacts in order to iterate forward driven by contingencies (Sarasvathy, 2001). Second, the use of metrics, which consist of quantitative indicators to evaluate if the pilot supports the development and growth of the business (Azabagic and Karpen, 2016; Ries, 2011). These first two aspects are encompassed by a prototyping logic, which refers to quickly materializing an innovation in order to test and further improve it (Calabretta et al., 2017; Ries, 2011). Specifically, the tool allows framing as a prototype – not only the value proposition and the product concept that underlies it, but the entire business model, including the core elements of value creation, delivery, and capture. In other words, the tool supports the materialization of all business model elements needed for executing the pilot.

The coming paragraphs list the core elements of the tool and the building blocks that have to be prototyped for this purpose, explaining in detail how they incorporate triple-bottom-line thinking, sustainability impact assessment, multi-stakeholder perspective, effectual reasoning, use of metrics, and a prototyping

logic.

Sustainable value proposition

Prototyping the sustainable value proposition element requires defining and materializing the following building blocks:

- Basic version of a product/service that can be quickly built with available resources.
- Network of available stakeholders needed for the creation and delivery of the product/service prototype, including end users/customers.
- One or more KPIs to measure the sustainability impact generated by the prototype.

The definition of this core element is based on the integration of the building blocks that constitute the value proposition in the business model canvas (i.e., product/service, customer segments) with triple-bottom-line thinking, and a multi-stakeholder perspective derived from existing SBMI tools and frameworks (Baldassarre et al., 2017; Bocken et al., 2013; Joyce and Paquin, 2016). Specifically, triple-bottom-line thinking is reflected by considering the sustainability impact of the value proposition; a multi-stakeholder perspective is reflected by acknowledging the presence of a stakeholder network to create and deliver the value proposition. Furthermore, effectual reasoning and prototyping logic are reflected by leveraging available means and stakeholders to materialize the product/service immediately. The use of metrics and sustainable impact assessment are reflected by the indication of defining and measuring the sustainability impact of the value proposition with rigor (Manninen et al., 2018; Ries, 2011).

Sustainable value creation and delivery

Prototyping the sustainable value creation and delivery elements requires defining and materializing the following building blocks:

- User journey: sequence of actions that end-users need to do in order to get and use the product/service prototype.
- Supporting processes: sequence of actions that each stakeholder involved in creating and delivering the prototype needs to perform for the user journey to take place.

The definition of this core element is based on replacing the building blocks that constitute value creation and delivery in the business model canvas (i.e., key partners, key activities, key resources, customer relationship, channels) with the service blueprint tool (Stickdorn et al., 2011). The service blueprint tool is used in strategic design practice to apply a prototyping logic to intangible process and service exchanges, which are difficult to materialize and test. The service blueprint supports this by framing them as a sequence of actions that end users and stakeholders need to perform (Bitner et al., 2008; Morelli, 2006). Such an action-based definition, in line with effectual reasoning, provides a business model script that can be acted upon immediately. Finally, the service blueprint tool supports a multi-stakeholder perspective in line with SBMI theory (Bitner et al., 2008; Stubbs and Cocklin, 2008).

Sustainable value capture

Prototyping the sustainable value capture element requires defining and materializing the following building blocks:

- Costs to create and deliver the product/service prototype and an explanation of how such costs are shared across stakeholders.
- Revenue streams generated by the product/service and an explanation of how such revenues are shared across stakeholders.

The definition of this core element is based on the integration of the building blocks that constitute value capture in a business model canvas (i.e., costs, revenue streams) with a multi-stakeholder

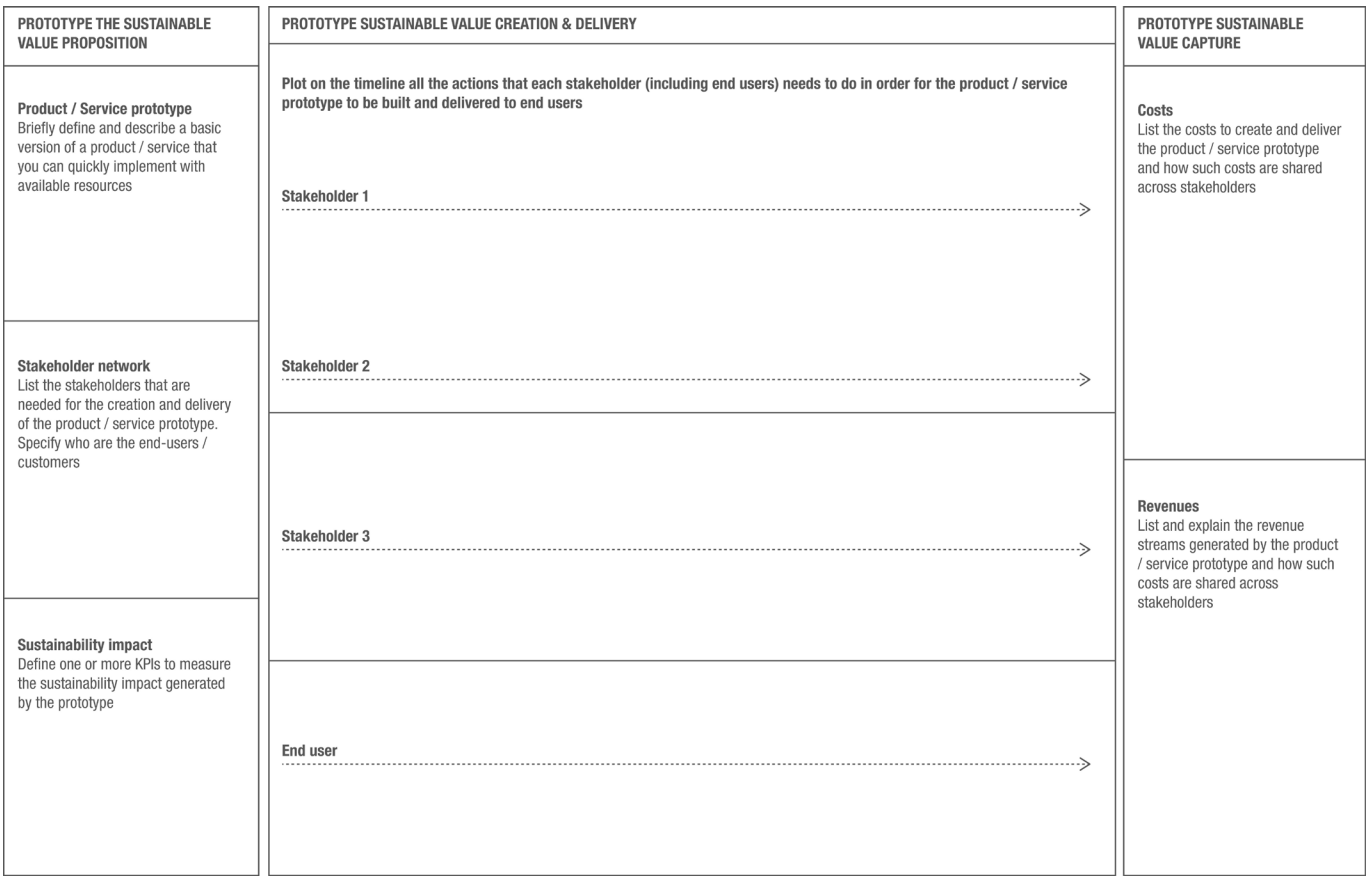

Figure 3. The SBM Pilot Canvas tool developed by combining relevant prototyping expertise from business experimentation and strategic design research with elements and knowledge from the sustainable business model innovation field

perspective derived from existing SBMI tools and frameworks, which prescribe to define how costs and profits shall be shared fairly across the involved stakeholders (Bocken et al., 2013; Joyce and Paquin, 2016). Finally, listing all the costs and revenues for executing the small-scale pilot is in line with effectual reasoning, providing a financial metric to quickly assess the viability of the business model (Azabagic and Karpen, 2016; Ries, 2011).

4.2 First iteration

Demonstration

The academics defined an SBM pilot as starting from a fictional idea. They had no problems using the tool but struggled when placing value creation and delivery actions on the same timeline because, when setting up a pilot, value creation actions precede value delivery actions. For this reason, some of them disrupted the structure of the tool to arrange the actions more logically according to their needs.

Evaluation

The objective evaluation indicates that the academics could plan a pilot; however, this pilot was not executed as part of the trial run. The subjective evaluation of the academics indicates that the tool may be useful for practitioners: "This tool could help companies implementing sustainable business models." Remarks were mostly related to the structure of the value creation and delivery element: "The user journey and stakeholder actions are challenging to plot. You need a workflow to get through this part. It should start with the customer journey." Another remark was related to the terminology used to define the business model elements: "Value creation is a complex term. Outside academia people might not understand what it means." This feedback is integrated into the tool (Table 1).

4.3 Second iteration

Demonstration

The startups planned and executed a small-scale SBM pilot by means of prototyping. Vegart, Baker's Best, and & Cricket prototyped the value proposition (i.e., sustainable food and drink products), delivered it, and sold it to customers. Kapitein Flotsam and Solar Solutions created and delivered a product-service combination (i.e., a floating ashtray to prevent cigarette littering and a bench integrated with a solar panel to charge mobile devices) but did not capture value by monetizing their efforts. Proper Plates delivered a dishwashing service to reduce the use of disposables but did so for free. Biopack and Studio Marc prototyped their value propositions (i.e., a biodegradable food packaging and a water filtration system) and showcased them as concepts. Zzinga was the only startup unable to plan and execute a pilot.

Demonstration example

We provide the example of the startup Solar Solutions to explain how the tool was used, as well as the related discussions and challenges. Figure 4 illustrates the output of the workshop session.

The starting point of the session was the initial idea of Solar Solutions. The intended environmental

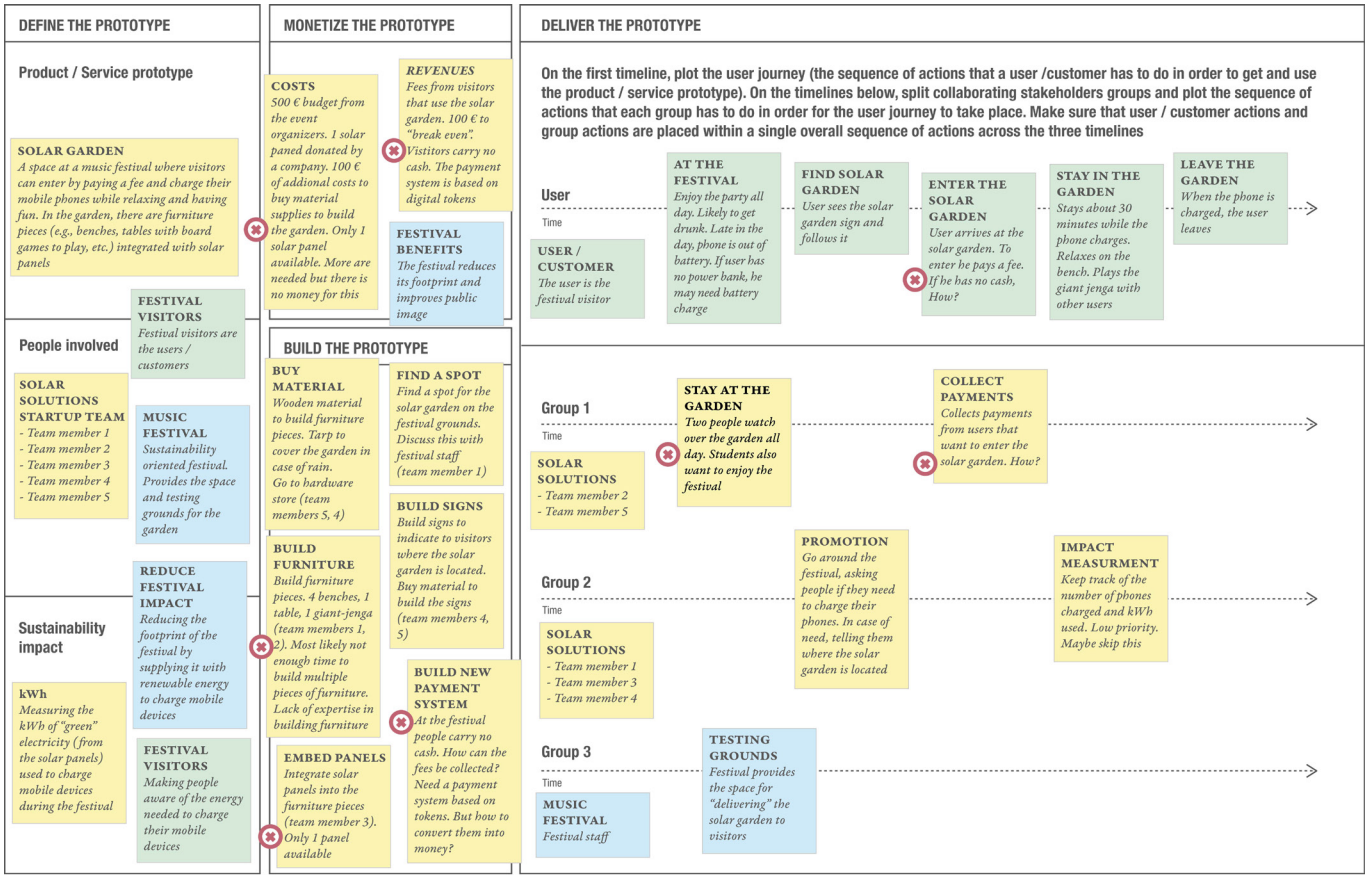

Figure 4. Improved tool after the first iteration and applied in the second iteration. The figure shows how one of nine startups used the tool. Implementation bottlenecks have been mapped ex post by the authors with a "red X."

value was supporting the music festival in producing renewable energy while, on the social side, making people aware of the amount of energy needed to charge their mobile devices. Building upon this, Solar Solutions defined a prototype called Solar Garden: "A confined space where festival visitors can enter by paying a fee and charge their mobile phones while relaxing and having fun. In the garden there are furniture pieces (e.g., benches, tables with board games to play) integrated with solar panels." As shown in Figure 4, Solar Solutions defined the stakeholders involved in the pilot, and mapped them onto the tool using Post-its of different colors to distinguish their roles and specific actions needed to

create, deliver, and sell the prototype.

The first stakeholder was the Solar Solutions team itself (yellow Post-its). Team members were assigned different actions to build the prototype (e.g., how many pieces of furniture to build, which materials to buy, how to integrate solar panels). They defined the costs of such actions and to what extent customer fees could cover prototyping expenses. Festival visitors were the second stakeholder (green Post-its). They were framed as customers. Realizing that service delivery and financial returns depend on visitors, Solar Solution plotted their actions on the user journey. Below, they plotted the supporting actions of the team members (e.g., informing visitors about the possibility to reduce their energy footprint at the festival by indicating the location of the Solar Garden). The third stakeholder was the music festival organization (blue Post-its), providing the grounds to run the pilot. To this end, Solar Solutions was dependent upon it and framed it as a partner. This required a constant exchange of information (e.g., defining where to execute the pilot without interfering with other festival activities and how such a pilot would benefit the organization). Ultimately, by using the tool and leveraging prototyping with a multi-stakeholder perspective, Solar Solutions was able to plan the pilot.

While planning, Solar Solutions discovered several bottlenecks (mapped "ex post" by the researchers on Figure 4 using a red "X") related to actions that could not be executed due to lack of expertise, time, and/or budget (e.g., nobody on the team had experience in building furniture and multiple pieces could not be built in a short time; there was no budget for multiple solar panels; festival visitors carried no cash, therefore requiring the creation of a new payment system). Consequently, Solar Solutions decided to build only one bench integrated with one solar panel where people could relax and charge their phone. No solution to the payment system was found in the available time; therefore, value was captured only to a limited extent through tips from those people who carried cash. In order to solve these bottlenecks in a short time and with limited money, Solar Solutions simplified the value proposition to execute the pilot as best they could, given the circumstances.

Finally, even though Solar Solutions had already defined how the pilot would generate environmental and social value for different stakeholders within the Sustainability Impact box of the tool, they struggled significantly in defining ways to quantify such impact. In fact, this box was initially filled in superficially, with a vague explanation about reducing the festival footprint by supplying renewable energy and making visitors more aware of their energy consumption. When nudged on the importance of actually keeping track of the Sustainability Impact with metrics, Solar Solutions came up with the idea of using kWh to measure the "green electricity" supplied to the festival. However, due to lack of time, they did not follow up with this measurement.

Evaluation

The objective evaluation shows that eight startups could plan and execute a small-scale pilot starting

from their sustainable business idea. However, next to the use of the tool, the entity of such steps depended on several contextual factors, which are difficult to assess (e.g., team dynamics, abilities of the entrepreneurs, complexity of the idea, etc.). In general, we observed that, while planning the pilot under time and financial pressures, several startups simplified the original value proposition in order to be able to create and deliver it. Furthermore, we observed that they were reluctant and/or unable to quantify the sustainability impact of their idea and treated sustainability more as an abstract driver rather than a necessary condition to be taken into consideration when executing the pilot. These observations are illustrated in our "demonstration example."

The subjective evaluation was positive. Feedback forms reported an average score of 6 for perceived usefulness. Comments and interviews highlighted that the tool helps to stop ideating and defines concrete actions, but also that many startups did not find the definition of sustainability metrics relevant. They explained that sustainability lies at the core of the idea, and that measuring is not a priority when time and budget pressures impose focus upon other issues. For example, a novice entrepreneur explained: "We are making a vegan snack to reduce the production and consumption of meat. This is good for people and reduces CO2 emissions. Our business is sustainable even if we do not measure it. Now there is little time and we have to focus on production." Concerning ease of use, feedback forms reported an average score of 4. The interviews provided different opinions. Negative remarks related to difficulties in plotting value delivery actions. Other remarks related to the lack of space to define the prototype, which was needed before defining the actions to execute the pilot. This feedback is integrated into the tool (Table 1).

4.4 Third iteration

Demonstration

The six groups of company employees planned various alternatives of small-scale SBM pilots around the electronic product. Two groups focused the pilot on the internal company processes needed to refurbish the product and generate value out of waste. Two groups focused the pilot on how to leverage partner relationships to sell the product as a service and reduce end-user consumption. One group broke down the pilot into a set of multiple hypotheses testing customer acceptance of leasing products for personal care (e.g., hygiene concerns, willingness to pay). The remaining group engaged in divergent thinking and was unable to use the tool to define a specific pilot plan.

Evaluation

The objective evaluation shows that five of the six groups could plan a small-scale pilot. Nevertheless, these plans were not detailed enough for immediate execution. The employees explained that they would discuss internally how to combine different elements into a single plan to execute it. We could not be involved in this, which is an important limitation of our study, but we observed how, while planning the pilot, the large company evaluated several options

and most groups placed a prominent focus on how the new sustainable proposition could be created and delivered. Furthermore, we observed that the definition of meaningful sustainability metrics was distorted by the need for delineating a compelling business case behind each pilot option.

The subjective evaluation was positive. Feedback forms reported an average score of six for perceived usefulness and five for ease of use. This is confirmed by their request for a printable canvas template, in order to follow up with it autonomously. The main remark on usefulness was related to the lack of space to explain the sustainability relevance of the pilot and the business case behind it. They suggested including such space to support the definition of sustainability metrics in line with it. The main remark on ease of use was related to a lack of clarity on the purpose of the tool, which became evident only after the researchers' explanation: "Add a title explaining that the tool helps to set up small-scale pilots. The term prototyping applied to a service may lead to misunderstandings." To further clarify the purpose of the tool, they suggested framing the core elements as questions, such as: "What is the idea?" or "How do you make money?" This feedback is integrated into the tool (Table 1).

4.5 Final tool

Facilitating sessions and receiving feedback allowed gradually upgrading the SBM Pilot Canvas. Specific improvement points are listed in Table 1, as well as their rationales deriving from the three iterations.

After the evaluation of the third iteration, all improvement points were condensed into a final version of the tool (Figure 5). This version is structured around five core elements: What is the idea? (Sustainable Value Proposition); Why is it sustainable? (Sustainability Impact); How do you make money? (Sustainable Value Capture); How do you make it happen? (Sustainable Value Creation); and How does it work? (Sustainable Value Delivery). Each core element is based on several building blocks, as listed below.

What is the idea? (Sustainable Value Proposition)

- Description of the main idea for a small-scale pilot around a new sustainable product/service that can be quickly executed with available resources.
- Definition and description of who will be the user/customer of the product/service provided in the pilot.
- Explanation of why the user/customer wants the product/service put forward by the pilot.

Why is it sustainable? (Sustainability Impact)

- Explanation of the sustainability impact generated by the pilot and the related business case.
- Definition of one or more indicators to measure the sustainability impact generated by the pilot.
- Assessment of the actual results for each indicator after executing the pilot.

Table 1. List of the improvement points defined by applying and evaluating the tool in three iterations

	Upgrades	**Improvement points**	**Rationale**	
1	**Clarify the purpose of the tool**	1a) Included a title to clarify its purpose (i.e., set up small-scale scale pilots for SBMs)	*Third iteration* Employees mentioned that purpose became clear after the explanations of the researchers and suggested making this explicit on the canvas. They argued that the term prototype might lead to misunderstandings and suggested using the term small-scale pilot instead	
		1b) Included a subtitle to indicate that the pilot should be executed immediately with available resources		
		1c) Adjusted the explanatory text to further specify the purpose of the core elements		
2	**Redefine and rename the core elements of the tool**	2a) Redefined/added the core elements twice across the three iterations by splitting/unbundling current ones	*First iteration* Academics suggested to use simpler names to make the core elements more understandable for practitioners (e.g., *build the prototype* instead of *value creation*)	*Third iteration* Employees suggested to clarify content by framing the elements as questions (e.g., *how do you make money?* instead of *monetize the prototype)*
		2b) Renamed the core elements twice. Final elements: *What is the idea?* (*Sustainable value proposition*) *Why is it sustainable?* (New. See 4a, 4b, 4c) *How do you make money?* (*Sustainable value capture*) *How do you make it happen?* (New. See 5b) *How does it work?* (New. See upgrade 5c)		
3	**Improve the *sustainable value proposition* element of the tool (*what is the idea?*)**	3a) Replaced the space for specifying the *stakeholder network* with a space for defining the *user/customer* and his/her *reason to buy/use* the prototype	*Second iteration* Startups struggled to start using the tool. They argued that the process of working with the tool could be more coherent and logically structured, starting from the plotting the initial idea, who would pay for it and why, and thinking about sustainability metrics and stakeholder actions later	
		3b) Unbundled *sustainability impact* from the *sustainable value proposition* (see row 4)		
4	**Add *sustainability impact* as a stand-alone element of the tool (*why is it sustainable?)***	4a) Included *Sustainability impact* as a stand-alone element labeled with the question: *Why is it sustainable?*	*Second iteration* Startups argued that sustainability is their motivation and does not need to be measured. In some cases, this resulted in losing focus and being unable to explain the sustainability impact of the business model pilot. In the third iteration, employees mentioned the importance of having a business case behind sustainability impact and defining metrics accordingly	
		4b) Included space to explain the sustainability impact of the pilot and related business case		
		4c) Next to space for *sustainability metrics* (now in line with the business case), included space to note the actual measurement after the pilot to verify if impact was achieved		

5	**Split and improve the *sustainable value creation and delivery* elements of the tool (*how do you make it happen?* and *how does it work?*)**	5a) Split *sustainable value creation and delivery* into two separate elements	*First iteration* Academics struggled with plotting value creation and value delivery actions on the same timeline because the first are needed to prepare the pilot and the latter to execute it. They suggested splitting the core elements to allow for more coherent activity planning. They also struggled to define *delivery actions* before plotting the *user/customer journey*, and suggested that the latter should be placed on top to make the process of working with the tool more coherent and structured	*Second iteration* Startups worked toward a pilot execution date; defining the resources needed; splitting tasks across team members and checking whether they had been performed in order to prevent delays. They also explained that using the term *people* instead of *stakeholders* would make the tool more understandable. They also improved the delivery element of the tool by naming items more clearly and removing multiple timelines to avoid confusion
		5b) Labeled the *sustainable value creation* element with the question: *How do you make it happen?* Next to the label, added a space to specify the execution date of the pilot. Within the element three columns were added for: Listing the *people* involved in the pilot Listing *available resources* provided by each person Listing *building actions* that each person performs (indicating to tick the action when completed)		
		5c) Labeled *sustainable value delivery* element with the question: *How does it work?* Within the element: Explicitly named the *user/customer journey* and placed it in the top part. Replaced the multiple timelines to plot stakeholder actions with a single timeline named *delivery actions*, (leaving below sufficient space to add more timelines)		
6	**Suggest working with Post-it notes of different colors**	6a) Added in the text the suggestion to work with Post-it notes of different colors to identify different stakeholders and respective actions within *sustainable value creation* and *sustainable value delivery*	*Second iteration* Startups worked with Post-it notes of different colors to visualize at a glance the tasks of different team members, as well as stakeholders involved in the pilot	

How do you make money? (Sustainable Value Capture)

- Definition of the costs needed to execute the pilot and how such costs are shared across stakeholders.
- Definition of the revenues deriving from executing the pilot and how such costs are shared across stakeholders.

How do you make it happen? (Sustainable Value Creation)

- List of all the people/organizations involved in setting up and executing the pilot.
- List of the resources (e.g., knowledge, expertise, network, and infrastructure) that each person/ organization brings to the table to set up the pilot.
- List of all the actions that each person / organization performs to set up the pilot.

How does it work? (Sustainable Value Delivery)

- Sequence of actions that a user/customer has to do during the pilot.
- Sequence of actions that the people/organizations

working on delivering the pilot have to do in order to support each step of the user/customer journey.

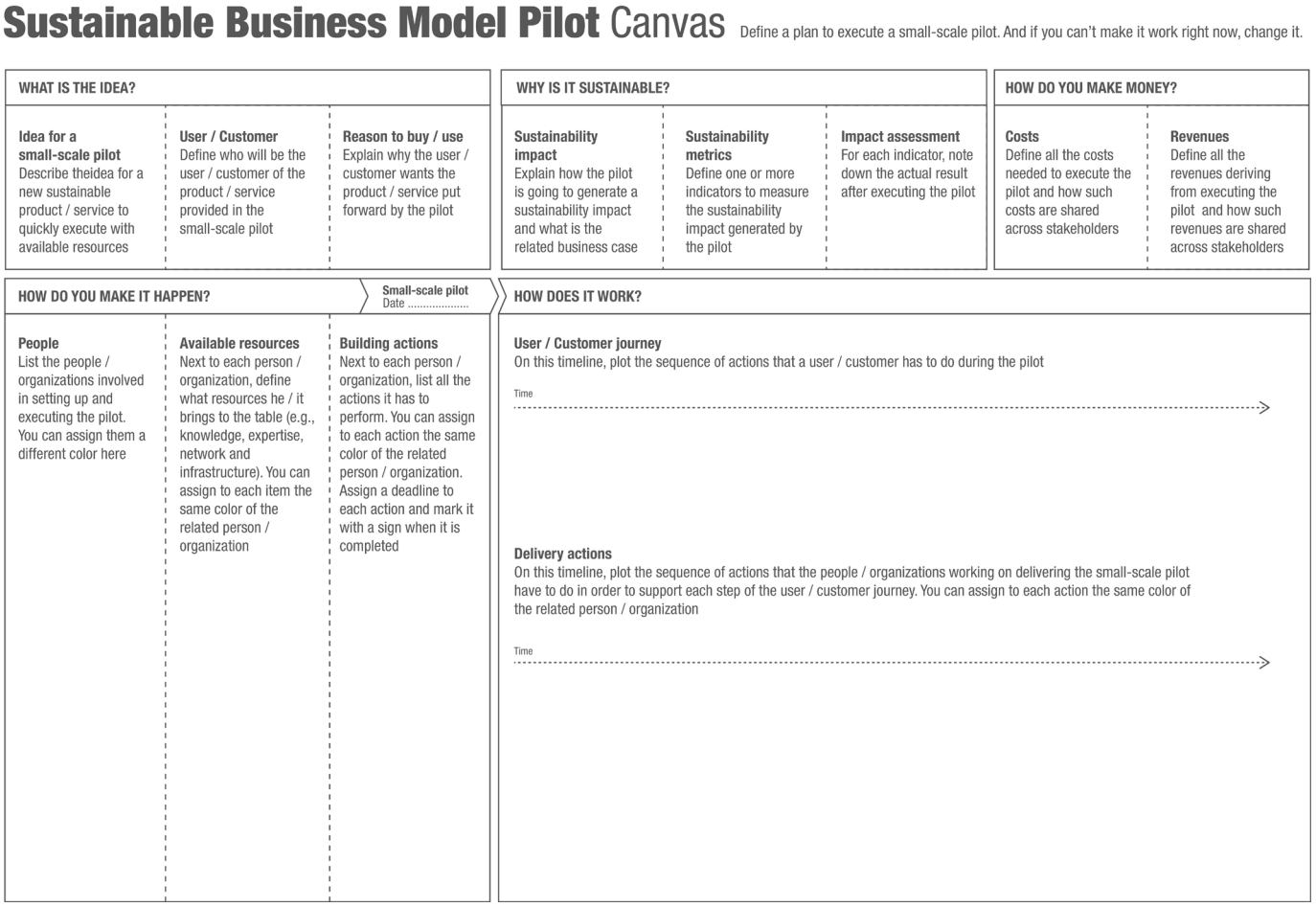

Figure 5. The SBM Pilot Canvas updated and improved after applying it and evaluating it in three iterations

5. DISCUSSION

5.1 Contribution to Sustainable Business Model Innovation theory

This research focuses on the design-implementation gap of SBMs. Indeed, this gap indicates that many promising SBM ideas are not implemented successfully (Geissdoerfer et al., 2018; Ritala et al., 2018). Addressing this issue is highly relevant to achieving the sustainable impacts promised by SBMI research (Abdelkafi and Täuscher, 2016). In fact, SBMI literature is driven by the argument that a more strategic and managerial perspective can be used to derive positive sources of value from negative impacts (Stubbs and Cocklin, 2008; Yang et al., 2017), which may be reduced by up to 90% (Tukker, 2004). Scholars outside the "sustainability niche" increasingly discuss the relevance of such a perspective in fostering the necessary transition toward sustainable development. For example, Massa et al. (2017) present sustainability as a future avenue for business model innovation research, while others maintain that management research should focus on grand sustainability challenges (George et al., 2016), such as achieving growth without depleting natural resources (George et al., 2015). Nevertheless, SBMI research focusing on how to address the design-implementation gap of SBMs is currently limited (Geissdoerfer et al., 2018; Tukker, 2015).

From a theoretical perspective, our main contribution lies in identifying and combining multiple literature streams advancing current theorizing around SBMI. We purposefully integrate insights of business experimentation (e.g., Weissbrod and Bocken, 2017) and strategic design (e.g., Baldassarre et al., 2019) literatures to inform SBMI. Drawing on these literature streams and our empirical study, we demonstrate how prototyping is central to linking insights across these literatures, while explaining how it can be leveraged to start addressing the design-implementation gap of SBMs. Indeed, we argue that prototyping can bridge the design-implementation gap by allowing the materialization of an SBM, setting up a small-scale pilot as a first critical step toward implementation.

More specifically, as part of this contribution, we specify that piloting a prototype forces organizations to consider from an early stage the desirability (i.e., whether users or customers are interested in the value proposition) and the sustainability (i.e., a multi-stakeholder perspective, triple-bottom-line thinking, and impact assessment orientation) of a new business model, in parallel with its feasibility (i.e., whether the organizations involved can create and deliver such value propositions) and viability (i.e., whether they can translate this effort into a financial return). By planning the pilot, the startups encountered several bottlenecks that forced early reconsideration of their sustainable value propositions, trading off desirability with feasibility and viability toward execution. Similarly, when planning pilot options to be executed early, the multinational put a major focus on feasibility and viability, besides thinking about the wishes of customers. Furthermore, in this process, both the startups and the multinational were

confronted early on with their inability to properly quantify the intended sustainability impact, which is an important recognition step when dealing with this critical aspect highlighted in the SBMI literature (Manninen et al., 2018).

Ultimately, our empirical work challenges current assumptions within SBMI theory; namely, that it is necessary to first conceptualize a sustainable value proposition that is desirable, and then move on to thinking about sustainable value creation, delivery, and capture (Baldassarre et al., 2017; Bocken et al., 2013, 2018. Conversely, we argue that focusing only on desirability and sustainability upfront and accounting for feasibility and viability at a later stage results in operational and financial bottlenecks, which are exacerbated by sustainability impact requirements, ultimately leading to a design-implementation gap (Geissdoerfer et al., 2018). We thus suggest that before detailing SBM ideas, piloting prototypes are crucial to considering simultaneously their desirability, sustainability, feasibility, and viability, and to verify early on if they can be implemented.

Finally, an important part of the contribution is the empirical development of a tool to support thinking in this direction, as visualized in Figure 6. By developing this tool through a design science research method, we advance normative theory on SBM implementation. Normative theory is important in providing a solid foundation for business practice and in offering prescriptive managerial considerations, ultimately guiding both ethical and/or rational thought (Hunt, 2011). While many normative frameworks consider either ethical (e.g., morally appropriate behaviors) or rational (e.g., goal-oriented decisions) drivers (Hunt, 2011), we argue that the proposed SBMI tool combines both aspects into one framework. Indeed, the developed and validated tool links sustainability concepts with the business-oriented concepts of desirability, feasibility, and viability.

Building upon these reflections in line with Whetten (2016), we briefly summarize our theoretical contribution to the SBMI field in terms of the what, how, and why questions. What – we have introduced the concepts of desirability, feasibility, viability, and sustainability by drawing from different theoretical domains. How – we have explained that through prototyping it is possible to shift the focus away from generating new sustainable business model ideas (that might remain "on paper"), and propose a tool to leverage these concepts simultaneously in order to set up small-scale pilots (that take place in reality). Why – we have justified how doing so is relevant for advancing our conceptual understanding and normative theory in the context of SBMI, bridging the design-implementation gap of new sustainable business models, and ultimately reducing the environmental impacts of organizations.

5.2 Contribution to Sustainable Business Model Innovation practice

The SBM Pilot Canvas aims to support small and large organizations interested in bridging the design-implementation gap of their SBM ideas, helping them to turn negative impacts into positive sources

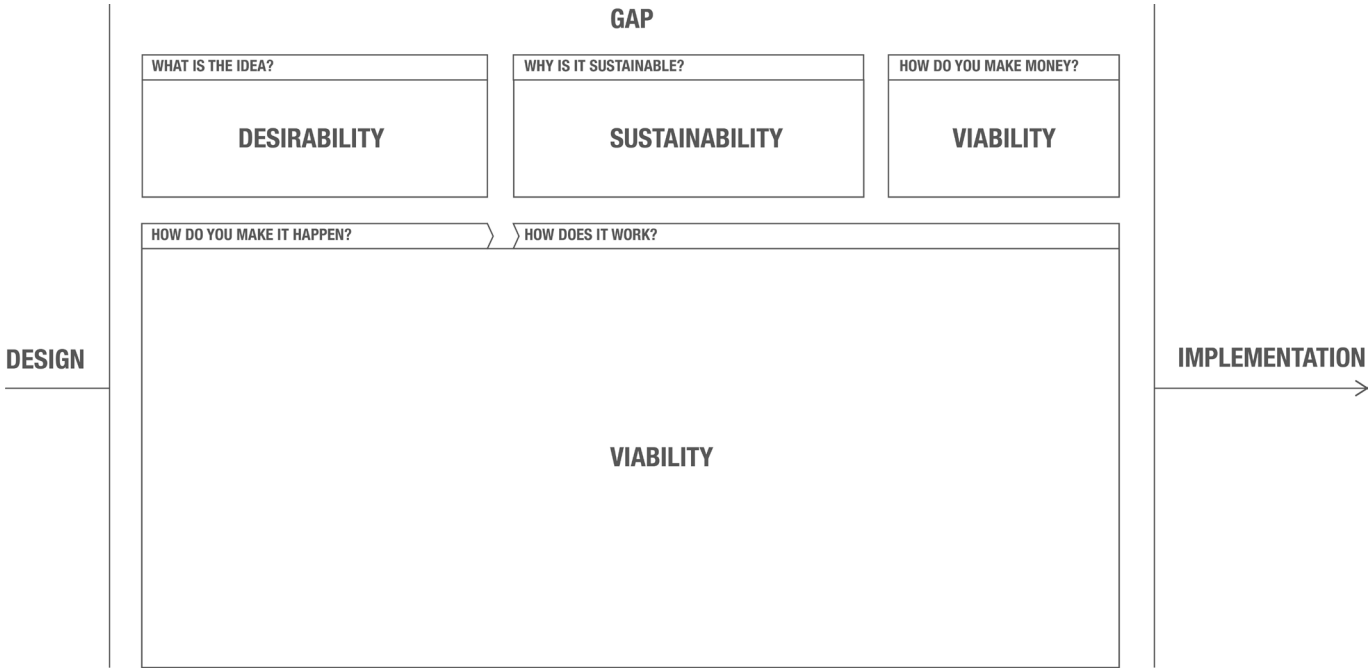

Figure 6. The SBM Pilot Canvas supports bridging the design-implementation gap of sustainable business models by leveraging and integrating simultaneously four constructs: desirability, feasibility, viability, and sustainability

of value. Specifically, the tool supports building prototypes and planning specific actions needed for executing small-scale pilots by simultaneously taking into consideration four main concepts: the desirability of the business idea, its sustainability, operational feasibility, and financial viability. The tool that we propose has been applied and evaluated by working in business practice with both startups and a multinational company. Its versatility and validity are important to highlight, as previous frameworks have been criticized for not providing empirical evidence and related reflections about how they can be used in practice (Bragd et al., 2002).

The SBM Pilot Canvas complements an existing collection of SBMI tools for ideating, implementing, and evaluating new SBMs (Bocken et al., 2019; Breuer et al., 2018). An analysis of this collection shows that currently no tool places a specific focus on the design-implementation gap. Accordingly, organizations may use the SBM Pilot Canvas starting from an existing SBM idea, and then work towards a first small-scale implementation. In addition, it is important to reiterate that this tool differs from the

business model canvas (Osterwalder and Pigneur, 2010), which is frequently used by practitioners to ideate and work with new business model ideas. As pointed out by previous research (Joyce and Paquin, 2016), this tool does not provide any support to incorporate sustainability thinking in the ideation of a new business model. Furthermore, it is mostly geared toward mapping and analyzing business models rather than defining details of the specific actions and success criteria that are needed for their implementation (Joyce and Paquin, 2016). The SBM Pilot Canvas addresses these issues by integrating features derived from SBMI, business experimentation, and strategic design (i.e., triple-bottom-line thinking, sustainability impact assessment, multi-stakeholder perspective, effectual reasoning, and the use of metrics – a prototyping logic). In doing so, the model also provides better support for practitioners aiming to go beyond ideation and confront all details and potential difficulties entailed with implementing a sustainable business model.

Our demonstration with nine startups indicates that using the tool can support small organizations in quickly establishing if customers and stakeholders are interested in the business model idea; whether such an idea is sustainable or not; if it can work from an operational point of view; and if it is possible to immediately generate money from it – an aspect that is essential to reach the market (Ries, 2017). Our demonstration with the multinational company context points out that using the tool can support large organizations in defining multiple pilot options and, consequently, in deciding how to move forward depending on various considerations mainly influenced by the business case, which must be aligned with the current business model of the company to ensure feasibility and viability (Azabagic and Karpen, 2016; Karpen et al., 2017; Schaltegger et al., 2012).

We further note that the tool may require facilitation from experts (i.e., researchers and/or consultants). In our cases, we saw that novice entrepreneurs and MSc students required facilitation in order to move beyond the definition of features of the value proposition and plan all the actions needed to create, deliver, and monetize the small-scale pilot. On the other hand, the employees of the multinational company, who have more experience in navigating the innovation process, encountered few difficulties in using the tool. After receiving a preliminary explanation, they were able to use it autonomously, which is further supported by their request to be provided with a printable template of the tool to support internal work.

6. CONCLUSION

6.1 Limitations and future research

The main limitation of this study relates to its exploratory nature. First, we applied and evaluated our tool by working with a limited sample of organizations for a limited period. The type of subjects we worked with and the short duration of the research influenced the generalizability of

our findings, which require further validation. Nevertheless, our study shows that investigating how prototyping can be leveraged to set up small-scale pilots is a promising avenue to advance research about the design-implementation gap in SBMI (Geissdoerfer et al., 2018). Consequently, we encourage future SBMI research along this trajectory by working with a larger sample of companies and for a longer period through longitudinal case studies, to pinpoint with more accuracy how small-scale SBM pilots can be planned and executed successfully. To this end, we suggest that the tool, and the four concepts of desirability, feasibility, viability, and sustainability put forward in this research may provide practical and conceptual guidance on the core criteria that have to be considered when planning and executing such pilots.

A second limitation relates to the issue of evaluation. Our study focused the evaluation on the tool itself, assessing from a subjective standpoint if the organizations found it useful and easy to use, and from an objective standpoint if it could help them to plan and execute sustainability-driven business model pilots. However, we did not evaluate the outcomes from using the tool. Advancing the evaluation to the outputs proved to be problematic in practice. Given the exploratory nature and short duration of our study, neither the organizations nor we evaluated if the executed pilots would be successful from a sustainability and/or a financial point of view. Nevertheless, this study paves the way for future work in this direction. Specifically, we suggest that future SBMI research, besides focusing on how prototyping can be leveraged to plan and execute pilots, should also investigate how such pilots can be rigorously assessed from a financial and sustainability standpoint. These two aspects are important if the design-implementation gap of SBMI is to be bridged with proper solutions that deliver tangible sustainability impacts.

6.2 Concluding remarks

SBMI plays a crucial role in integrating environmental and social concerns into the objectives and operations of firms aiming to transition towards sustainable development (Stubbs and Cocklin, 2008; Tukker, 2004). To this end, it is necessary not only to ideate new SBMs but also to implement them successfully in markets (Tukker, 2015). To date, this remains a major challenge (Ritala et al., 2018). This exploratory study proposes theoretical and practical contributions to start bridging this critical design-implementation gap so that organizations can make an actual difference.

ACKNOWLEDGEMENTS

The authors would like to acknowledge financial support through the ZERO BRINE project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730390.

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CHAPTER IV

DESIGNING ECO-INDUSTRIAL CLUSTERS IN A CIRCULAR ECONOMY

FOURTH STORY

"Dit is de trein naar Vlissingen!" The train rolls smoothly on the steel rails. Outside the window I see green meadows, trees, canals, greenhouses, farms, and the chimney fumes of factories that never sleep. Unlike my poor motherland, entrenched into corruption and never ending lunch discussions about politics seasoned with abundant olive oil, I am always amazed at how this country is so well organized and efficient. In The Netherlands trains are always on time and, visibly, the nation's economy is made up by industrious individuals: big milk drinkers, tallest men and women on the planet and responsible citizens, the Dutch are in the first place competent innovators and unbeatable traders. In the middle of the XVI century, while the Spanish were busy fighting with the British for the control over the newly established commercial routes in the Atlantic Ocean, a few provinces in the north-western corner of the old continent seized the opportunity to revolt against Philip II of Spain, one of the last representatives of an already crumbling Holy Roman Empire. In the subsequent eighty years of war to break free from the Spanish crown, the provinces managed to gain political power through an intense economic growth. Many trade unions and competing companies were merged into the first megacorporation in history, the Dutch East India Company, soon followed by her western sister, which played a crucial role in making the coalition of provinces one of the most important commercial forces of the time. These circumstances eventually led to the emergence of the modern national state that we

now know as The Netherlands. Despite ethical questions related to the colonial past and present tax-optimization schemes to attract foreign capital unfairly, it is undeniable that the Dutch are remarkably good at doing business. They do so in an innovative and collaborative way, which ultimately makes the Netherlands one of the most successful economies in the world considering its relatively small number of inhabitants crammed like sardines on bikes inside a tiny surface area. However, the world is changing faster and faster, and with it the rules of the economic game. Population is growing exponentially along with the demand for resources required to sustain an accelerating human development. Mountains of trash are produced every day. We are starting to talk about the need for a different economy, a circular one, where waste becomes the input for new industrial products and processes. No doubt, achieving this in practice is one of the biggest challenges we face today, and just like in the XVI and XVII centuries, the Dutch do not shy away when the game becomes tough, armed with pragmatism in the left hand, a glass of milk in the right one, cycling against the wind under the pouring rain that regularly swipes their plains below sea level. A concrete example of their effort to shift to a circular economy is located exactly where I am heading now, in the flat surroundings of Vlissingen, a rather uneventful place nonetheless dignified by an almost mythological name that in my mind recalls one of the ancient elven kingdoms of the Lord of the Rings. The rectangular constructions and

cylindrical silos of a chemical factory emerge like towers next to several wind turbines in the middle of a methodically exploited plain covered in greenhouses. Although difficult to suspect, I was told that there is something cool happening here: the heat and carbon dioxide emissions from the factory are channeled through a piping system right into the greenhouses, where local farmers need them for growing tomatoes. This is definitely a good thing for the environment: first, because the industrial emissions are not released into the atmosphere, contributing to global warming; and second, because the energy needed by the farmers to keep the greenhouses operating is sourced from waste instead of virgin inputs, alleviating the issue of unsustainable resource consumption. On a small scale, this is in essence a circular economy. The only problem that remains unsolved is the lack of taste of Dutch tomatoes, but after living in the country for several years I am aware that this would be asking too much. Sitting next to me is Micky, a master student at TU Delft who is specializing as an industrial ecologist. I am pleased to find out that she shares my concerns on the taste of the tomatoes "and to be precise", she explains, "the whole thing we are looking at is not called circular economy but rather industrial symbiosis". To be honest, at this stage, I know nothing about this industrial ecology symbiosis stuff, and I am curious to learn more about it. "It is like when there is a bunch of factories in the same place right", she continues, "but then it's ecological, because the waste of each factory is not trashed away

but it is used by others to do their thing. That's why they call it symbiosis. It happens also in nature, with the clownfish for example. From the cartoon Finding Nemo, you know? He lives inside a purple anemone right, and then he gets protection from it. The anemone also benefits though, because it feeds on the leftovers from the fish. Both species benefit, and with factories it is just the same: an industrial symbiosis. Industrial ecologists are those people who work with this subject. In the end it's about nature you see? I like nature". I get the concept, and on Wikipedia—best source of all times—I immediately find out that the Dutch are not the only ones busy with industrial symbiosis. It is all over Europe, and outside too. The Chinese, for example, are most definitely on top of the game, building very quickly massive industrial facilities based on these principles, to ultimately make their whole manufacturing-based economy more circular. We arrive at our destination. Marlon and Jenny are the project managers that are tasked to make ends meet around here: from getting things started with the available government funding, to overseeing the construction of the piping systems, checking that the whole facility operates properly and delivers on the expected environmental and economic benefits. Hearing their story, I understand their struggles. Besides the engineering challenges, the most difficult part is making sure that all stakeholders are happy. It is a fluid and dynamic collaboration taking place simultaneously on a technical, commercial, institutional and importantly, on a social level, meaning that

ultimately people need to get along to make it work. At the same time, while this process of refining, optimizing, discussing and compromising unfolds over time, the financial ties need to bind in the immediate present, to avoid going bankrupt. There must be a functioning business model to make sure that the facility generates profit as it operates. I begin to see the tension between the two things: the process perspective and the business perspective. Thinking from a third perspective ingrained in my professional background, the question that naturally arises in my mind is: "How to design for all of this?"

FOURTH SCIENTIFIC PUBLICATION

Industrial symbiosis: Towards a design process for eco-industrial clusters by integrating circular economy and industrial ecology perspectives

This article has been published in the Journal of Cleaner Production. Please cite as:
Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., and Calabretta, G. (2019). Industrial Symbiosis: towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives. Journal of cleaner production, 216, 446-460.

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Abstract
Industrial Symbiosis (IS) is a collective approach to competitive advantage in which separate industries create a cooperative network to exchange materials, energy, water and/or by-products. By addressing issues related to resource depletion, waste management and pollution, IS plays an important role in the transition towards sustainable development. In the literature, two conceptual perspectives on IS can be identified: the Industrial Ecology (IE) and the Circular Economy (CE) perspective. Despite the recognition of these two perspectives, their relationship remains unclear and explicit attempts to develop an integrated perspective have not been made yet. Consequently, the goal of this research is to highlight and start addressing this critical gap of knowledge in order to support future research and practice geared towards the design of new IS clusters. We pose the following research question: How can the IE and CE perspectives on IS be combined in order to support the design of IS clusters? To this end, we first investigate the two perspectives more in depth and compare them in terms of nature, features and relevance for the study of IS. This is done by applying them as conceptual lenses for the analysis of the same case study, an existing IS cluster. The comparative analysis provides insights into how the two perspectives differ, ultimately demonstrating that they are complimentary and both necessary to fully describe an IS cluster. While the CE perspective is more suitable to explain how a cluster functions from a business standpoint in the operating phase, the IE perspective is more suitable to explain its development over time and its impacts on the environment, the economy and society. Building upon the outcomes of the comparative analysis, we leverage on the discipline of strategic design and integrate the two perspectives into a process for designing new IS clusters. We suggest two directions for future research. First, improving our comparative analysis of the two perspectives by looking at a wider and sample of IS clusters of different sizes and in different contexts. Second, focusing with more specificity on the issue of how IS clusters can be designed, potentially by trying to apply the process we propose on a real case aimed at designing a new IS cluster.

1. INTRODUCTION

Industrial Symbiosis, defined as a collective approach to competitive advantage in which separate industries exchange materials, energy, water and/or by-products, plays an important role in the transition towards sustainable development (Chertow, 2000, 2007). Specifically, Industrial Symbiosis addresses issues related to resource depletion, waste management and pollution by using waste streams to generate value more efficiently across networks of industrial actors (Chertow, 2007; Massard et al., 2014).

The concept of Industrial Symbiosis (IS) finds its origin in the field of Industrial Ecology (IE), with the industrial park of Kalundborg figuring as a prominent example (Chertow, 2007; Ehrenfeld and Gertler, 1997). Within social science oriented IE literature, IS is typically studied as a dynamic collaborative process evolving over time (Boons et al., 2014; Boons et al., 2011). In line with the system perspective of IE, IS is viewed as a process of interacting firms, which over time produces (emergent) outcomes (Boons et al., 2014, 2011). More recently, IS is also studied as an example of a business model for Circular Economy (Bocken et al., 2014; Forum for the Future, 2016; Short et al., 2014).

Circular Economy (CE) is a concept that has recently gained traction in policy, business and academia to advocate a transition from a linear 'take-make-dispose' model, with raw materials one the one end and wastes at the other, towards a circular model, in which waste is a resource that is valorized through recycling and reuse (Gregson et al., 2015; MacArthur, 2013). The appeal of CE is that it promises to reconcile environmental and economic goals by reducing resource use and stimulating economic growth at the same time. While concepts related to sustainable development come and go, CE has been very successful in gaining policy, business and civic traction (Hobson et al., 2018). Since IE can be considered as one of the main roots of CE (Bocken et al., 2017; Lüdeke-freund et al., 2018), a large communality between the CE and IE strands of literature is not surprising. Both IE and CE are based on the idea of closing energy and material loops in order to make economically appealing a reduction of the environmental impact of industries (Ehrenfeld, 2004; MacArthur, 2013).

The IE process perspective on IS and the CE business model perspective on IS both put emphasis on different, but equally relevant aspects of IS. The IE perspective provides good understanding of how IS comes into being, but pays limited attention to the role of economic logic in symbiotic exchange; the CE perspective provides a good understanding of economic logic but does not pay attention to systemic behavior of IE (e.g. the role of path dependencies and lock-in in the development of IS). This suggests that an integration of the two perspectives will result in a richer insight into IS and support a better design of new IS clusters (Bocken et al., 2017; Fraccascia et al., 2016; Short et al., 2014). Accordingly, we pose the following research question:

How to design an eco-industrial cluster from a

process and business model perspective?

We aim to answer this research question by posing two sequential research objectives. The first objective is investigating the IE and CE perspectives on IS more in depth, by comparing them in terms of nature, features and relevance for the study of IS. Building upon it, the second objective is to show how this comparison can be used to support IS practice by making an initial attempt to combine the CE and IE perspectives into a process for designing new IS clusters. Since both the IE and the CE perspective have no explicit design orientation, within our second objective we leverage upon insights from the field of strategic design (Calabretta et al., 2016). Strategic design is a stream of research and applied discipline based on using design principles and practices for the formulation and implementation of innovation strategies for organizations, including industrial networks (Calabretta et al., 2016).

The remainder of this paper is structured as follows. In section 2 we will draw on the literature review to articulate the research gap in more detail, by elaborating and comparing the IE and CE perspective on IS. Section 2 is divided in four parts: part one puts IS in context across the CE and IE perspectives; part two frames IS from the IE perspective; part three frames IS from the CE perspective; part four elaborates on the research gap reiterates our research objectives. Section 3 discusses the methodology and is divided in two parts: part one describes the research process and methods to address the objectives; part two introduces the case study going over selection criteria and concise background information. Section 4 presents the findings in two parts: part one reports the findings based on the IE perspective on IS; part two reports the findings based on the CE perspective on IS. Section 5 presents our discussion divided into two parts: in part one, a comparative analysis of the two perspectives is presented; in part two we do the initial attempt to combine them into a design process for IS. Section 6 presents our conclusions divided into two parts: the first part lists and describes our contributions; the second part pins down the limitations of our study and suggests directions for future research.

2. LITERATURE REVIEW

2.1 Industrial Symbiosis in context

Industrial Ecology (IE) emerged in the early 1990s due to concerns about the impact of industrial activities on the environment (Frosch and Gallopoulos, 1989). IE is a discipline that takes the ecosystem as an analogy for the design of industrial systems with an eye on reducing their impact on the environment by closing energy and resource loops (Ehrenfeld and Gertler, 1997; Erkman, 1997; Lifset and Graedel, 2015; Massard et al., 2014). The discipline of IE finds practical application in the design, implementation and evaluation of eco-industrial clusters, defined as a physical “communities of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental

and resource issues including energy, water, and materials" (Ehrenfeld, 2004; Ehrenfeld and Gertler, 1997; Massard et al., 2014). Again drawing on the ecosystem analogy, the functioning of eco-industrial clusters is labeled, already defined as the interaction of separate businesses entities that create a cooperative network to achieve competitive advantage by physical exchange of materials, energy, water, and/or by-products as well as services and infrastructures (Chertow, 2000, 2007; Ehrenfeld, 2004; Ehrenfeld and Gertler, 1997; Massard et al., 2014). From a technical standpoint, Industrial Symbiosis can take place in different ways: process oriented IS refers to a cooperative network around an industrial process; residue oriented IS refers to a cooperative network around a residual flow; place oriented IS refers to a cooperative network bound to a specific location (Boons et al., 2015). Also from an organizational standpoint IS can take place in different ways, namely anchor manufacturer, eco-cluster development, government planning and business incubator (Boons et al., 2011; Chertow, 2000; Mulrow et al., 2017; Sun et al., 2017). Anchor manufacturer means that there are one or two industries with large production volumes, resources and byproducts seeking economic, strategic and environmental benefits through resource exchange (Sun et al., 2017). These large industries provide the critical mass for IS to develop within an eco-industrial cluster (Chertow, 2000). Eco-cluster development means that IS is initiated by a governmental and/or industrial actors who make a joint strategic plan to create the network (Boons, Chertow, Park, Spekkink, and Shi, 2017). The aim is generally boosting innovation and economic development while gaining competitive advantage. Government planning means that IS is initiated by a public/governmental institution aiming to boost the economy's productivity and resilience while reducing environmental impact (Boons et al., 2017). Business incubator means that the IS is initiated by a private project implementer who is economically interested in attracting or growing industrial or commercial tenants capable of engaging in symbiosis (Mulrow et al., 2017). All of these can be defined as IS dynamics, namely the ways in which an IS is generated and structured from a technical and organizational standpoint.

The Circular Economy (CE) is a concept based on ideas that date back decades and refers to an industrial system that is restorative or regenerative by intention and design (MacArthur, 2013). The CE may be defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer, Savaget, Bocken, and Hultink, 2017; Lüdeke-freund et al., 2018). The origins of the concept may be traced back to the 1960s when publications such as Silent Spring (Carson, 1962), the Tragedy of the Commons (Hardin, 1968) and Operating Manual for Spaceship Earth (Fuller, 1969) drew attention to global environmental issues such as finite resources and toxicity (Blomsma and Brennan, 2017). However, the concept has gained momentum more recently in business, policy and academy, not the

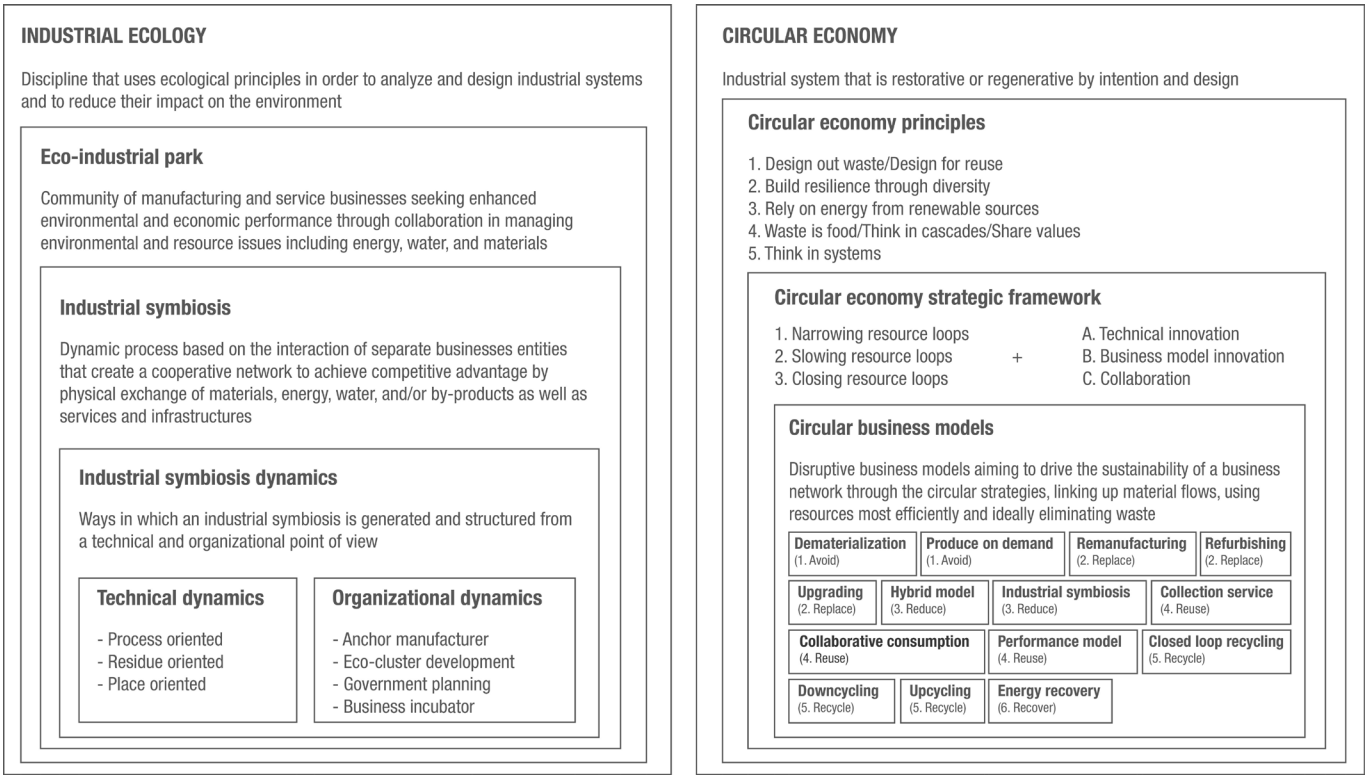

Figure 1. Locating Industrial Symbiosis in the Industrial Ecology and in the Circular Economy research streams

least catalyzed by the Ellen MacArthur Foundation who created the 'Butterfly Diagram' as a way to visualize a hierarchy of circularity strategies, which combine business and resource perspectives (Bocken et al., 2017; MacArthur, 2013). The foundations of the Circular Economy have been in place for many years and recent developments have put the concept high on the policy and business agenda. Ultimately CE is an umbrella concept based on five principles: design out waste, building resiliency through diversity, rely on renewable energy, waste is food, think in systems (Blomsma and Brennan, 2017; Lewandowski, 2016; MacArthur, 2013). Going a layer deeper, we find that the transition to a Circular Economy can be achieved through a framework based on three strategies, namely narrowing, slowing, closing resource loops and three pillars, namely technical innovation, business model innovation and collaboration (Bocken et al., 2016; Kraaijenhagen et al., 2016; McDonough and Braungart, 2002; Stahel, 1994). Narrowing loops means using less material input for production in order to have less waste output at the end of life. Slowing loops means lengthening the use phase. Closing loops can be understood as recycling.

Circular innovations always entail a technical, collaborative and business model aspects, therefore the three pillars should be taken into consideration simultaneously. Zooming in further in the business model innovation niche of CE, we find circular business models, namely business models aiming to drive the sustainability of a business network through the circular strategies. Amongst several archetypes of circular business models we find Industrial Symbiosis, framed as an archetype to create value from waste (Bocken et al., 2014; Forum for the Future, 2016).

Figure 1 locates visually the IS concept within the IE and CE research streams. It is immediately visible that while the CE stream frames IS as a specific type of business model archetype within a much larger context, the IE stream frames IS as a prominent example of how IE principles are applied, and therefore the concept has been studied significantly more in depth.

2.2 Industrial Ecology perspective on Industrial Symbiosis

From the IE perspective, IS is framed as a socio-technical process based on the cooperative interaction of separate business entities exchanging materials, energy, water, by-products, services and infrastructures to achieve competitive advantage (Boons et al., 2014, 2011; Chertow, 2007; Massard et al., 2014). The IE perspective often places a major focus on quantitatively assessing the positive environmental impacts of IS though Life Cycle Assessment (LCA) and Material Flow analysis (MFA) (Massard et al., 2014). Below (Figure 2) we visualize this definition into a descriptive framework based on three pillars of the IS process, namely starting conditions, events and outcomes (Boons et al., 2014, 2011). The first pillar, starting conditions, is about the antecedents leading to the establishment of an IS cluster in terms of organizations involved, their business profile and specific features, their previous relationships and triggers to collaborate, their initial ideas concerning the technical system and selection of a potential location for the cluster (Boons et al., 2011; Massard et al., 2014). The second pillar, events, is about the chain of technical, social and policy actions leading from starting conditions to the implementation of the IS cluster (Boons et al., 2011; Sun et al., 2017). The third pillar, outcomes, is about the economic, environmental and social impact related to the implementation and evaluation of the Industrial Symbiosis cluster (Massard et al., 2014).

Figure 2. Industrial Symbiosis framed as a socio-technical process. Based on: (Boons et al., 2017, 2014, 2011; Chertow, 2007; Massard et al., 2014; Sun et al., 2017)

2.3 Circular Economy perspective on Industrial Symbiosis

From the CE perspective, IS is framed as business model archetype based on sharing infrastructures and by-products to improve resource efficiency and creating value from waste (Bocken et al., 2014; Forum for the Future, 2016; Kraaijenhagen et al., 2016; Lombardi and Laybourn, 2012; Short et al., 2014). Short et al. (2014) investigate the potential of IS as a business model innovation for sustainability through the case of British Sugar's internal symbiosis. Below (Figure 3) we visualize this definition into a descriptive framework based on the three pillars of a circular business, namely technical innovation, collaboration and sustainable business model innovation (Kraaijenhagen et al., 2016). In the case of IS, the first pillar essentially entails a technical innovation based on the exchange of waste, resources and energy across multiple production process (Albino and Fraccascia, 2015; Bocken et al., 2014; Fraccascia et al., 2016; Short et al., 2014). The second pillar, collaboration, is about identifying the stakeholders who need to collaborate in order for the IS cluster to be implemented and operate successfully (Kraaijenhagen et al., 2016; Short et al., 2014). The third pillar, sustainable business model innovation, is about defining a specific value proposition around the elimination of the concept of waste, specific value creation / delivery activities and cross industry partnerships to eliminate life cycle waste, specific value capture mechanisms to turn waste into value and save virgin material and energy (Bocken et al., 2014; Richardson, 2008; Short et al., 2014; Teece, 2010).

2.4 Research gap and objectives

In section 2.1 we showed that IS is studied from two perspectives: IE and CE. In section 2.2 and 2.3 we reviewed how these two perspectives frame IS. The IE perspective frames IS as a socio-technical process unfolding through a set of events from starting conditions towards outcomes, with a strong focus on environmental impact assessment. The salient quality of the IE perspective is providing the study of IS with a dynamic process dimension emerging from events and collaborative interactions of multiple stakeholders; its drawback is being theoretical and complex in language, hence difficult

TECHNICAL INNOVATION	COLLABORATION	SUSTAINABLE BUSINESS MODEL INNOVATION
Exchange of waste / energy / resources across industrial processes	List of stakeholders involved in the development / operations of the IS cluster	Value proposition + value creation / delivery + value capture: elimination of the concept of waste to reduce economic and environmental costs

Figure 3. Industrial Symbiosis framed as a circular business model. Based on: (Albino and Fraccascia, 2015; Bocken et al., 2014; Fraccascia et al., 2016; Kraaijenhagen et al., 2016; Short et al., 2014)

to act upon for practitioners (Boons et al., 2017, 2014, 2011; Chertow, 2007; Massard et al., 2014).The CE perspective frames IS as a sustainable business model in which several stakeholders collaborate on a technical innovation, with a strong focus on business viability. The salient quality of the CE perspective is bringing business model thinking and language into the study of IS; its drawback is not being able to completely break free from the static and firm centric approach typically entailed with business model thinking itself (Albino and Fraccascia, 2015; Bocken et al., 2014; Fraccascia et al., 2016; Kraaijenhagen et al., 2016; Richardson, 2008; Short et al., 2014; Teece, 2010).

Recent articles about IS have recognized the existence of this twofold perspective and have started to cross-pollinate them in order to combine the qualities and address the drawbacks of the separate perspectives (Albino and Fraccascia, 2015; Bocken et al., 2017; Fraccascia et al., 2016; Lange et al., 2017; Lombardi and Laybourn, 2012; Mulrow et al., 2017; Paquin et al., 2015; Short et al., 2014; Walls and Paquin, 2015). This is essential to advance both IS research and practice. In fact, an integrated perspective would provide researchers with an improved theoretical understating of IS, which is necessary to support practitioners aiming to design new IS clusters more effectively (Albino and Fraccascia, 2015; Fraccascia et al., 2016; Lange et al., 2017; Lombardi and Laybourn, 2012; Mulrow et al., 2017; Paquin et al., 2015; Short et al., 2014). Additional rationale in favor of an integrated perspective is that IE researchers have been studying IS more extensively and for a longer time, therefore CE researchers should look into their work in order to gain insights on the technical side and environmental assessment aspects of IS (Bocken et al., 2017; Lüdeke-freund et al., 2018).

However, even though the existence of these two perspectives is recognized and the relevance of an integration is acknowledged by IS researchers, their relationship remains unclear and explicit attempts to develop an integrated perspective have not been made yet. Consequently, this paper addresses two sequential objectives: first, comparing the two perspectives in terms of nature, features and relevance; second, using the outcome of the comparison into an initial attempt to combine the two perspectives into a design process for new IS clusters.

3. METHODOLOGY

In order to assess to what extent the combination of an IE and CE perspective can lead to deeper insight in IS, we applied both perspectives as conceptual lenses in a case study (Yin, 2017). Case study research is the preferred strategy to investigate contemporary issues and related "how questions" (Yin, 2017). We apply the IE and CE perspectives as two conceptual lenses to investigate the same case. This allows us gain insight into how the two perspectives differ theoretically and empirically. In order to combine the IE and CE perspectives into a process for designing new IS clusters we conducted a strategic design co-creation workshop (Calabretta et al., 2016; Sanders and Stappers, 2012). Recently, strategic design has

influenced sustainable business model innovation research and practice: co-creation workshops have been used to support multiple industrial stakeholders to collectively synthesize the outcomes of an analysis into a tangible business model output (Baldassarre et al., 2017; Bocken et al., 2018; Calabretta et al., 2016; Geissdoerfer et al., 2016; Sanders and Stappers, 2012; Schuit et al., 2017). Thus, together with four academic experts we apply strategic design as a conceptual lens to frame the results of the comparative analysis. This allows us to condense them into a process to design IS clusters. The following parts of this section provide more information on the selected case study (section 3.1) and on the steps performed to execute the methodology (section 3.2).

3.1 Case study selection and background information

The selection of our case study is based on the following criteria. First, in order to be recognized as an IS, the IS cluster must be based on the collaboration of multiple stakeholders of different kind, exchanging waste and / or energy, materials, infrastructure (Chertow, 2007). Second, the IS cluster must have explicit environmental and social objectives next to economic ones. Third, the IS cluster must be in the operating phase since without this requirement it would not be possible to investigate how the IS cluster was developed and what was the impact of its formation. Fourth, enough documentation on the IS cluster should be available in order to be able to conduct background research on it. Fourth, the IS cluster should be located in Europe in order to obtain a European perspective on IS (see limitations in section 6). The case that we select according to these criteria is an IS cluster located in the south of the Netherlands. Before starting our own investigation, we perform a background research online, on project reports and through academic publications in order to collect more information on the IS cluster (Boons et al., 2017, 2015, 2014; Makkink, 2016; Spekkink, 2015).

In the IS cluster selected as a case study, waste heat and CO2 of a large industrial company are collected and used as resource inputs for sustainable greenhouse farming in nearby areas. The IS cluster is based on the collaboration of several stakeholders including the local government (Local province / Local Municipality / Local Port Authority), the industrial company, local horticulture entrepreneurs and WarmCO2. The goal of the local government is to promote sustainable development: boosting the economy of the region by using waste as a resource, reducing the footprint of the industrial company on the local environment, creating jobs and improving quality of life in the area. The goal of the industrial company is to gain competitive advantage by better managing its waste streams of heat and CO2, improving its environmental performance and reducing its footprint. The goal of the local horticulture entrepreneurs is to receive CO2 and thermal energy as inputs for their greenhouses in a way that is financially convenient and environmentally sustainable. This convergence of intents resulted in the creation of WarmCO2 in 2009. WarmCO2 is a small spinoff company started

by the local government and the industrial company specifically to manage all the work related to the development and operations of the IS cluster. The IS cluster is currently in the operating phase. WarmCO2 owns and operates the infrastructure for collecting and distributing residual CO2 and waste heat from the industrial company into the greenhouses. During the development phase of the IS cluster also a large commercial bank and a construction company were involved. The role of the commercial bank was to provide a financial loan to WarmCO2 for building the infrastructure while the role of the construction company was to actually build it.

This IS cluster represents a simple yet paradigmatic example of how several stakeholders of different type can engage in a long term collaboration aimed at generating economic, environmental and social value at the same time. Further in the paper, the details of this collaboration are critically analyzed from a CE perspective (section 4.1) and from a IE perspective (section 4.2).

3.2 Methodology steps

Recent articles on IS have argued that an integration of IE and CE perspectives on IS is needed to support the design of IS clusters (Albino and Fraccascia, 2015; Bocken et al., 2017; Fraccascia et al., 2016; Karpen, Gemser, and Calabretta, 2017; Short et al., 2014) This gap in IS research is substantiated through a literature review of IS within the CE and IE literature streams. The literature review identifies key elements from both perspectives and crystallizes them visually into two separate descriptive frameworks (Corbin and Strauss, 2008). Such frameworks represent two different conceptual lenses for the study of IS (figure 2 and 3). This is the starting point of a research process in which two objectives aiming to contribute in filling the gap are posed and addressed sequentially through three research steps. The first two steps are functional to address the first research objective, namely making a comparative analysis of the IE and CE perspectives on IS in order to advance towards an integrated perspective. The third step builds on the previous ones to address the second research objective, namely combining the CE and IE perspectives into an initial attempt of defining a process for designing IS clusters. Within each step several qualitative research methods for data collection and analysis are used. An overview of the research process is provided in figure 4.

The first step is to use a case study of an IS cluster to enrich the two theory-driven conceptual lenses with empirical data. This step begins with case study selection and background research on it (see section 3.3). After identifying an IS cluster suitable for our research purpose, we interview its operating and financial managers. The two managers are interviewed separately for three times in total with a conversation approach (Patton, 2002). Two of the interviews take place face to face; one of them takes place over Skype. All interviews are digitally recorded. During the interviews, respondents are asked to provide a comprehensive overview of the IS cluster twice: first using the IE framework as a guideline to describe it as a socio-technical process and then using the CE

framework as a guideline to describe it as business model. While one researcher leads the interview, a second one takes notes directly on the frameworks using them as guiding templates for structuring the collected data. Throughout the interviews, next to collecting data the interviewers collaborate with the respondents in the analysis of such data. The templates with raw data noted upon them are progressively adjusted and improved by adding new key elements according to the practice-based inputs provided from the interviewees. This approach is in line with qualitative research procedures for visually analyzing data and conceptualizing findings (Corbin and Strauss, 2008; Miles, Huberman, and Saldaña, 2013). In parallel, the researchers use the recordings of the interviews to support additional literature searches aiming to partially corroborate new framework elements from a theoretical standpoint. This results in two improved descriptive frameworks for the IE and CE perspectives on IS, based on literature as well as on empirical data (figure 5 and 6).

The second step is comparing the IE and CE conceptual lenses on IS. In this step, the two lead researchers set up three brainstorming sessions with five academic experts within the CE and IE fields. The brainstorming sessions focus on visually analyzing the frameworks produced in the previous step by looking at their differences in of nature, features and relevance (Corbin and Strauss, 2008; Miles et al., 2013). After the brainstorming sessions, the two researchers condense the outcomes of the analysis in table 1 and distill guiding principles to design IS clusters (Corbin and Strauss, 2008; Miles et al., 2013). Table 1, related reflections and guiding principles represent out outcome for the first research objective.

The third step aims at addressing the second objective of the article, namely combining the two lenses into a process for designing new IS clusters. For this purpose, two academic experts in the strategic design domain are involved in a research workshop together with one academic expert on CE and one academic expert on IE, in order to combine the two frameworks. Strategic design refers to the use of design principles and practices for the co-creation of business strategies and processes (Calabretta et al., 2016). Thus, strategic design principles, can guide the development of a process for designing new IS clusters. Previous IE literature has already called upon a design lens in order to derive prescriptive knowledge for the development of IS (Lange et al., 2017). Additionally and more broadly, previous research has provided evidence for the effectiveness of design practices to improve sustainable innovation (Baldassarre et al., 2017; Manzini, 1999; Manzini and Vezzoli, 2003; Schuit et al., 2017). During this workshop, the IE and CE frameworks, the table with the comparative analysis and guiding principles are posted on the wall to trigger a discussion: the different expert views are combined through a strategic design lens into rough sketches of the process to design IS clusters. Consequently, the sketches are refined into a final version by the lead researchers (Corbin and Strauss, 2008; Miles et al., 2013). The Industrial Symbiosis Design Process represents an initial attempt to address the second research objective.

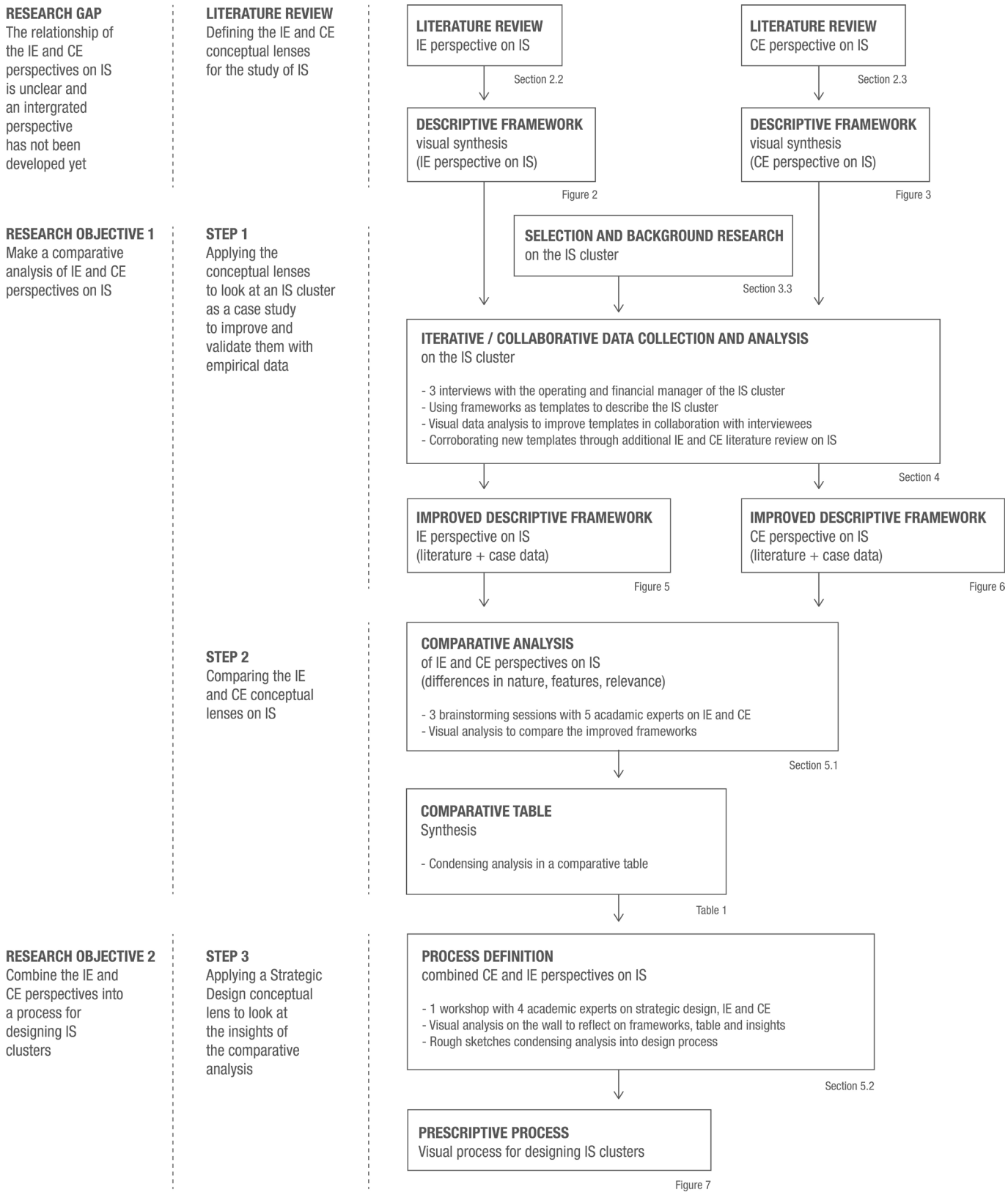

Figure 4. Research process to compare the CE and IE perspectives on IS and combining them into a process for designing IS clusters

4. FINDINGS

This section reports the findings that emerged from the analysis of the case study on the IS cluster performed from the IE and CE perspective.

An overarching finding is that both frameworks were very useful for interviewees describing the IS cluster. We found that while the IE framework is more suitable to explain its development over time and impacts, the CE framework is more suitable to explain how the IS cluster functions from a business standpoint in the operating phase. This finding, grounded into a concrete case, supports the necessity to combine the IE and CE perspectives in order to get a full and clear picture of how to set up and manage IS.

The rest of this section is divided in two parts, each explaining how findings related to the IE or CE perspective on IS are condensed into key elements to be added to the related framework. An improved framework filled in with the data from the case is presented at the end of each part, explaining its implications and applicability.

4.1 Improved Industrial Ecology framework for Industrial Symbiosis

The framework about the IE perspective on IS based on literature (developed in this research) is grounded on three pillars: starting conditions, events and outcomes. During the iterative process of collecting and analyzing data in collaboration with the interviewees, we uncovered the following findings.

First, the case study suggests that starting conditions of IS could be framed through five key questions: who is the initiator of IS, why did he initiate the IS, how did the IS process start, where is the IS located, what type of technical system underlies the IS. In our case study the initiator of IS is the local government, represented by a coalition between the Local Province and Local Municipality commission execution to the Local Port Authority. Initially, their objective was to create space for new greenhouses, an endeavor pushed top down through government planning. However eventually, thanks to synergies stemming from geographical proximity and bottom up convergence of intents, this objective evolved into the creation of an innovative IS cluster that would contribute to the sustainable development of the region by creating new jobs through farming and by reducing emissions into the air and local waterways from the chemical company's side. Concerning lS location and its scale, those were fixed constraints determined by the chemical company's location and by the place for the greenhouses selected by the local government. Concerning the type of technical system, centered on a waste recovery process, pipes would have to be built in order to channel CO2 emissions and residual heat from the chemical company as inputs into the greenhouses. The nature of the system was determined by the type of waste emissions available, which were aligned with the inputs needed by greenhouses. According to the interviewees, it is essential to get a clear picture of what starting conditions of IS are and this can be achieved by categorizing factors

leading to it. Such finding is corroborated by literature talking about different Industrial Symbiosis dynamics, contingencies leading to the emergence of an IS cluster (Boons et al., 2017, 2015, 2011; Mulrow et al., 2017). However, the interviewees pointed put that such categorization and related naming is rather complex and therefore we opted for a simpler alternative based on the five key who, why, how, where, what questions. Consequently, we improve the framework by making this explicit, adding to the starting conditions pillar five key elements related to the five key questions. By answering to those, the framework provides a clear yet simple picture of the starting conditions of IS.

Second, events related to IS are based on a chain of different types of actions taking place in different phases. In our case study we see first a preparation phase followed by a development and operation phases through which chains of institutional, financial, technical, commercial and social actions occur. On the institutional level we see, in the preparation phase, the action of establishing a partnership between the local government and the chemical company giving birth to a venture called WarmCO2. The financial chain of actions begins in preparation with the local government providing a guarantee of 65M € needed to implement the project. In development, WarmCO2 takes the loan from the bank and starts paying for infrastructure development, while in operation WarmCO2 gradually pays back the loan by buying waste streams from the chemical company and reselling them to farmers in the form of a 15 years contract. The technical chain of actions begins with a feasibility study in the preparation phase followed by the construction company building the infrastructure in development and by WarmCO2 taking care of continuous process optimization in operation. At this stage the chemical company also works on system maintenance and the construction company abandons the endeavor. Commercial actions start only in the operation phase, which sees WarmCO2 continuously comparing the price of its offering with energy market prices in order to support the IS cluster business case. The chain of social actions is about stakeholder engagement and conflict management and takes place all through preparation, development and operation. According to the interviewees is important to distinguish between different types of actions and phases to fully understand the process of how an IS cluster comes to being. Such finding is corroborated by literature. Concerning the nature of actions, literature mentions social, institutional and technical / physical actions (Boons et al., 2011; Sun et al., 2017). Concerning process phases, literature mentions all phases of preparation, development and operations reported from interviewees, although with slightly different terms (Massard et al., 2014). Consequently, we improve the framework by making this explicit, adding several key elements to the event pillar: the three phases, namely preparation, development, operation and the five action categories, namely technical, institutional, financial, commercial and social actions. In the framework each IS related action can be associated to a phase and to a category.

Third, outcomes of IS include environmental, social and economic impacts taking place in parallel on

a micro firm / local level and on a macro national / global level. In our case study, environmental impact on the micro level is related to a reduction in CO2 and heat emissions from the chemical company's side into the air and local waterways: these emissions are channeled into pipes and used as input for greenhouse farming. On the macro level, environmental impact is related to avoided greenhouse emissions and avoided use of natural gas as thermal energy source to heat the greenhouses. Social impact is related to job creation through the IS cluster, which is a positive gain on the local as well as national scale. In addition, reduced emissions also bring a positive impact on the wellbeing of local population. Economic impact on the micro scale is mostly represented by gains for the chemical company: small profits in the short term, derived by selling the waste streams to WarmCO2; competitive advantage in the long run, derived by the acquisition of know how into waste management in view of more stringent future policies. On the macro scale, economic impact is related to sustainable economic development of the Netherlands and Europe through the implementation of an innovative IS cluster. According to the interviewees, impact should be defined and quantified not only in terms of categories but also in terms of scale. This is relevant to have a more clear and precise picture of the impact that could eventually be used strategically to inform future developments. Such finding is corroborated by literature on CE impact assessment, reporting on the importance to have impact indicators on different scales of magnitude (McDowall et al., 2017). Consequently, we improve the framework by making this explicit, adding new key elements to the outcomes pillar impact: impact categories, namely environmental, social, economic, and impact scale, namely micro and macro. In the framework each outcome can be reported in terms of category and scale.

Fourth, IS as socio-technical process is not linear but iterative in nature. Starting conditions determine events, which determine outcomes, which in turn impact the starting conditions, meaning that new collaboration may arise in the same context and / or amongst the same actors. Moreover, events are iterative in nature themselves, meaning that preparatory activities determine development activities, which determine operational activities, which in turn determine a new cycle of activities. In our case study, project outcomes provide important lessons learned for all stakeholders and increased collaborative capacity, which laid the foundation for the implementation of future projects. For example, the operating manager of WarmCO2 was recently hired by the industrial company to work on IS related tasks in another country. Concerning the iterative nature of events, WarmCO2 continuously takes care of optimizing the IS process, which requires new preparation and development activities over time. According to the interviewees, it is essential to stress the iterative nature of the IS cluster development and implementation process in order to make sure that all stakeholders involved have realistic expectations and embrace the endeavor with a "trial and error" mindset towards success. Consequently, we improve the framework by making this explicit, adding two loops in the top part showing the iterative nature of

the whole process and events.

The final framework of the IE perspective on IS is visualized in Figure 5. The framework is based on literature and on case study data, which complement and corroborate each other providing a comprehensive view on how IS is framed from a IE perspective. This comprehensive view provided by the framework can be applied by IS research and practice. IS researchers can apply it to better investigate and discuss all the elements entailed with the process of developing an IS clusters over time. IS practitioners can apply it as well to map all the details related to the development of an IS cluster. The interviewees explicitly stated that "this frameworks is a very helpful tool to map how the IS cluster was developed over time and to explain

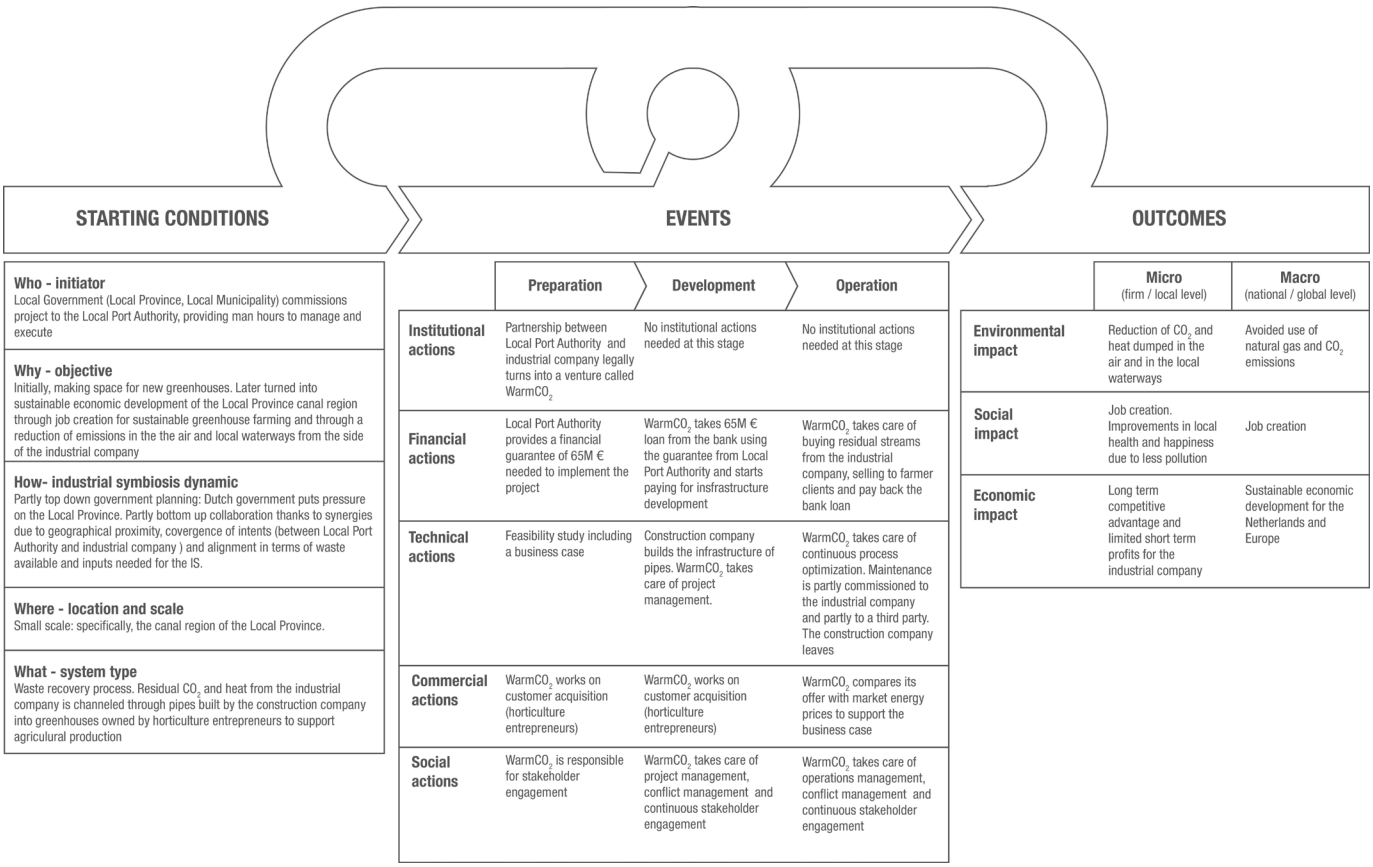

Figure 5. Socio-technical process to develop the Industrial Symbiosis cluster. Based on case study data and adapted from: (Boons et al., 2017, 2015, 2014, 2011; Chertow, 2007; Massard et al., 2014; McDowall et al., 2017; Mulrow et al., 2017; Sun et al., 2017)

its impacts to the other stakeholders and third parties". This aspect is particularly relevant to understand how IS clusters can be created and what impact they bring.

4.2 Improved Circular Economy framework for Industrial Symbiosis

The original framework about the CE perspective on IS based on literature (developed in this research) is grounded on three pillars: technical innovation, collaboration and business model innovation. During the iterative process of collecting and analyzing data in collaboration with the interviewees, we uncovered the following findings.

First, IS technical innovation entails a specific system type. In our case study, such system is centered on waste exchange: residual heat and CO2 from the chemical company is channeled into nearby greenhouses to support sustainable tomato farming. According to both interviewees, a system type description is crucial to understand how the cluster functions. Such finding is corroborated by IE literature describing different system types (Albino and Fraccascia, 2015; Boons et al., 2015; Fraccascia et al., 2016). Consequently, we improve the framework by making this explicit, adding a new key element to the technical innovation pillar: a "system type label", where the technical system based on waste exchange may be described.

Second, IS collaboration encompasses different stakeholders in terms of type, size and role. In our case study there are six stakeholders. The Local Province / Local Municipality / Local Port Authority collaborate as one stakeholder representing the local government at the large, medium and small scale. Their role was to provide the initial IS idea along with a guarantee on the initial investment needed to implement it. The chemical company is a large private enterprise producing chemicals including fertilizers. The company is based in the Local Municipality and its role is providing waste as input within the IS cluster. WarmCO2 is a small enterprise started in order to have an entity that could embody the partnership between the local government and the chemical company. The role of WarmCO2 is taking care of the implementation, coordination and technical maintenance of the IS cluster during the operating phase. The commercial bank is a large private company that provided the financial resources needed to start the IS cluster. The construction company is a medium size enterprise that built the piping system to channel the chemical company's waste streams into the greenhouses. Local famers as a stakeholder consist in a multitude of small private enterprises, which use the chemical company's waste streams as key resource input for their business. According to the interviewees, stakeholder type, size and role play a crucial role in the implementation and operations of an IS cluster because they are often the root of converging or diverging priorities, objectives and expectations. Therefore, it is essential taking into account these stakeholder features when developing an IS cluster. Consequently, we improve the framework by making this explicit, adding a new key element to the collaboration pillar: a "stakeholder label", which allows to go beyond simply listing

stakeholders towards mapping their collaboration by defining type, size and role for each one of them.

Third, sustainable business model innovation for IS entails various value proposition, creation / delivery and capture mechanisms that take place in parallel at the level of each stakeholder. In our case, the Local Province / Local Municipality / Local Port Authority aims to promote economic development and job creation in the region through the sustainable farming of tomatoes, which is a key aspect of the IS cluster value proposition. In terms of value creation and delivery they contribute by providing the land on which the cluster is built and a guarantee for the bank loan. On the value capture side they make a financial investment in the form of working man-hours and, being public sector, do not expect to have any revenue from it. The chemical company produces chemicals and fertilizer, which is a key aspect of the IS cluster value proposition. In terms of value creation and delivery, it provides the residual heat and CO2 as waste inputs for the system and takes care of technical maintenance. In terms of value capture, it has costs on the personnel working on maintenance, small revenues by selling the waste streams to WarmCO2 and long term competitive advantage by exploring alternative possibilities for waste disposal in view of more stringent future policies. WarmCO2 embodies the IS cluster by providing a legal and commercial entity for collaborating partners, an essential aspect for the very existence of the IS cluster value proposition. On the value creation and delivery side, WarmCO2 takes care of managing development, operations and stakeholder engagement. In terms of value capture, it has costs for the salaries of three employees and revenues by reselling the waste streams from the chemical company to the farmers. These revenues are entirely used for covering the salaries and paying back the bank loan needed as initial investment. Up to date, WarmCO2 does not make profit. Farmers contribute to the overall value proposition of the IS cluster by growing tomatoes more sustainably and selling them to people. In terms of value creation and delivery, they build the greenhouses themselves, which are necessary system infrastructure. In terms of value capture, their costs lay in the investment for building the greenhouses, buying waste as input from WarmCO2, paying a fee for land use to the Province and their revenues are associated to selling their products. The bank and the construction company are not involved during operations but only during the development of the IS cluster. Therefore, they do not contribute to its value proposition but only to value creation in the initial stages by providing respectively the financial loan to build the system and the actual piping infrastructure. In terms of value capture their costs and revenues lay respectively in the giving the loan and getting back the interest for the first, and in paying the salaries of workers to build the infrastructure and getting a commission fee for that by WarmCO2. According to the interviewees each stakeholder, given its own individual objectives and role, contributes to the overall business model of the IS cluster by bringing different components of the value proposition, creation, delivery and capture mechanisms. In other words, the overall business model emerges by combining these components in such a way

that stakeholder incentives are aligned and the performance of their current processes is not altered negatively. Furthermore, next to the other business model dimensions, it emerged that in order to fully capture how the IS cluster operates, a value missed and destroyed dimension should be incorporated. For example, a malfunctioning in the system would create serious damages to the industrial company's plant and a decrease in productivity for horticulture entrepreneurs. Such finding is corroborated by literature, which refers to value missed and destroyed next to the other dimensions (Bocken, Short, Rana, and Evans, 2013). Consequently, we improve the framework by making all of this explicit, adding to

TECHNICAL INNOVATION	COLLABORATION	SUSTAINABLE BUSINESS MODEL INNOVATION			
System type	Stakeholders	Value proposition	Value creation / delivery	Value capture	Value missed / destroyed
Waste exchange Residual CO_2 and heat from the industrial company is channeled through pipes into greenhouses to support agricultural production	**Name** Local Province / Local Municipality / Local Port Authority **Type** Local Government / commercial authority **Size** Large, small / medium **Role** Provider of initial idea and investment guarantee	Sustainable economic development and job creation in the Local Province	Ownership of the land to build the system and guarantee for the bank loan	Costs: time of people involved in the project. Revenues: land fees fom horticluture entrepreneurs. Does not make profit	Space used for greenhouses could have been used for something else
	Name Commercial bank **Type** Private enterprise **Size** Large **Role** Loan provider		Provide money to $WarmCO_2$ as a loan. Financial transaction	Costs: initial investment. Revenues: get back money from investment	Could have invested in something else
	Name Industrial company **Type** Private enterprise **Size** Large **Role** Provider of waste streams / technical maintenance	Produce chemicals and fertilizer	Supplies waste streams (CO_2 + heat) to the system. Maintenance of the technical system (heat exchanger + CO_2 pipes): employees are working on it	Costs: employees working on maintenance. Revenues: long term competitive advantage, limited short term profit by selling waste stream to $WarmCO_2$	If the system malfunctions loses money
	Name Construction company **Type** Private enterprise **Size** Medium **Role** Construction of physical infrastructure		Know how about infrastructure building. Building infrastructure of pipes	Costs: building pipes infrastructure. Revenues: commission fee	
	Name $WarmCO_2$ **Type** New venture / spinoff **Size** Small **Role** Legally needed for the three above to partner	Embody the IS cluster by providing a legal and commercial entity to collaborating partners	Project management, operations management, conflict management, stakeholder engagement	Costs: employee salaries (project coordinators), buying waste from industrial company; pay back investment to banks / Local Port Authority. Revenues: 15 year contract with farmers. Does not make profit	
	Name Horticulture entrepreneurs **Type** Many small private enterprises **Size** - **Role** End users / customers	Grow and sell sustainable vegetables to people	Build the greenhouses necessary for the system to work	Costs: investment to build the greenhouses, buy waste heat from $WarmCO_2$, buy land from the Local Port Authority. Revenues: sell vegetables	If the system malfunctions, productivity decreases

Figure 6. Business model of the Industrial Symbiosis cluster. Based on case study data and adapted from: (Albino and Fraccascia, 2015; Bocken et al., 2013, 2014; Boons et al., 2015; Fraccascia et al., 2016; Kraaijenhagen et al., 2016)

the business model pillar new key elements: "value proposition, value creation / delivery, value capture, value missed / destroyed labels". In the framework, each stakeholder can be associated to all the business model dimensions in order to map how it contributes to the overall IS cluster business model.

The final framework of the CE perspective on IS is visualized in Figure 6. The framework is based on literature and on case study data, which complement and corroborate each other providing a comprehensive view on how IS is framed from a CE perspective. This comprehensive view provided by the framework can be applied by IS research and practice. IS researchers can apply it to better investigate and discuss all the elements entailed with the business operations of an IS clusters. IS practitioners can apply it as well to map all the details related to the business operations of an IS cluster. The figure shows how this has been done for the IS cluster we examined as a case study. The interviewees explicitly stated that "this frameworks is a very helpful tool to map how the IS cluster functions as a business and can be used to plan and manage operations with the stakeholders involved". This aspect is very important align stakeholders before and during the operating phase by making explicit their roles, contributions and incentives within the IS business model.

5. DISCUSSION

This research aims to investigate the IE and CE perspectives on IS and to advance towards their integration for the design of IS clusters. Accordingly, this discussion section is divided in two parts. The first part critically analyzes and compares the two perspectives by looking at how they differ in terms of nature, features and relevance. The second part, uses the analysis in an initial attempt to combine the two perspectives into a process to design IS clusters.

5.1 Comparative analysis of the IE and CE perspectives on IS

The comparative analysis of the IE and CE perspectives on IS is based on the comparison of the two frameworks presented in the findings section (figure 5 and 6), which represent the result of our effort to crystallize the two perspectives using both literature and case study data. Consequently, we compare the two frameworks and related perspectives in terms of their nature, features and relevance. Our comparative analysis is summarized in Table 1.

In terms of nature, our comparison takes into consideration the differences of the IE and CE perspectives in the following aspects: definition of Industrial Symbiosis, focus and language. According to literature, the IE and CE perspectives define IS differently: the first defines it as a socio-technical process (Boons et al., 2011; Chertow, 2007; Massard et al., 2014) while the second defines it as a sustainable business model (Bocken et al., 2014; Forum for the Future, 2016; Short et al., 2014). Building upon the literature, our case study and improved frameworks (figure 5 and 6) show that these different definitions have repercussions on the focus that each perspective brings. The CE perspective

Table 1. Comparative analysis of the CE and IE perspectives on IS

		Industrial Symbiosis	
		Industrial Ecology perspective	**Circular Economy perspective**
Nature	**Definition**	Socio-technical process	Sustainable business model
	Focus	Process understanding and environmental impact assessment	Business viability and operations
	Language	Scientific language of technical and social sciences	Operative business language
Features	**Pillars**	Starting conditions > events > outcomes	Technical innovation + collaboration + business model innovation
	Key elements	Initiator (who), Objective (why), Industrial symbiosis dynamic (how), Location and scale (where), System type (what), Event phases (preparation, development, operation), Action categories (institutional, financial, technical, commercial, social), Impact scale (micro, macro), Impact categories (environmental, social, economic)	System type, Stakeholders (name, type, size, role), Value proposition, Value creation / delivery, Value capture, Value missed / destroyed
	Time dimension	Dynamic and iterative process of the *IS* cluster developed over time	Still snapshot of a moment in time during the operating phase of an *IS* cluster
	Point of view	*IS* collaborative project as unit of analysis and design (cross-organizational)	Based on separate stakeholder roles (firm-centric)
	Overall complexity	High	Low
Relevance	**Function**	Understand the starting conditions, development dynamics and impact of the *IS* cluster	Understand how an *IS* cluster operates in terms of value proposition, creation / delivery, capture, missed / destroyed
	Use	Describe the development process and impact of an *IS* cluster over time	Prescribe how to define and manage the business operations of an *IS* cluster

focuses on the business the operations underlying an IS cluster. (Albino and Fraccascia, 2015; Short et al., 2014). This business focus is very important to "align stakeholders, ensure financial viability and survival of the IS cluster" (IS cluster manager interviewee). The IE perspective focuses on understanding the process and the impact related to the creation of an IS cluster (Boons et al., 2011; Massard et al., 2014). This focus on process and assessment is very important to "understand the context around the IS cluster and its stakeholders and to keep track of the environmental and social impacts" next to the economic side (IS cluster manager interviewee). Furthermore, the different focuses are also reflected in different languages used to talk about IS. The CE perspective uses the language of business innovation practitioners and researchers (Bocken et al., 2014). "When operating an IS cluster, using a business language that

is direct and simple is essential to plan, communicate and execute effectively" (IS cluster manager interviewee). On the other hand, the IE perspective uses a more scientific and technical language at the boundary across engineering and social sciences (Chertow, 2000; Massard et al., 2014).

In terms of features, our comparison takes into consideration the following aspects: pillars, key elements, time dimension, point of view and overall complexity. According to literature, both perspectives are based on three main pillars: starting conditions events and outcomes for the IE perspective (Boons et al., 2014); technical innovation, collaboration, business model innovation for the CE perspective (Kraaijenhagen et al., 2016). Building upon the literature, our case study and improved frameworks (figure 5 and 6) show that these pillars are characterized by several key elements (see table 1 for the complete list). However, we observe that the IE perspective is characterized by more key elements than the CE perspective, and therefore it can be used to analyze an IS cluster more in detail. This difference is also related to another crucial feature, which is the time dimension. The CE perspective provides a still snapshot of how ad IS cluster functions businesswise in the operating phase and as such it does not take the time dimension into consideration (Albino and Fraccascia, 2015; Bocken et al., 2014; Fraccascia et al., 2016). The IE perspective on the other hand, does take the time dimension into consideration by framing IS as an iterative process that takes place over time, as indicated by the arrows in our framework and in those found in IE literature (Boons et al., 2014, 2011; Massard et al., 2014). Acknowledging this iterative time dimension is very important because "an IS cluster is never finished: its processes are constantly improved to increase positive impact over time" (IS cluster manager interviewee). Another feature that sets the IE and CE perspectives apart is their different point of view. The CE perspective distinguishes stakeholders according to their role but, in line with traditional business modeling perspectives, it is still anchored to a firm-centric point of view and therefore it does not easily support the definition of a collective point of view (Albino and Fraccascia, 2015; Bocken et al., 2014; Fraccascia et al., 2016; Osterwalder and Pigneur, 2010; Richardson, 2008; Short et al., 2014; Teece, 2010). On the other hand the IE perspective, by defining IS as a collaborative innovation process, fosters a cross-organizational point of view in which the IS cluster is joint project, unit of analysis and design (Boons et al., 2014; Massard et al., 2014; Mulrow et al., 2017). "Adopting a collective point of view is the most difficult yet important thing to do: developments should be constantly discussed and agreed with all stakeholders over time for the benefit of the project otherwise the IS cluster fails" (IS cluster manager interviewee). Due to a higher number of key elements, a cross-organizational point of view and the presence of a time dimension, we note that the IE perspective, presents a higher overall complexity when compared to the CE perspective.

Finally, in terms of relevance, our comparison takes into consideration the function and use of the two perspectives. According to literature and to our case study, the two perspectives have different

functions and uses. The IE perspective is functional to understand the starting conditions, development dynamics and impact of the IS cluster (Boons et al., 2014; Massard et al., 2014; Sun et al., 2017). Therefore it can be used to retrospectively describe the development and impact of an IS cluster over time, as explained by the managers we interviewed within our case study when commenting on the final IE framework (see the last paragraph of section 4.1). The CE perspective is functional to understand how an IS cluster operates in terms of value proposition, creation / delivery, capture, missed / destroyed (Bocken et al., 2014; Short et al., 2014). Therefore, it can be used descriptively but also prescriptively for the definition and management of the business operations of an IS cluster, as explained by the managers we interviewed within our case study when commenting on the final CE framework (see the last paragraph of section 4.1).

The main insight of our comparative analysis is that the IE and CE perspectives on IS are complimentary. We argue that their differences in nature, features and relevance should be leveraged in combination to get a more thorough understanding IS clusters and to better design them accordingly. This insight is supported by former literature on IS which has already attempted cross-pollinate the two perspectives in order to combine their qualities and address their drawbacks (Bocken et al., 2017; Lange et al., 2017; Lombardi and Laybourn, 2012; Mulrow et al., 2017; Paquin et al., 2015; Short et al., 2014; Walls and Paquin, 2015). Our empirical case study confirms the relevance of this insight. For example, by using both perspectives it is possible to get a full picture about the role and aims of the local government with in the IS cluster development and operations. The IE perspective tells us that that the original intent of the local government was not creating an IS cluster but rather using a piece of land for greenhouse farming to support job creation and eventually that job creation was used as a measure to determine project success; the CE perspective tells us that the local government owns the land on which the IS cluster is built. This type of complimentary information is needed in order to better understand existing IS clusters and to design new ones accordingly. This insight clarifies the relationship between the two perspectives, addressing a knowledge gap in current IS research and reinforcing the argument that future research should move beyond the current state of cross-pollination and attempt an explicit integration.

5.2 Industrial Symbiosis Design Process

We use the comparative analysis as a starting point to explicitly combine the two complementary perspectives. The integration of the perspectives is an initial attempt and it is done through a strategic design lens.

Strategic design is a stream of research and applied discipline based on using design principles and practices for the formulation and implementation of innovation strategies for organizations, including industrial networks (Calabretta et al., 2016). A typical strategic design project entails supporting companies in formulating an innovation vision and in identifying

business opportunities consistent with the vision. Strategic design has recently been leveraged in sustainable business model innovation research and practice in order to support collaborative innovation process across multiple stakeholders (Baldassarre et al., 2017; Geissdoerfer et al., 2016). Thus, strategic design is suitable to address the challenge of setting up and growing an IS cluster. The core principles of strategic design include an iterative and collaborative approach for the generation of new ideas, through a set of specific design practices, methods and tools such as creative sessions and (early) prototyping of concepts (Brown, 2008; Calabretta et al., 2016; Dorst, 2010). Consequently, strategic design offers a good lens to address the IS Design Process as collaborative innovation project. Finally, strategic design integrates design principles with a business mindset, combining long-term strategic directions with short-term tactical decision and implementation actions in order to hit both long term and short term performance goals (Calabretta et al., 2016; Grant, 2016; Hultink, 1997). Ultimately, strategic design is about defining the strategic vision for an innovation, designing a concept and the business around it and finally assessing results before moving into a new iteration (Baldassarre et al., 2017; Calabretta et al., 2016). Applying this strategic design lens allows us combining notions from the IE perspective (the iterative dimension and focus on impact assessment) with notions from the CE perspective (the simplicity, business model focus and prescriptive thinking) into a process for designing IS clusters.

The Industrial Symbiosis Design Process (figure 7) is the result of our attempt to integrate the IE and CE perspectives on IS through a strategic design lens. Leveraging on the IE perspective, the process takes the "collaborative innovation project" as unit of design (Massard et al., 2014; Mulrow et al., 2017). In line with the IE perspective, the context box indicates that the process does not take place in the vacuum place within a specific historical, geographical, political, and organizational setting while the time arrow at the bottom indicates that each iteration should take place in a definite timeframe (Boons et al., 2014, 2011; Massard et al., 2014). Again, building onto the IE perspective, each iterative cycle takes places in three steps (Boons et al., 2014). However, leveraging the CE perspective, these steps are framed prescriptively and using a simple business language (Fraccascia et al., 2016; Kraaijenhagen et al., 2016). Through the strategic design lens, the three steps of the process are defined as strategy definition, business design and impact assessment (Calabretta et al., 2016). In order to support practice, we specify objectives, methods and tools and type of decisions for each step. The first step is defining the strategic vision. The objective of this step is developing a joint shared vision and related strategic goals for the IS innovation project (Calabretta et al., 2016). The definition of the vision and of the strategic objectives can be supported by design methods and tools, namely stakeholder analysis, system mapping and vision creation (Calabretta et al., 2016; Stickdorn et al., 2011). The second step is business design. Borrowing from the CE perspective, the objective of this step is developing a business model for the IS cluster (Fraccascia et al., 2016; Kraaijenhagen et

al., 2016; Short et al., 2014). Business design can be supported by the value mapping tool and sustainable business model canvas (Bocken et al., 2018, 2013). As stressed by the strategic design lens, this step is iterative in nature; short-medium term tactical decisions to involve stakeholders and reach consensus on the business model are repeatedly taken here (Calabretta et al., 2016; Hultink, 1997). The third step is impact assessment. In line with the IE perspective, the objective of this step is assessing the sustainability impact of the IS cluster (Boons et al., 2014; Massard et al., 2014). In line with strategic design, this is done according to the criteria developed in step 1 (Calabretta et al., 2016). Again borrowing from the IE perspective and triple bottom line thinking, such criteria need to relate to environmental, social and economic impact (Elkington, 1998; Hall, 2011; Massard et al., 2014). According to the IE perspective, impact assessment of IS can be supported by life cycle assessment tools: traditional Life Cycle Assessment (LCA) for environmental impact, Social Life Cycle Assessment (S-LCA) for social impact and Life Cycle Cost (LCC) for economic impact (Dreyer et al., 2006; Massard et al., 2014; Norris, 2001; Sala et al., 2015).

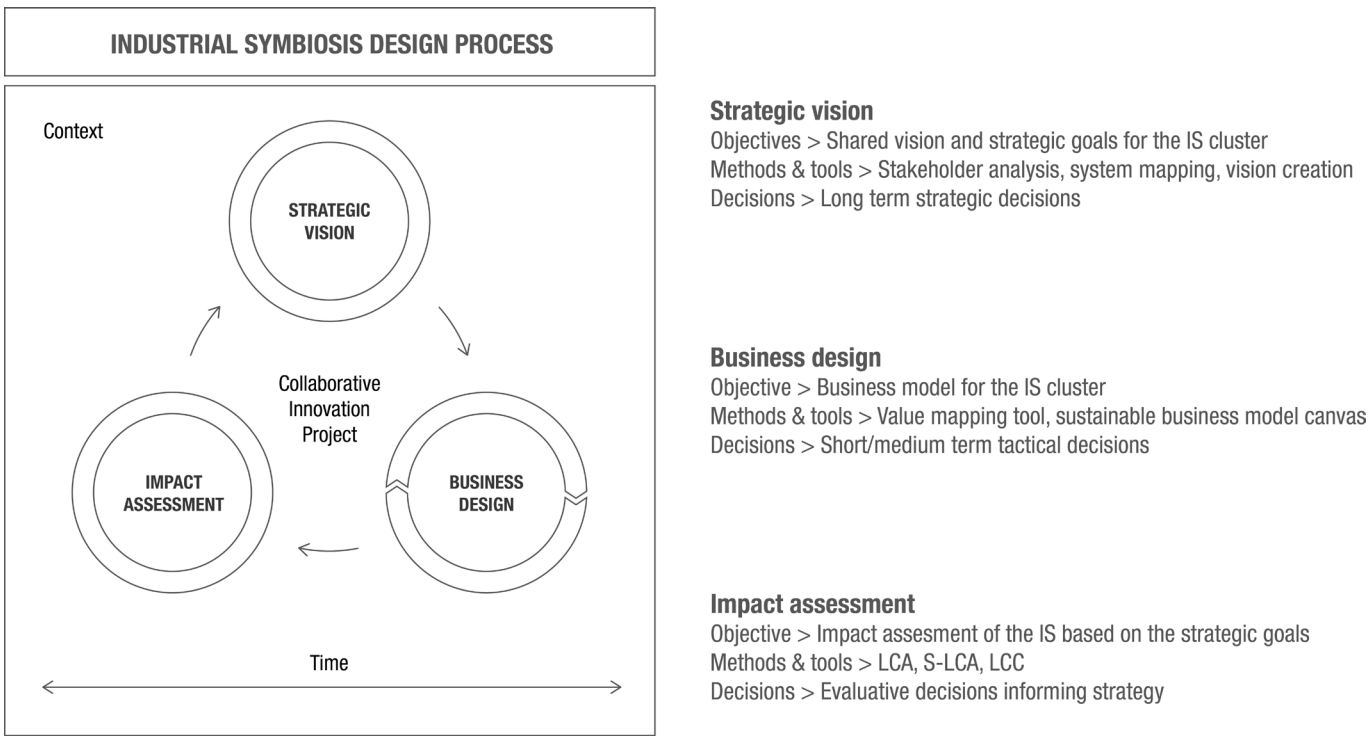

Figure 7. A process for designing IS clusters. Based and adapted from: (Bocken et al., 2018; Boons et al., 2014; Calabretta et al., 2016; Massard et al., 2014)

A final mention on this process concerns the starting point of the process, which may not necessarily be the definition of a strategic vision. As the IE body of literature mentions, IS projects are often the result of previous collaborations of stakeholders in relation to different and disparate objectives, therefore an IS collaborative project may as well begin by assessing existing realities or by introducing incremental improvements into existing business models (Boons et al., 2014, 2011; Spekkink and Boons, 2016).

6. CONCLUSION

This paper addressed the question of how the IE and CE perspectives on IS can be combined in order to support the design of IS clusters. In order to answer this question we first made a comparative analysis of the two perspectives by looking more in depth at how they differ in terms of nature, features and relevance for the study of IS, based on literature study and a case study. Secondly, we used the comparative analysis in an initial attempt to combine the two perspectives into a process for designing new IS clusters.

6.1 Contributions

This paper contributes to IS research and practice. The contributions to IS research are four. First, clearly positioning IS as a research subject within and across the IE and CE research streams (table 1). Second, crystallizing the IE and CE perspectives on IS into two frameworks based on literature and case study data (figure 5 and 6). Third, making a structured comparison of the IE and CE perspectives on IS, explaining how they differ in terms of nature, features and relevance, ultimately showing that they are complimentary (table 1). Fourth, making an initial attempt to combine the two perspectives in an integrated process (figure 7). These contributions are relevant to IS research because they build on previous attempts to cross-pollinate IE and CE work on the subject, reinforcing the arguments calling for an integrated perspective and advancing the theoretical understanding of the phenomenon of IS (Albino and Fraccascia, 2015; Bocken et al., 2017; Fraccascia et al., 2016; Lange et al., 2017; Lombardi and Laybourn, 2012; Mulrow et al., 2017; Paquin et al., 2015; Short et al., 2014; Walls and Paquin, 2015). In doing so, these contributions also touch upon a broader issue that has been recently mentioned explicitly: the need of creating a bridge between IE and CE, allowing researchers in both streams to learn from each other (Bocken et al., 2017).

The contributions to IS practice are three. First, the IE framework that we defined based on literature and on case study data, can be used by practitioners to map the development of IS clusters over time and to describe their impacts (figure 5). Second, the CE framework that we defined based on literature and on case study data, can be used by practitioners map how an IS clusters functions businesswise and to manage operations accordingly (Figure 6). The third and main contribution to practice is the process to design new IS clusters (figure 7). This process combines the most relevant qualities of the IE and CE

perspectives and frames them with an explicit design orientation derived from the discipline of strategic design (Calabretta et al., 2016). The goal is not only to provide practitioners with a more comprehensive understanding of the challenges and aspects that have to be considered when setting up a new IS cluster (e.g. iterative developments, stakeholder collaboration, business incentives, etc.), but also to provide them with knowledge that is actionable. To this end, for each step of the process, it is clearly stated what is the purpose and which methods and tools can be used by practitioners to move forward.

6.2 Limitations and future research

The first limitation of this research is that our findings and contributions are based on a combination of IE and CE literature with empirical data from a single case, a small IS cluster located in the Netherlands. Therefore, we acknowledge that our findings and contributions may provide an incomplete view, influenced by the characteristics and context (e.g. geographical, historical, political, etc.) of the case at hand. As such, they may only be representative for small European clusters, which are mostly based on bottom up collaborative approaches in contrast with structured top down approaches driven entirely by government planning, as for instance in the Chinese context (Bocken et al., 2017; Ghisellini et al., 2016; Massard et al., 2014; McDowall et al., 2017; Sun et al., 2017). We suggest that future research on IS should apply the IE and CE perspectives in combination as we did in this study, but instead of focusing on a single case, it should extend the range of the analysis by looking at a wider sample of IS clusters of different sizes and in different contexts. We believe that this analysis would contribute to a better and more holistic understanding of IS as a phenomenon, which is essential to improve future IS practice, which ultimately plays a role in the transformation of industry in the transition towards sustainable development (Chertow, 2000, 2007).

The second limitation of this research is that the Industrial Symbiosis Design Process that we propose is, for the time being, only a concept. This means that it has not yet been validated in practice. This opens up a broader discussion that we consider particularly critical and relevant. According to a strand of IS research rooted in the IE field, to this day many IS clusters (especially in Europe) have "emerged" rather than being "intentionally designed" (Chertow, 2007; Ehrenfeld and Gertler, 1997; Spekkink, 2015; Spekkink and Boons, 2016). This raises a question on to what extent IS can, at all, be designed, which is what some of the research with a CE business model focus seem to suggest (Bocken et al., 2014; Fraccascia et al., 2016). In fact, the idea of "intentionally designing" an IS cluster presumes that somebody has to play the role of designer, something that in a context that requires the collaboration of multiple stakeholders (who in most cases have different incentives and motivations) can be quite challenging. The Industrial Symbiosis Design Process that we propose only scratches the surface of this issue by suggesting that the unit of design of new IS clusters should be a "collaborative innovation project" based on the iteration of three steps over time. However, it does not elaborate further on who should play the

designer's role and how, and if there can be multiple designers involved over time. We suggest that future research on IS should draw both on CE and IE literature and focus with more specificity on the issue of how IS clusters can be designed. A possible way to start doing this, can be leveraging on our work by interviewing IS practitioners about the process we proposed and by trying to apply such process on a real case aimed at designing a new IS cluster.

ACKNOWLEDGEMENTS

We would like to thank Jenny Crone and Marlon Pijpelink for their support with the investigation and analysis of the WarmCO2 case and Prof. Erik-Jan Hultink for his support and advice throughout the research process.

This project was part funded by the International Intelligence and Business Development Network on Circular Economy Business Opportunities with China (IntCEB) project under Framework Partnership Agreement No. [FPA 2016/EIT/EIT Raw Materials], Grant Agreement No. [EIT/RAW MATERIALS/ SGA2017/].

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CHAPTER V

USING DESIGN THINKING TO COLLABORATE IN RESPONSIBLE INNOVATION

FIFTH STORY

"Welcome to Australia!" Says the immigration officer behind the counter at the passport check. I walk past him and I am officially Down Under. I had been waiting for this moment for more than 25 years, since the first time I saw the Disney Classic "Rescuers Down Under", where the intrepid mouse Bernie and his glamorous partner Bianca embark on an intercontinental journey to save a giant eagle and a human boy from the clutches of a treacherous poacher. In the process of completing their very important mission, Bianca and Bernie ride many fantastic animals including Wilbur the wandering albatross, a huge aquatic snake and a fleet of shiny lightning bugs, as they travel across one of the wildest territories on Earth, where the kangaroos roam undisturbed. At last, I am roaming freely amongst the kangaroos too. My old friend Daniela, our hippie companion Montanna from Chicago and I, pitched the tent on top of grassy hill covered with strange vegetation rising behind a broad beach washed by the waves of the Pacific Ocean. Just before the night falls and the Southern Cross appears in a dark sky bursting with the unfamiliar stars of this bottom hemisphere, the Kangaroos get closer to us, and I can finally contemplate the remarkable marsupials from behind my glasses of academic. Sitting on top of the inflatable sleeping mat, wearing my warmest pair of woolen socks, I have the chance to redefine my own understanding of empty space: the coastline of cliffs made of yellow and red terrain stretches away in both directions as far as eye can see. I know that the colored earth of this massive island is as

full as it can be of natural resources. Bauxite, for example: which is extracted from five enormous mines, processed into aluminum and shipped to China on massive container ships, where it is then turned into all the Apple iPhones hidden inside the bags and pockets of men, women, elderly and children of all the nations on the surface of the globe. Minerals are the main source of Australia's wealth, and in order to get them out of the ground British colonialists have wiped out the Aboriginal population that had already been living for more than 50,000 years on this strange island, in peace with its weird animals and rich ecosystems. Now, ecosystems, animals and people, white colonialists included, are literally living on the edge of a precipice due to climate change, which is causing increasing drought, water scarcity and devastating bushfires that sooner than later might make this place less livable than Mars. Nevertheless, thanks to the mining sector the Australian economy continues to prosper inside its ethereal bubble of rainbows and unicorns, while political leaders are ignoring current and approaching problems with a delusional stance. This irresponsible and shortsighted behavior makes a strange bundle with the friendliness of the people I meet in the streets, who are surrounded by a halo of laid-back awesomeness, groovy vibes, and a "no-problem-mate" attitude. Still, problems are knocking on the front door, and waste is one of them. So far, a large part of it has been regularly shipped to China in order to avoid dealing with it. But in 2018 the Chinese Republic, factory of the

entire world, said that this agreement is no longer going to continue as it did in the past, due to increasing concerns about the pollution of its own ecosystems and related health problems for 1.4 billion people. I read about this on the National Waste Policy Action Plan and on Recycling Victoria, two official documents drafted in 2019 by the Australian government on a federal and provincial level. In fact, the purpose of my visit to this island isn't only chilling with the Kangaroos, but also working on some research with my supervisor Ingo based at RMIT University in Melbourne. Simultaneously, the aim is achieving a better understanding on how circular economy developments are unfolding overseas, and contributing to establish related collaborations between Europe and Australia. Indeed, in Europe things are quite different, and that is not surprising since we don't have China's manufacturing capacity, nor Australia's raw materials. In order to be able to say something on the global stage, European countries have no other choice than sticking close together on a political and economic level. The Circular Economy Action Plan is a document recently drafted by the European Commission that embodies one of the most recent steps to have a common economic development strategy, an effort that had already begun back in 1951 with the foundation of the European Coal and Steel Community. In view of the current global situation, the main drivers behind this strategy are evident: first, we must leverage our shared history made of diverse cultures to innovate collaboratively, because in this way we

have more brain and manpower to compete with external forces in the long run; second, we must make sure that while we innovate we do not waste precious natural resources, because they are not only running scarce but are also located outside Europe's borders, in the hands of countries that are not necessarily our historical friends. I am currently working on a project that seems to substantiate these unpolished, maybe a bit simplistic speculations. The project is called Zero Brine, a 10 million Euro project funded by the European Commission with public tax-money coming from the pockets of its citizens. The objective of Zero Brine is testing the technical feasibility and business viability of a new solution for recovering minerals out of industrial wastewater. From the perspective of a person with no process engineering knowledge like me, this solution can be understood as a black box containing some magical equipment that is connected to the water outlet of a factory: dirty water goes in, clean water is either reused or discharged into the environment, and inside the box you are left with precious resources ready to be picked up, sold and ultimately used as inputs for the products and processes that make our European markets spin. Over 20 organizations from 10 different countries are working together to make this happen. The main demonstration is taking place in the Port of Rotterdam, and the material that is going to be recovered is magnesium. This is not a case. Magnesium is on the list of critical materials identified by the Commission. There is not much of it available within the

boarders of the Union, yet we need it for a lot of very important industrial applications. It is interesting to know that 96% of the magnesium used in Europe is imported. 86% of these imports come from China, while most of the remainder is sourced from Turkey and Russia. These are all countries that are, in a way or another, in competition with Europe, not to say in conflict. The cold war officially ended soon after 1989, the year that I was born. Its epilogue is impressed in our collective memories with images of the Berlin Wall falling down. Nevertheless, I sometimes ask myself if this war actually finished or if it has just changed its face. For sure the shape of the power blocs and their interactions have evolved quite a bit, but below the surface, the competition for global supremacy based on the ownership of land, resources and more recently data, has never stopped. The Dutch are very smart people, and like in their golden age, understand well that it is especially in the turbulent times that being good traders is a winning strategy. This could be just fantasy, but as I attend an event at the top floor of a fancy skyscraper in Melbourne Central Business District, where the Dutch premier and representatives of the Australian government are signing a memorandum of understanding about their collaboration toward a circular economy, I wonder whether this isn't also a way for the Netherlands to establish some kind of preferential trading channels with a country that is rich in raw materials. I am convinced that these types of agreements should be driven by the EU and not by individual member

states, but at the same time I am also glad that The Netherlands is being proactive and paving the way in this regard. While I am busy raiding over the trays of fruit pastries, Dai pats me on the shoulder. I can see he is enjoying the pastries too. He is a Dutch representative who is doing a great and persistent job in catalyzing this intercontinental collaboration with a genuine smile on the face and a suitcase full of positive energy. I admire his ability. Talking to him always puts me in a good mood, but it is also inspiring, as it allows me to better understand the policy side of the circular economy from the experiences of a person that is directly involved in it. Riding home on my bike I find myself reflecting on all these things. Is the circular economy a regenerative system to turn waste into a resource using renewable energy—this is what the theory suggests—or is it instead a ductile keyword that different countries adopt in a different way as they navigate macroscopic geopolitical dynamics? The more I study the issue, the more I understand that changing things for the better is extremely complicated. It isn't just business organizations that are interlocked in a competitive and unsustainable system, but also entire countries. In this crazy poker game everyone is afraid to make the first move, and finding who's responsible for what is really difficult. In the end, it is a matter of being altogether more responsible. European policy makers recently started to use this keyword as an overarching theme underlying the entire innovation agenda of the Union, which includes the transition to a circular

economy but also a lot more stuff that is supposed to improve collective well-being, like healthy food supply, for example. From a policy perspective, the main idea is that the fundamental aim of responsible innovation should be to collectively design a future that is socially desirable, environmentally sustainable and ethically acceptable. As I read about it, I have the feeling that this may be the ultimate frontier of design, miles away from material objects and beyond the world of businesses that I have so far studied, maybe a bit abstract, yet too important to be neglected.

FIFTH SCIENTIFIC PUBLICATION

"Doing design thinking" in the context of responsible innovation toward sustainable development

This article is under review with the Journal of Product Innovation Management. Not for sharing.

Authors

Brian Baldassarre, Giulia Calabretta, Ingo Karpen, Nancy Bocken and Erik Jan Hultink

Abstract

The expression design thinking refers to rational yet creative process to develop something new. In the past decade, this process gained momentum in a business context, as an approach to innovate faster, iteratively and more radically. Former innovation management research has discussed how firms may leverage design thinking through a set of specific practices. These include (re)framing business problems in novel ways, defining future visions, co-creating potential solutions with customers, and prototyping promising concepts. Currently, this innovation management view of design thinking rests upon two underlying assumptions. First, that this approach should be applied from a firm-centric perspective driven by a competitive advantage rationale. Second, that the outcomes of its application should be assessed only in terms of what people desire, what is technically feasible, and what is financially viable. In this paper, we challenge these assumptions through "problematization", a theorizing process aimed at developing more insightful contributions within management studies, rather than supporting incremental theory building. We argue that the aforementioned assumptions are problematic because they prevent the application of design thinking on a cross-organizational level. In an increasingly globalized and complex world, cross-organizational collaboration is essential for firms to remain relevant and uphold their responsibility in addressing pressing challenges such as climate change, resource depletion, poverty and injustice. Consequently, we integrate the current understandings of design thinking with insights from responsible innovation theorizing, to develop alternative assumptions and propose a new conceptual framework. Our main contribution to research is grounding design thinking practices into cross-organizational innovation, driven by a shared responsibility to achieve outcomes that are ethically acceptable and environmentally sustainable. Accordingly, the main implication for innovation managers is the need of collaborating with entrepreneurs, academic institutions and the public sector toward the resolution of the grand challenges of our times.

1. INTRODUCTION

In the past decade, design thinking gained significant momentum in a business context as an approach for firms to innovate faster, iteratively and more radically (Brown, 2008). Particularly, design changed from being a function of the organization dealing only with aesthetics and minor technical issues (Dell'Era and Verganti, 2010), becoming a strategic driver for creating meaningful innovation outcomes (Verganti, 2011) and gain competitive advantage (Martin, 2009). Nevertheless, despite the increasing interest, design thinking has also been surrounded by skepticism—especially within industry (Nussbaum, 2011), but also in academia (Rylander, 2009)—related to its "intangible" and "fuzzy" nature.

Such criticism triggered an academic debate aimed at consolidating design thinking as a relevant topic for business managers (Dunne and Martin, 2006; Kolko, 2015) and as a worthy subject of scientific inquiry (Cross, 2007; Roworth-Stokes, 2011). As part of this process, the debate on design thinking shifted its main focus from defining the ontology of this concept, toward clarifying how organizations can actually use it (Micheli et al., 2019). More specifically, an important strand of management research clarifies that "doing design thinking" essentially revolves around a set of design practices, namely the ways in which designers—and / or design managers as well as everyone in the organization who seeks to innovate (Dell'Era et al., 2017)—think and act in a professional context (Elsbach and Stigliani, 2018; Micheli et al. 2019). Performing these practices allows gaining a competitive advantage by balancing desirability (i.e., what people need and want), feasibility (i.e., what is technically achievable), and viability (i.e., what is economically possible) when developing a new product, service, experience, and more broadly a new value proposition (Brown, 2009; Brown and Martin, 2015).

Applying design thinking is indeed relevant to support firms in innovating in a meaningful way while markets are becoming "overcrowded" with new ideas (Verganti, 2017). However, this firm-centric perspective (Micheli et al., 2018) driven by competitive advantage (Martin, 2009) prevents the application of design thinking on a cross-organizational level (Wilson and Zamberlan, 2015). In fact, most businesses currently frame competitive advantage as a race against other firms to achieve superior financial performance in the short term (Porter and Kramer, 2011). In the 21st century, this issue is particularly problematic (Inns, 2010; Porter and Kramer, 2011). Cross-organizational collaboration is now an imperative for firms to remain relevant (Chesbrough, 2003; West et al., 2014). In an increasingly globalized, complex and dynamic world, cross-organizational collaboration is essential to create shared value while the purpose of the capitalist system evolves beyond mere economic growth (Porter and Kramer, 2011) toward the resolution of grand challenges such as climate change, resource depletion, poverty and injustice (Ferraro et al., 2015; George et al., 2016; Reinecke and Ansari, 2016).

The historical roots of design thinking show

that addressing such "wicked problems" was the original goal of this approach (Buchanan, 1992; Rittel and Webber, 1973). Indeed, design thinking originally emerged in the 1960s with the scope of collaboratively devising new solutions to guide human development (Simon, 1968), while addressing complex problems affecting society and the environment (Fuller, 1957, 1969; Papanek, 1971; Schön and Rein, 1994). Besides balancing desirability, feasibility and viability—as stated in current management research on design thinking—this view entails also the responsibility (i.e., what is ethically acceptable, sustainable for society and the environment) of innovating (Von Schomberg, 2011a). Innovation managers have the responsibility to innovate for the common good (Drucker, 1973). In the awareness of the environmental crisis, they must play a role in the transition toward sustainable development by promoting a more responsible innovation paradigm (George et al., 2016; Voegtlin and Scherer, 2017).

Responsible innovation is rapidly emerging as an innovation management research stream (Voegtlin and Scherer, 2017) and as an important concept in policy making (European Commission, 2013). In line with seminal design thinking ideas, the concept of responsible innovation refers to an iterative and transparent process in which multiple stakeholders collaborate on the development of solutions to address environmental and societal grand challenges (i.e., wicked problems) (Ferraro et al., 2015; Reinecke and Ansari, 2016; Von Schomberg, 2011a). Considering that today businesses are held politically accountable for the impact of their activities on society and the environment (Scherer and Palazzo, 2011; Scherer et al., 2016), managers are becoming aware of the necessity to innovate responsibly, and collaborate with other stakeholders toward the resolution of grand challenges (George et al., 2016). Consequently, management scholars are increasingly discussing the theoretical relevance and practical implications of responsible innovation for current and future innovation management research (George et al., 2015; Voegtlin and Scherer, 2017).

The aim of this conceptual paper is to strengthen the foundations of innovation management research on "doing design thinking" (Micheli et al., 2019) by connecting to responsible innovation theorizing (Stilgoe, Owen, and Macnaghten, 2013). Limitations of the theoretical status quo render it highly relevant to move beyond the current firm-centric perspective on design thinking (Elsbach and Stigliani, 2018; Micheli et al., 2018), and to focus on the collaborative side of innovation, which goes hand in hand with the issue of the responsibility of firms in addressing pressing contemporary problems (Scherer, Rasche, Palazzo, and Spicer, 2016; Voegtlin and Scherer, 2017). At the same time, we aim to reconnect current innovation management research on design thinking with the seminal ideas of early theorists around applying this approach to address wicked problems affecting society and the environment (Buchanan, 1992; Fuller, 1957; Schön and Rein, 1994). To date, innovation management research on how design thinking can be leveraged to collectively address these problems is scant (Eppinger, 2011; Esslinger, 2011)

and not identified as a priority (Micheli et al., 2019). Accordingly, we pose the following research question:

How can organizations apply design thinking in the context of responsible innovation, to collaboratively address societal and environmental challenges?

In response to that, we adopt a "problematization" approach (Alvesson and Sandberg, 2011). Through this theorizing process, we identify central assumptions underlying design thinking, which we challenge to advance its foundation. On these grounds, we develop and illustrate a framework on how multiple organizations can apply design thinking collaboratively in the context of responsible innovation, to address grand societal challenges. The framework integrates the current understandings of design thinking with insights from responsible innovation theorizing. In doing so, we advance the mainstream understanding of design thinking based on a firm-centric perspective (Elsbach and Stigliani, 2018; Micheli et al., 2018) and centered on the typically considered criteria of desirability, feasibility and viability (Brown, 2009). Our main contribution to innovation management research is explaining how the design thinking process, phases and practices can be applied on a cross-organizational level, while rediscovering the crucial importance and the need for "responsibility" as core design thinking criterion (Fuller, 1957, 1969; Papanek, 1971). The main implication for practice is that business firms—and in particular innovation managers—should work in concert with entrepreneurs, academic institutions and the public sector, in order to uphold their moral and political responsibility (Drucker, 1973; Scherer and Palazzo, 2011) to address the grand societal and environmental challenges of our times (George et al., 2016).

2. THEORIZING THROUGH PROBLEMATIZATION

The conceptual development of our framework follows "problematization" as a conceptual approach (Alvesson and Sandberg, 2011). Rather than supporting incremental theory building by addressing knowledge gaps found within a conceptual domain, problematization aims to challenge the assumptions underlying existing theories, with the aim of developing more insightful contributions within management studies (Alvesson and Sandberg, 2011). This approach is based on six steps: 1) identifying the conceptual domain and its key texts; 2) identifying key assumptions in the targeted domain; 3) evaluating the identified assumptions; 4) developing alternative assumptions; 5) relating the assumptions to their audience; 6) evaluating the new assumptions.

The first and second steps are encompassed by the literature review section. In this section, we focus on the domain of design thinking. By analyzing its origins and current developments, we make a distinction between "classic" and "innovation management" research on design thinking. The classic stream broadly concentrates on the study of design as a discipline, building onto six decades of research work about creative problem solving (Cross, 1982,

2007). The innovation management stream of design thinking literature emerged more recently with a more specific focus on how design can be leveraged by business organizations to gain competitive advantage (Brown, 2009; Martin, 2009). Within this stream, we detail the design thinking innovation process and its underlying assumptions. Specifically, the innovation management view assumes that design thinking should be applied from a firm-centric perspective (Micheli et al., 2018). Furthermore, it assumes that innovation outcomes are the result of the firm's ability to identify customers and interpret what they need (i.e., desirability), the firm's ability to leverage its own resources and stakeholder network to create such outcomes (i.e., feasibility), and the firm's ability to profit from this effort (i.e., viability) (Brown, 2009; Martin, 2009).

The framework section covers the third and fourth steps of the problematization approach. In this section, we evaluate the above-mentioned assumptions, explaining why they are problematic. Specifically, we argue that the firm-centric perspective prevents further investigation on how design thinking may enable cross-organizational collaboration, which is needed for firms to remain relevant, while addressing the grand societal and environmental challenges of our times (Voegtlin and Scherer, 2017, West et al., 2014). To address these critical limitations, we leverage seminal design thinking ideas about the responsibility of innovators in fostering sustainable development (Fuller, 1969; Papanek, 1971), and connect to current innovation management research on responsible innovation (George et al., 2016; Voegtlin and Scherer, 2017). Through a focused analysis of the alignment and complementarity between design thinking and responsible innovation we explain the rationale for combining these two innovation approaches. Consequently we develop a conceptual framework resting upon the alternative assumptions that the design thinking process should be applied with a cross-organizational perspective, and that desirability, feasibility and viability should be integrated with the criteria of responsibility to meaningfully assess the outcomes of such process.

The fifth step of the problematization approach comes to life in the section where we illustrate our framework through a real project in which the authors have been directly involved. Through our illustrative project, we relate our assumptions to their audience, which entails explaining how a cross-organizational design thinking process—aimed at creating desirable, feasible, viable and responsible outcomes—may unfold in practice. Thus, consistently with our proposed alternative assumptions, and with responsible innovation research, our illustrative project is an international collaboration across 10 different countries, involving 20 stakeholders including large businesses, entrepreneurial ventures, academic institutions and the public sector. We illustrate the framework by describing their responsible innovation efforts on a project aiming to collaboratively design a solution for the grand challenge of resource depletion. Finally, in the discussion section we extrapolate our theoretical contributions and managerial implications, which is a way to evaluate our own assumption against existing

theory and practical matters. This represents the sixth and conclusive step of the problematization approach.

3. REVIEW OF DESIGN THINKING LITERATURE

The roots of design thinking date back to the ideas of Buckminster Fuller in the late 1950s. He stated that a "Comprehensive Anticipatory Design Science" (Fuller, 1957) was needed to define an "operating manual for spaceship Earth" (Fuller, 1969) addressing the environmental crisis, while optimizing the use of resources and ensuring their fair distribution (Carson, 1962; Fuller, 1969 Hardin, 1968). With the aim of envisioning a better future, Fuller heralded the 1960s as the "design science decade" (Chamberlain et al., 2012; Cross, 2001). In 1968, Herbert Simon wrote "the sciences of the artificial", in which he argued that while "natural sciences" study "how things are", "design sciences" are concerned with "how things ought to be" (Simon, 1968). With this book, Simon was the first to conceptualize Design as a rational process to create solutions for complex problems (Simon, 1968).

In the 1970s, a new generation of design theorists criticized Simon's theories to "fit reality into a framework", arguing for a shift in focus toward the actual practice of designing (Bayazit, 2004; Cross, 2007; Huppatz, 2015). While Victor Papanek, with his book "design for the real world", stressed the responsibility of designers to put forward solutions to pressing environmental problems (Papanek, 1971), Horst Rittel and Melvin Webber raised the issue that design problems are "wicked", thus cannot be solved in the context in which they originated (Rittel and Webber, 1973). Throughout the 1980s and 1990s, Donald Schön built on these ideas. He argued that designers can deal with wicked problems by framing them from an arbitrary point of view (Schön, 1983). This enables them to prototype potential solutions (Schön, 1992; Schön and Rein, 1994), and reflect upon results within the course of action, in order to progressively reach an acceptable outcome (Cross, 2001; Schön, 1983). In parallel several academics worked to legitimate design as a discipline of its own, located at the intersection between science and the humanities (Archer, 1979; Chamberlain et al., 2012; Cross, 1982). As a result, several scientific journals about design emerged, as well as university departments teaching and researching the subject (Bayazit, 2004; Cross, 2001). This is the context where the expression design thinking emerged for the first time. Richard Buchanan stated that design is in fact a way of thinking, a creative yet rational process to address wicked problems, that may result in different types of outcomes, ranging from graphics, to material objects, services and even complex systems such as entire cities (Buchanan, 1992).

By the early 2000s, these ideas had started to consolidate and soon became mature enough for design thinking to be applied in industry (British Design Council, 2007a; Dorst, 2011). For instance the global consultancy firm IDEO was very successful in interpreting the current situation, and "selling" design thinking to companies in the right way at the right time. Nonetheless, behind well-marketed

consultancy formulas, research continued in a new and interesting way, guided by the assumption that a firm-centric perspective on design thinking could transform it from a tactical driver (i.e., a single function of the organization based on a department-centric perspective) into a strategic driver for the entire organization to gain competitive advantage (Martin, 2010; Micheli et al., 2018). In particular, research focusing on introducing design thinking in business soon realized that in order to get full attention it was necessary to go beyond its definitions and rationale, and get into the "nitty-gritty" of how design thinking can be practiced to promote business growth (Dell'Era and Verganti, 2010; Liedtka, 2015; Micheli et al., 2018).

Current research on this subject builds on decades of ideas stressing the interdisciplinary nature of the design profession (Chamberlain et al., 2012), by elaborating on the capabilities of designers in facilitating the co-creation of innovative solutions with users and business stakeholders (Dell'Era and Verganti, 2010; Seidel and Fixson, 2013). More specifically, this can be done through a set of design "practices", namely the combination of actions and interaction patterns representing a habituated way of doing and dealing with things (Reckwitz, 2002; Vaara and Whittington, 2012). The underlying assumption is that such practices allow to achieve innovation outcomes that are economically viable (viability), technically feasible (feasibility) and, at the same time, more desirable (desirability) for customers (Brown, 2009; Calabretta et al., 2016). Multiple research efforts have been directed to enumerate (Micheli et al., 2019), codify (Karpen et al., 2017), and categorize (Dell'Era et al., 2020; Magistretti et al., 2019) such practices, while making it clear for organizations how they can be leveraged throughout different phases of a design thinking process (Elsbach and Stigliani, 2018). Over the years, this straightforward consideration resulted in a proliferation of visual process models explaining how design thinking may unfold in practice. Relevant examples include the models put forward by the D-School at Stanford University (Plattner et al., 2009), by the global consultancy firm IDEO (Brown, 2009), and more recently by Google ventures (Knapp et al., 2016). Besides more or less relevant differences, all these visual models have a common denominator in making it easier for people within organizations to get on the same page when navigating the design thinking process and practices. In this paper we take as a reference the Double Diamond Model developed by the British Design Council (British Design Council, 2007a) (Figure 1), as prior innovation research has already built on this model clarifying how different design practices can be leveraged during the different phases of the process (Calabretta et al., 2016; Elsbach and Stigliani, 2018).

The design thinking process is iterative in nature and relies on a sequence of divergent and convergent phases whose boundaries may not always be clear-cut (Elsbach and Stigliani, 2018; Gruber et al., 2015). The process usually starts with a discovery phase, in which a problematic situation is explored through an acute observation of the stakeholders involved and of the system's context and constraints. The goal of this phase is generating different perspectives

and insights on the problem at hand, ultimately identifying the boundaries and the key variables that characterize a problem space (i.e., the design practice of framing), in which more creative, meaningful and collaborative solutions can emerge (Hey et al., 2007; Schön, 1988). In the subsequent definition phase, the different perspectives and insights related to the problem space are integrated into a shared vision (i.e., the design practice of envisioning) and objective for the innovation process (Fuller, 1957; Verganti, 2008). Consequently, during the development phase, involved stakeholders collaborate to shape a solution space while conceptualizing and discussing potential ideas (i.e., the design practice of co-creating) to solve the problem and address the needs of the parties involved (Gemser and Perks, 2015; Sanders and Stappers, 2008). The process concludes with the delivery phase, in which some concepts are quickly built and tested with users and stakeholders (e.g., the design practice of prototyping), and subsequently refined towards their implementation (Liedtka, 2015; Schön, 1992).

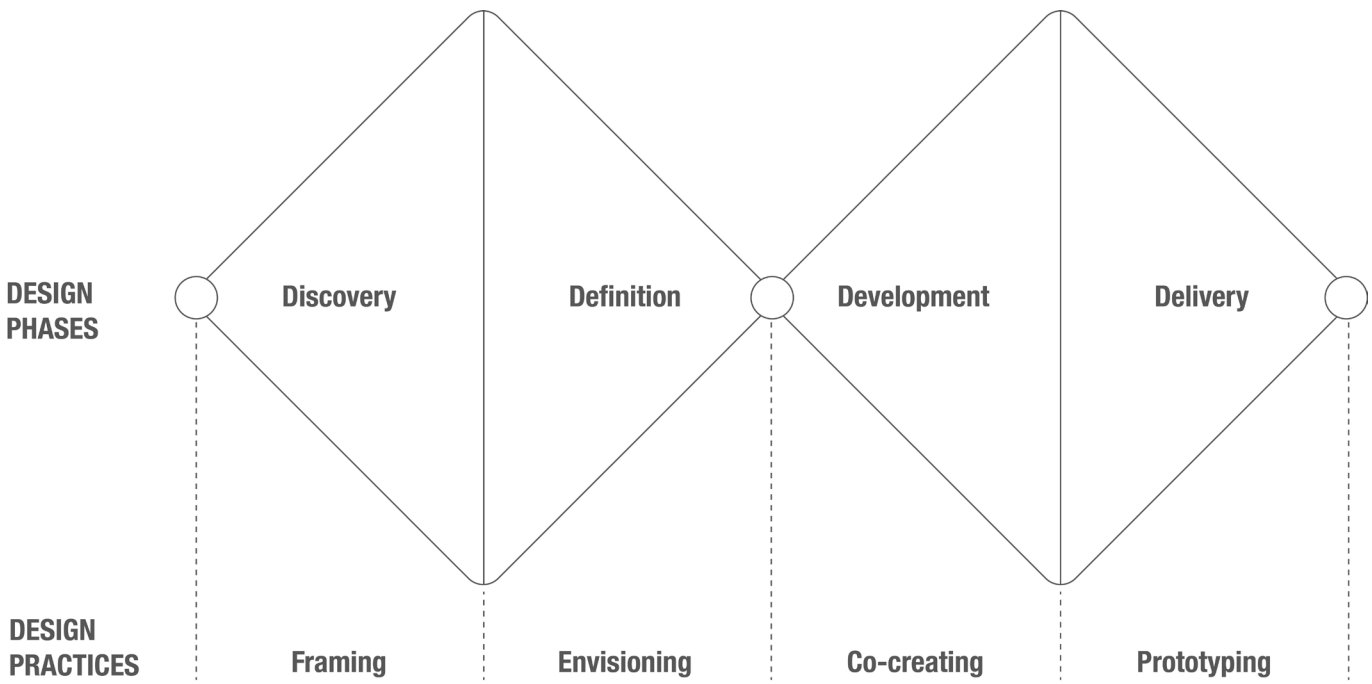

Figure 1. Double Diamond model for the design thinking process. Based and adapted from (British Design Council, 2007a; Elsbach and Stigliani, 2018; Gruber et al., 2015)

4. DESIGN THINKING FRAMEWORK FOR PERFORMING RESPONSIBLE INNOVATION

In the literature review section we identified two core assumptions of innovation management research on design thinking. First, that this approach should be applied from a firm-centric perspective. Second, that this approach should assess innovation outcomes only in terms of desirability, feasibility and viability. Evaluating the first assumptions through problematization, we see that the firm-centric perspective is unfavorable. Such perspective hinders collaboration in innovation on a more systemic level, which is essential for firms to remain relevant in an increasingly dynamic innovation landscape (Chesbrough, 2003; Chesbrough and Appleyard, 2012). In regard to the second assumption, we note that the criteria of desirability, feasibility and viability are not sufficient to assess innovation outcomes. These criteria reflect strategic thinking based mainly on an economic rationale (Martin, 2009). In turn, the wicked problems that design thinking is supposed to tackle (Buchanan, 1992) have negative impacts also on society and the environment (Fuller, 1969; Schön and Rein, 1994), which are hard to capture with a purely economic logic (Elkington, 1998). Business firms have the responsibility to consider these impacts (Drucker, 1973; Voegtlin and Scherer, 2017), while government and citizens are increasingly holding them politically responsible for this (Scherer and Palazzo, 2011; Scherer et al., 2016). Informed by our historical analysis of seminal design thinking ideas endorsing sustainable development (Fuller, 1969; Papanek, 1971), and by the present relevance of the responsibility of businesses in this regard (Voegtlin and Scherer, 2017), in this section of the paper we develop alternative assumptions for innovation management research on design thinking by connecting to responsible innovation theorizing.

The origins of the concept of responsible innovation are rooted in decades of ideas around procedural justice (de Hoop et al., 2016) in policy making (European Commission, 2018). More recently, this concept has gained rapid momentum in innovation management research (Lubberink et al., 2017; Voegtlin and Scherer, 2017), as a response to the increasing pressure on business organizations to mitigate their negative impacts (Whiteman et al., 2013) in a globalized world (Scherer and Palazzo, 2011). Responsible innovation is regarded as an iterative, experimental and collaborative process (Voegtlin and Scherer, 2017; Von Schomberg, 2013) aimed at addressing grand challenges—which are essentially wicked problems such as climate change, resource depletion, poverty and injustice (George et al., 2016, 2015)— affecting the planet and societies on a global scale (Ferraro et al., 2015; Reinecke and Ansari, 2016). Furthermore, responsible innovation is characterized by four theoretical dimensions, namely: reflexivity, anticipation, inclusion and responsiveness (Stilgoe et al., 2013). Reflexivity entails using dialogue to go beyond individual perspectives and jointly reflect on critical issues, and their ethical, social and environmental implications. Anticipation entails thinking in a systemic way and foreseeing plausible and desirable outcomes for innovation. Inclusion entails involving a broader range of

relevant stakeholders and collectively negotiating the objective of innovation while taking all interests into account. Responsiveness entails considering emerging knowledge and insights and consequently adjusting the shape and direction of innovation.

Our focused analysis of responsible innovation shows alignment and complementarity with innovation management research on design thinking. Design thinking and responsible innovation are aligned because they both relate to an iterative process of adaptive learning (Schön, 1983; Voegtlin and Scherer, 2017) for devising solutions to wicked problems (Buchanan, 1992; George et al., 2016). Concerning the complementarity, we note that while responsible innovation elaborates more in depth on what should be the scope of the process and what are its characteristics from a theoretical standpoint, design thinking encompasses important knowledge about the phases and practices functional to implement the aforementioned process beyond theorizing (Brown, 2008; Schön, 1983). In terms of scope, responsible innovation goes beyond the abstract expression "wicked problem", prescribing collaborative action to address specific grand challenges on a cross-organizational scale toward a future situation that is ethically acceptable and environmentally sustainable (Voegtlin and Scherer, 2017; Von Schomberg, 2011). In terms of characteristics, responsible innovation goes deep into innovation theorizing, deriving reflexivity, anticipation, inclusion and responsiveness as core dimensions that distinguish an innovation process for addressing grand challenges through cross-organizational collaboration (Stilgoe et al., 2013; Voegtlin and Scherer, 2017). Nevertheless, responsible innovation research has been so far mostly concerned with abstract conceptualizations (Blok and Lemmens, 2015; Voegtlin and Scherer, 2017), "shying away" from the less "idealistic" contradictions of practice (Klaassen et al., 2017). To address this important limitation, some scholars have recently suggested focusing the discussion on specific practices that can be used to concretely make the innovation process more responsible (Klaassen et al., 2017). This request for a more concrete and micro-level understanding of organizational practices is aligned with recent developments in innovation management research about design thinking (Calabretta et al., 2017; Dell'Era et al., 2017; Micheli et al., 2019). Indeed, recent management research on "doing design thinking" (Micheli et al., 2019) has listed and categorized a set of specific practices (Dell' Era et al., 2020; Karpen et al., 2017), explaining how and when organizations may apply them in different phases of the innovation process (Elsbach and Stigliani, 2018; Gruber et al., 2015).

These complementarities can be leveraged to embed the design thinking process, phases and practices into the scope and theoretical dimensions of responsible innovation. To this end we hereby propose and explain a conceptual framework for "doing design thinking" in the context of responsible innovation. This framework intends to address the limitations of current assumptions of innovation management research on design thinking while proposing alternative ones. The main assumption underlying our framework is that design thinking should be

applied with a cross-organizational perspective, in order to collaboratively address grand societal and environmental challenges. A second assumption is that desirability, feasibility and viability should be integrated with the criteria of responsibility, in order to meaningfully assess the ethical acceptability and environmental sustainability of the outcomes of such process. The framework is visualized in Figure 2. The design thinking process phases are visualized using similar visual features used to depict the Double Diamond (British Design Council, 2007a) in Figure 1. The discovery phase is visualized in top left

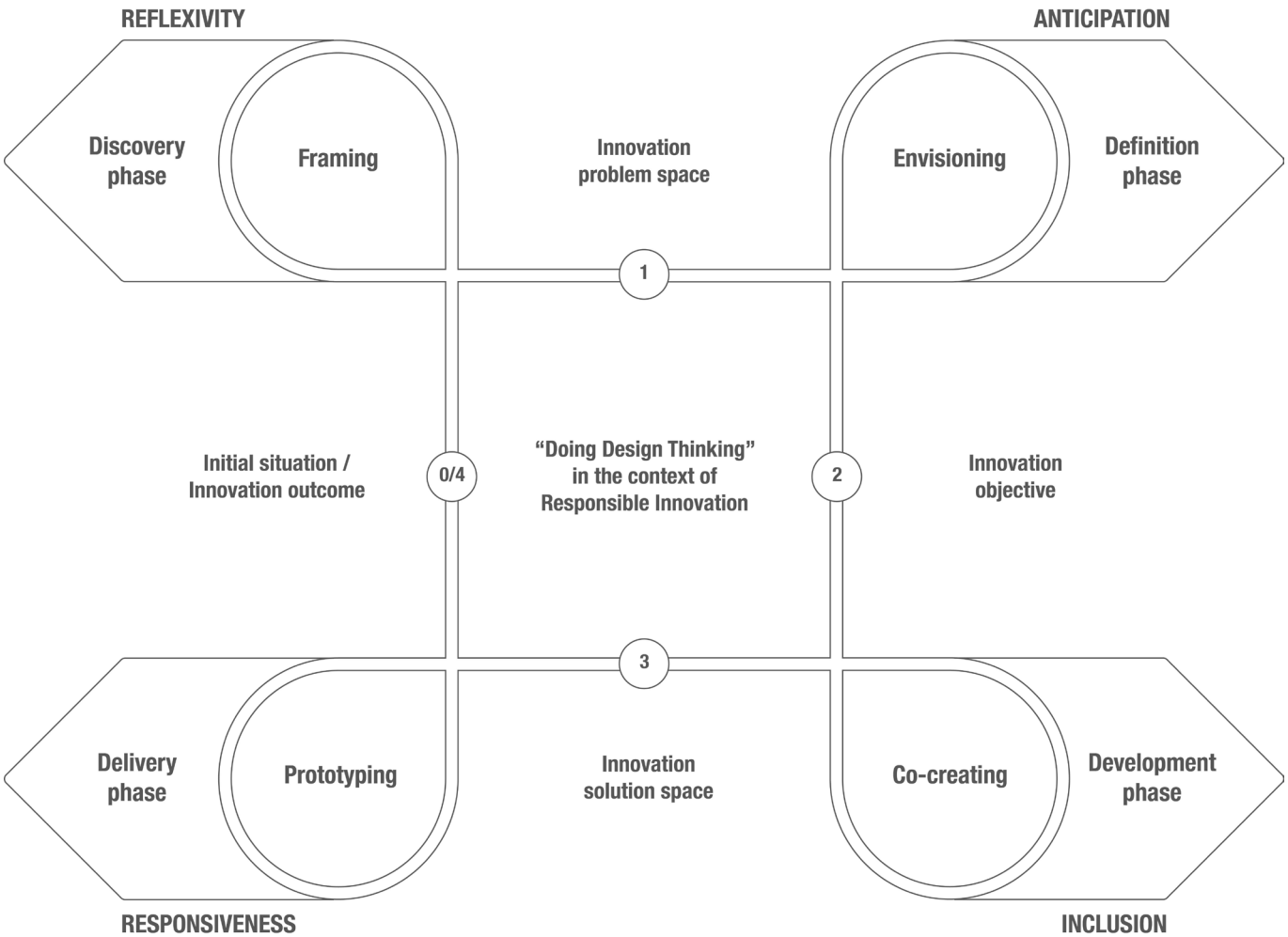

Figure 2. Conceptual framework for performing design thinking in the context of responsible innovation

part of the figure. Clockwise, follow the definition, development and the delivery phases. As in Figure 1, each phase is associated to a main underlying practice—namely framing, envisioning, co-creating and prototyping—derived from recent research on how to perform design thinking (Elsbach and Stigliani, 2018; Gruber et al., 2015). Furthermore, in Figure 2, each phase and related practice, is also associated to one of the theoretical dimensions of responsible innovation—namely reflexivity, anticipation, inclusion and responsiveness (Stilgoe et al., 2013). The aim is to visualize that the phases and practices that occur in "doing design thinking" (Elsbach and Stigliani, 2018; Micheli et al., 2019) can be grounded into the theoretical dimensions of responsible innovation (Stilgoe et al., 2013). In parallel, we visualize how "doing design thinking" permits implementing responsible innovation, by indicating when, and through which practices, it is possible and more advisable to act in a reflexive, anticipatory, responsive and inclusive manner. The loops used to visualize each phase and the resulting overall flow of the process (as indicated by the numbers in the Figure) highlight its iterative (or even recursive) nature, which is rarely characterized by a linear sequence.

The process for performing design thinking in the context of responsible innovation begins with the identification of a problematic situation related to a grand challenge. In Figure 2, the initial situation is visualized on the left side and marked with the number 0 as a starting point. By reflecting through the practice of framing, the initial situation iteratively turns into an innovation problem space, which is visualized on the upper part of the figure and marked with the number 1. By anticipating through the practice of envisioning, the innovation problem space gradually becomes an innovation objective, which is visualized on the right side of the figure and marked with the number 2. By including stakeholders through the practice of co-creating, the innovation objective progressively evolves into an innovation solution space, which is visualized with on the lower part of the figure and marked with the number 3. Finally, by responding through the practice of prototyping, the innovation solution space is gradually transformed into an innovation outcome, which is again visualized on the left side of the figure and marked with the number 4, feeding into a new cycle of the process. The next four paragraphs explain in more detail the four phases and how the four dimensions can be operationalized through the practices.

4.1 Linking framing and reflexivity

In the discovery phase of the design thinking process, the problematic situation is identified and jointly explored by the involved actors, in order to understand the context, share different perspectives, identifying constraints and generating a problem definition space including a variety of directions for the following steps (Gruber et al., 2015). This open and constructive dialogue is a key component of the reflexivity dimension of responsible innovation, during which involved actors are asked to challenge their own perspectives and value systems to acknowledge the moral obligations of responsible

innovation, and pave the way to a responsible solution of the given grand challenge (Burget et al., 2017; Stilgoe et al., 2013). The design thinking practice of framing may serve to engage in reflexivity during the early stages of innovation. Framing can be defined as designers' efforts to view a problematic situation in new and interesting ways by the adoption of different perspectives for interpreting the situation itself (Hey et al., 2007; Schön, 1988). Framing entails asking open, hypothetical and provocative questions to challenge shared perspectives within a group and iteratively determine a point of view that is functional to understand and solve a problematic situation (Paton and Dorst, 2011). Thus, framing allows (re)interpreting problems to lay the foundation for the design of innovative solutions (Dorst, 2011), transforming an abstract reflection into the premise for concrete action (Schön, 1983). Former literature links the practice of framing to innovation in social domains. Schön and Rein (1994) discuss how framing is highly relevant for reflecting on "intractable policy controversies", and consequently addressing them in a more informed manner. Within the context of responsible innovation, the practice of framing allows initiating reflective conversations to support involved actors in bonding with each other, exploring hidden links across their interest and achieving a common understanding of the grand challenge that has to be addressed.

4.2 Linking envisioning and anticipation

Once the different perspectives and directions are outlined, in the definition phase of the design thinking process the insights are combined into a problem definition with the potential of generating meaningful solutions for the problem at hand (Gruber et al., 2015). The forward-looking nature of this phase aligns with the anticipatory dimension of responsible innovation. Being anticipatory means thinking in a systematic way about a grand challenge, envisioning the course of actions and foreseeing the outcome of responsible innovation and its societal and ethical impact (Burget et al., 2017; Stilgoe et al., 2013). Anticipation plays an important role in indicating the direction to take and should occur early in the responsible innovation process (Burget et al., 2017). Thus, the practice of envisioning, which prevalently occurs in the definition phase of the design thinking process, may enable anticipation. Envisioning refers to designers' efforts in defining future directions and using these as starting points for developing innovative solutions (Fuller, 1957; Karpen et al., 2017). In design thinking research, this practice is discussed extensively and embedded in a variety of methods. For example, Hekkert and van Dijk (2011) developed a methodology to design new products and services, which revolves around the idea of creating a future vision and then defining the design brief and the course of actions accordingly. Verganti (2008) introduced design-driven-innovation as an approach that firms can use to envision a new meaning for their product and service solutions and thus pursue radical directions in their innovation paths. Previous literature already postulated a link between envisioning and societal challenges. Already in the 1950s, Fuller (1957) called for a "comprehensive anticipatory design science", which allowed defining a vision

and related objectives to guide human development and solve global problems. The design practice of envisioning entails a collaborative and experiential approach to the process of vision creation (Karpen et al., 2017). Involving different stakeholders in the development of future visions and having them experiencing the vision through future scenarios contribute to reducing the perceived uncertainty of the selected future direction and the related institutional and cultural resistance towards moving into them (Stigiani and Ravasi, 2012).

4.3 Linking co-creating and inclusion

The development phase of the design thinking process focuses on using collaborative and creative approaches to engage users and project stakeholders in the generation of a variety of solutions (Gruber et al., 2015). In a similar manner, responsible innovation research underlines the importance of being inclusive and working collaboratively to address the complexity of grand challenges (Mazzucato, 2018; Stilgoe et al., 2013). Despite being inclusive should characterize the entire responsible innovation process, it is particularly relevant when the practical implementation of an innovative solution starts to emerge, to maintain consensus around the direction previously selected (Burget et al., 2017). The design thinking practice of co-creating facilitates the theoretical dimension of inclusion in the development phase of the process. Co-creating entails the collaborative generation of innovation solutions by leveraging inputs and resources from the involved stakeholders (Gemser and Perks, 2015; Micheli et al., 2018). Design thinking research has developed a variety of tools for co-creating, including Lego Serious Play (Roos et al., 2004), rapid co-creation (Gardien et al., 2016), and a variety of brainstorming techniques (Brown, 2008). What makes the design approach to co-creating and the above-mentioned tools particularly suitable for the responsible innovation context is their broad participatory nature and, more specifically, their focus on actively involving "users" (Sanders and Stappers, 2008). In line with the call for including the public in responsible innovation (Stilgoe et al., 2013), design methodologies for co-creating put particular emphasis on users (in addition to stakeholders) as co-designers of innovation solutions, and on discerning when and how users should play a more participatory role (Sanders and Stappers, 2008).

4.4 Linking prototyping and responsiveness

The delivery phase concludes the design thinking process by iteratively testing promising solutions with users and stakeholders, in order to improve them and ultimately select one for further implementation (Gruber et al., 2015). This phase, and in particular the practice of prototyping, could be relevant to enact the responsiveness dimension of responsible innovation. Responsiveness requires being flexible about the shape and direction of innovation in reaction to new emerging knowledge (Stilgoe et al., 2013) and to the dynamic nature of the grand challenges themselves (George et al., 2016). To this end, building a prototype allows constructing artifacts that can be readily implemented and progressively adjusted over time acknowledging that new requirements

will be found (Liedtka, 2015; Schön, 1992). By combining different communication languages (e.g., visualization, working models), prototypes make innovation ideas more tangible, thus explicative and understandable (Karpen et al., 2017). As a result, stakeholders can experience the innovation solution and its fit with the initial problem, gaining a more informed perspective. In the context of responsible innovation, this means making the perceived risks, technological complexities, and system strengths more transparent and accessible through the prototype of the responsible solution, and thus facilitating the discussion and adoption of the solution itself. When stakeholders are able to experience possible solutions for the complex ethical and societal problem at hand, they can better deal with their resistance to act due to their lack of sufficient knowledge (Blok and Lemmens, 2015). Furthermore, the visual and experiential nature of prototypes stimulates emotional engagement with the solution (Calabretta et al., 2017), potentially reducing the difficulties of implementing responsible innovation related to stakeholders' focus on their individual interests and power struggles ((Blok and Lemmens, 2015; de Hoop et al., 2016).

5. ILLUSTRATION OF THE FRAMEWORK

In line with the problematization approach (Alvesson and Sandberg, 2011), in this section we relate our assumptions to their audience by illustrating our conceptual framework through a real project. The project we selected is "Project X"1, a large cross-organizational collaboration funded by the European Commission as part of the Horizon 2020 program and the Circular Economy Action Plan. The Horizon 2020 program is the main financial platform to promote responsible innovation in Europe (European Parliament, 2018). The Circular Economy Action Plan is a strategy developed specifically to address the grand challenge of resource depletion by pursuing sustainable production, consumption, and conversion of waste into material inputs (European Commission, 2015). The grand challenge of resource depletion (i.e., a wicked problem) refers to the issue of natural resources being used and disposed at an ever-faster rate, which will soon make some critical material no longer available (Rockström et al., 2009). This problem is serious because European businesses, the economy and ultimately society depend upon these critical materials (George et al., 2015; Whiteman et al., 2013).

Within this context, "Project X" is a responsible innovation project where design thinking is being applied with the objective of redesigning the supply chain of water and minerals by building a plant for recovering minerals and clean water out of industrial wastewater effluents. The process underlying "Project X" is iterative and collaborative. On paper, the project has a total duration of four years, spanning from 2017 to 2021. However, its history began earlier, when the European Commission put forward an innovation framework and financial platform to address the problem of resource scarcity, and eventually when the different project stakeholders started to interact, forming the consortium and defining specific goals. Around 20 stakeholders including diverse

organizations (i.e., academic institutions, new ventures, medium and large companies) from multiple European countries are involved, making "Project X" challenging due to the complexity of the technology and the need of aligning diverging interests.

Information on the illustrative project derives from the authors' direct participation in project activities, from the consultation of official project and policy documentation, and from recurrent and direct contact with project stakeholders (i.e., policy makers,

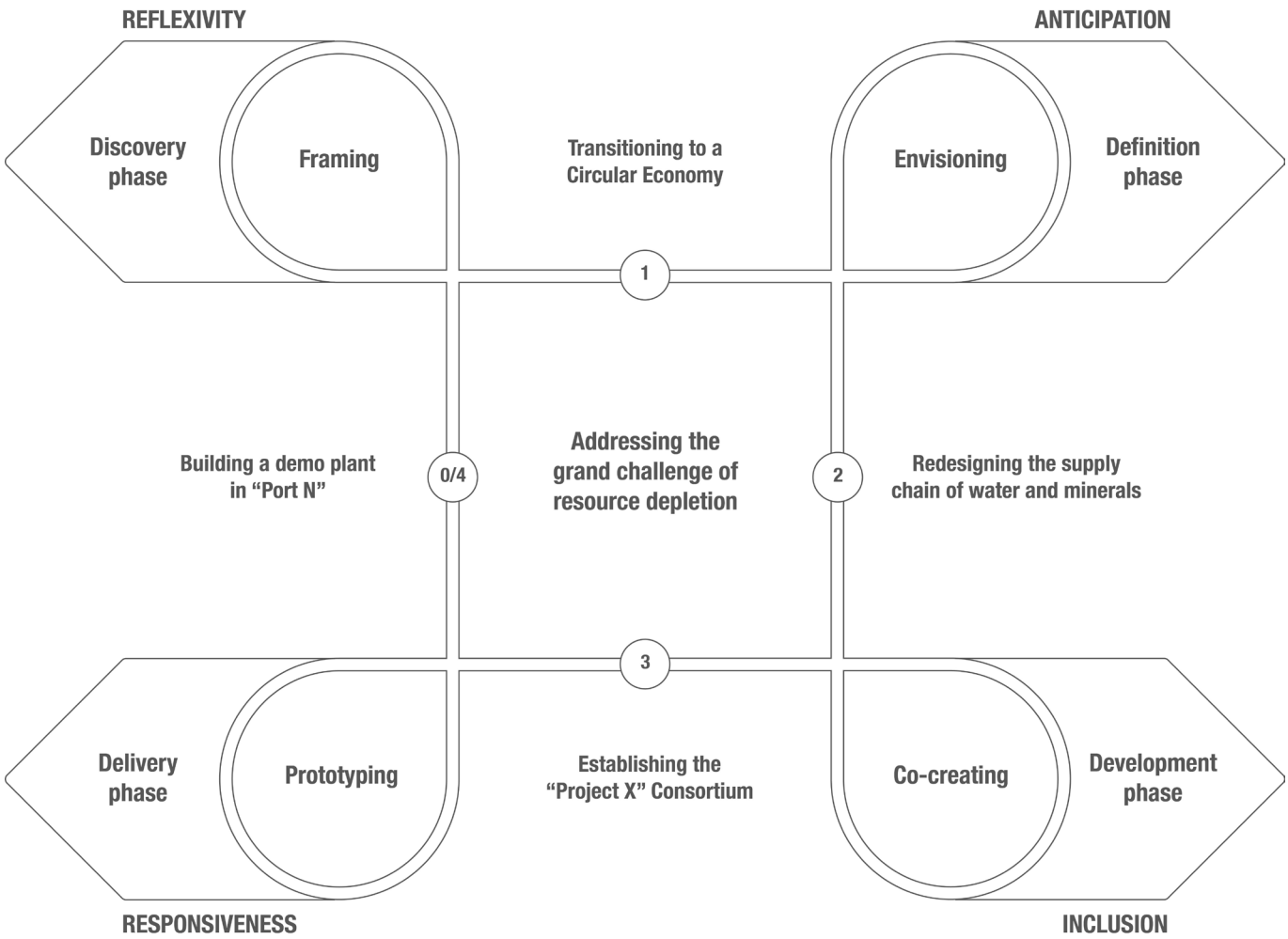

Figure 3. The framework for performing design thinking in the context of responsible innovation applied to "Project X", addressing the grand challenge of resource depletion

entrepreneurs, academics and company managers). Based on this information, in Figure 3 we mapped the different stages of "Project X" against our design thinking framework for performing responsible innovation. In the coming paragraphs we explain how these stages unfolded.

5.1 Reflective framing: transitioning to a circular economy

The antecedent and starting point of "Project X" is represented by an extended discovery phase, in which multiple stakeholders gradually framed issue of "raw material" scarcity (i.e., resource depletion) through an open and constructive dialogue informed by diverse perspectives and inputs. This grand challenge was identified in 1982, and presented by the European Commission as a priority area within the first European Framework Program for Research and Innovation (FP1). By using reflective framing, multiple stakeholders—including the European Commission, representatives of national governments, business firms, entrepreneurs and academic institutions—started to set the variables and boundaries of a problem space for a cross-organizational collaboration aimed at tackling the issue of resource depletion. Over the next decades, the European Commission kept steering these efforts, promoting joint reflective framing. This discussion led to the FP evolving several times, until FP8, called Horizon 2020, and spanning between 2014 and 2020. In this context, the Circular Economy Action Plan emerged. This strategic framework and Horizon 2020 represent the main finance support platform for projects aimed at recovering critical materials and putting them back on the market. Between 2016 and 2018, through a Horizon 2020 call related to the circular economy, a large budget was made available for projects focusing on solving this challenge, and triggered the creation of "Project X".

This initial phase of the project illustrates how grounding design thinking in the context of responsible innovation enables cross-organizational collaboration in the form of reflective framing aimed at addressing grand challenges. Specifically, the top-left quadrant of Figure 3 shows that in the discovery phase of the design thinking process multiple stakeholders gradually reflect on the grand challenge of resource depletion by collectively framing it as an action plan for transitioning toward a circular economy. The Circular Economy Action Plan represents a tangible output of these reflective framing efforts—one of the most recent steps of an iterative process that spanned several years, exploring different directions, combining different perspectives, and ultimately providing multiple stakeholders with a common problem space and point of view to collaborate around the issue of resource depletion. Furthermore, the illustrative project also shows that policy makers are a driving stakeholder in this initial phase. Specifically, the European Commission steered these reflective efforts on framing the resource scarcity issues over the course of five decades, fostering several initiatives supporting the action of multiple stakeholders, such as the Circular Economy Action Plan and Horizon 2020 funding "Project X".

5.2 Anticipatory envisioning: redesigning the supply chain of water and minerals

After the Circular Economy Action Plan and related Horizon 2020 funding created a common problem space and a financial platform, multiple stakeholders collaborated in a definition phase aimed at anticipating a focused solution to resource depletion through the practice of envisioning.
An entrepreneur, who collaborated with multiple stakeholders to envision the proposal for "Project X", drove these anticipatory efforts. Leveraging his academic PhD background in chemical engineering at "University B", and his deep scientific knowledge, the entrepreneur founded "Startup A". This was functional to establish a wide network across industry and academia. Under the leadership of the entrepreneur, this cross-organizational collaboration gradually took shape, and with it the definition of the core idea behind "Project X": redesigning the supply chain of water and minerals by turning wastewater into a valuable resource input. This is how the proposal for "Project X" emerged. The collaborative process of drafting, adjusting and improving the proposal for "Project X" spanned over three years, during which the envisioned approach was enriched and refined through frequent interaction with the European Commission and a variety of inputs from a growing network of stakeholders across industry and academia. In 2017, the final version of the "Project X" proposal was accepted.

This phase of the project illustrates how grounding design thinking in the context of Responsible innovation enables cross-organizational collaboration in the form of anticipatory envisioning aimed at addressing grand challenges. Specifically, the top-right quadrant of Figure 3 shows that in the definition phase of the design thinking process, multiple stakeholders gradually anticipate a solution to the grand challenge of resource depletion by collectively envisioning the proposal for "Project X", aimed at redesigning the supply chain of water and minerals by turning wastewater into a valuable input. The proposal for "Project X" represents a tangible output of the anticipatory efforts of multiple stakeholders striving to define a focused way to address resource depletion. Furthermore, the project also shows that entrepreneurs are fundamental in this phase. Specifically, over the course of four years, the founder of "Startup A" played a crucial role in envisioning ideas and bringing together multiple stakeholders (i.e., European Commission, academia, and businesses), in order to shape them further into the final proposal of "Project X".

5.3 Inclusive co-creation: establishing the consortium of Project X

Once the objective of "Project X" was envisioned, the cross-organizational collaboration advanced in a development phase, where additional stakeholders were included in the co-creation of a solution space. Particularly, the opportunity of jointly redesigning the supply chain of water and minerals progressively resulted in the inclusion of additional stakeholders, leading to the co-creation of the "Project X" consortium. In this instance, the inclusion of new

stakeholders in the consortium of "Project X" was fostered by the reputation and scientific knowledge held by "University B". This academic institution enabled the entrepreneur in acquiring essential knowledge on the wastewater treatment technologies and their potential applications for resource recovery. Furthermore, it supported him in establishing connections with many relevant stakeholders with necessary expertise to inform the solution space. In this process, several academic and industry partners were progressively included. A large supplier of demineralized water based in "Port N", was involved in the consortium, contributing to the co-creation of the solution space by providing the infrastructure and wastewater streams for the recovery of minerals. Consequently, a firm that commercializes such minerals was also included in the consortium, bringing into the solution space its expertise in this regard. In parallel, an engineering consulting firm that designs and builds systems for wastewater treatment became part of the consortium as well, informing the co-creation of the solution space with its technical know how. "University F" was also included, providing additional technological expertise—needed to separate valuable critical materials from water in an energy efficient way—as well coordination capabilities needed to formally encompass over 20 collaborating partners into the consortium of "Project X".

This phase of the project illustrates how grounding design thinking in the context of responsible innovation enables cross-organizational collaboration in the form of inclusive co-creation aimed at addressing grand challenges. Specifically, the bottom-right quadrant of Figure 3 shows that in the development phase of the design thinking process, multiple stakeholders are gradually included in addressing the grand challenge of resource depletion by collectively co-creating the consortium of "Project X". This consortium represents a solution space encompassing the necessary expertise to carry out a targeted effort for addressing the issue of resource depletion. This inclusive co-creation was a collaborative feat, which became possible thanks to the inputs of all the stakeholders involved. Nevertheless, our illustrative project also shows that academia is a driving force in this phase of the responsible innovation process. Specifically, the scientific and interdisciplinary knowledge and connections of "University B" and "University F" were functional for reaching out to relevant stakeholders, gathering their inputs and ultimately coordinating the co-creation and the management of the "Project X" consortium.

5.4 Responsive prototyping: building a demo plant in "Port N"

"Project X" has currently entered the delivery phase and its members are currently responding to the grand challenge by translating the solution defined in the proposal into a series of large-scale prototypes (e.g., a demonstration plant in "Port N") to further understand and validate how the wastewater can be turned into a valuable input by recovering minerals from it. Building the plant entails gradually detailing, adjusting and installing the proposed technology into

the industrial facilities of the demineralized water supplier, collecting valuable critical materials from wastewater. This work is carried out as a cross-organizational collaboration of various stakeholders under the coordination of "University F". While "Startup A" collaborates with the engineering consulting firm on design tasks, the demineralized water supplier is supporting the operations to run the plant. This is critical to combine the responsibility goals with the technical feasibility of the demonstration and its economic viability when scaling up at an industrial level. In this process, the specifics of the technology are constantly modified as new knowledge and requirements emerge. For example, the intake flow of wastewater into the system was modified. Due to technical and operational constraints, the demo plant was moved from the facilities of the demineralized water supplier to the facilities of a new stakeholder, which was included in the consortium with the main task of providing a more flexible space to adjust and test the system.

This phase of the project illustrates how grounding design thinking in the context of Responsible innovation enables cross-organizational collaboration in the form of responsive prototyping aimed at addressing grand challenges. Specifically, the bottom-left quadrant of Figure 3 shows that in the delivery phase of the design thinking process, multiple stakeholders gradually respond to the grand challenge of resource depletion by collectively prototyping a demo plant in "Port N". The demo plant and the business model around it, represent a tangible output of responsiveness efforts performed by the stakeholders involved in "Project X". Next to allowing to gradually building and adjusting the output of the responsible process in a responsive way, prototyping also enables a more close and practical collaboration across the involved stakeholders, which is essential for them to establish mutual trust and ultimately align their interests. Furthermore, the project also shows that business firms are a driving stakeholder in this phase. Specifically, the demineralized water supplier, the engineering consulting firm, "Startup A" and the new stakeholder are currently providing the consortium with the key know how and necessary infrastructure to enable the implementation and industrial application of the technology solution.

5.5 Subsequent developments

The stakeholders of "Project X" are currently collaborating to build the demo plant in "Port N". Meanwhile they are required by the European Commission to continuously report their progress and outcomes. This knowledge is functional to further reflect and inform subsequent developments aimed at addressing resource depletion. Ultimately, the illustrative project indicates the continuous, iterative and emergent nature of the design thinking process in the context of responsible innovation. As shown in Figure 3 at the intersection between the bottom-left and top-left quadrants, the outcomes of "Project X" are going to become an input for a new cycle. Specifically, the European Commission is going to use the learning from "Project X" to inform new European project calls, to allocate additional funding

in a more targeted way, and to make industry and academia aware of the status quo and priorities on the way forward to address the issue of resource depletion.

6. DISCUSSION AND CONCLUSION

This paper connects the streams of management research on design thinking and responsible innovation. Establishing this connection is important because management research on design thinking has so far been inward oriented, meaning that scholars have mostly focused on defining the ontology of this concept and the business case of the related approach (Kolko, 2015; Martin, 2009). As a result, the scientific discourse on the subject has unfolded "in the vacuum" and independently from other innovation theories. By connecting to responsible innovation research, we consolidate the foundations of design thinking, grounding them into another important stream of innovation research (George et al., 2016; Voegtlin and Scherer, 2017). Specifically, we show how the design thinking process, its phases (discovery, definition, development, delivery) and underlying practices (framing, envisioning, co-creating, prototyping) can be grounded into the theoretical dimensions of responsible innovation (reflexivity, anticipation, inclusion, responsiveness). In parallel, we also show how design thinking can inform other research domains through its performative knowledge in terms of innovation process, phases and practices. Specifically, we explain how such knowledge can be leveraged to address the key question of how responsible innovation may be performed (Blok and Lemmens, 2015; Voegtlin and Scherer, 2017) by operationalizing its theoretical dimensions. In doing so, we increase the relevance of design thinking outside its own "niche", contributing to important work on responsible innovation, which is emerging as a key paradigm in management research (Voegtlin and Scherer, 2017) and in policy making (Von Schomberg, 2011b), as a response to major problems faced by humanity today (Ferraro et al., 2015; George et al., 2016). Indeed, business firms have a moral and political responsibility to play a role in these critical efforts (Drucker, 1973; Scherer et al., 2016). As a direct consequence, related management as well as interdisciplinary research is intensifying at impressive speed (Allwood, 2018). We see an opportunity for design thinking scholars to contribute to the management debate on the subject by bringing a more holistic perspective geared towards action. While making an initial attempt in this direction, we aim to open a new avenue for design thinking research, focusing on explaining how businesses can collaborate with each other, and with other stakeholders, in the context of responsible innovation toward sustainable development.

Pursuing a problematization approach (Alvesson and Sandberg, 2011), our main contribution to innovation management research on design thinking is advancing theorizing beyond the current firm-centric perspective (Micheli et al., 2018), which often assesses design outcomes by way of desirability, feasibility and viability. Such a perspective is problematic because it hinders deep explanations of how design thinking

may enable cross-organizational efforts innovation, and of which criteria to draw upon when assessing their effectiveness. Cross-organizational collaboration is essential for two crucial reasons. First, it is essential for firms to remain relevant in an increasingly dynamic innovation landscape (Chesbrough, 2003; Chesbrough and Appleyard, 2012). Second, to prevent their negative impacts on society and the environment, while government and citizens are increasingly holding business politically responsible for this (Scherer and Palazzo, 2011; Scherer et al., 2016). Responsible innovation research defines the scope of innovating in terms of addressing grand societal challenges (i.e., wicked problems) (Ferraro et al., 2015; George et al., 2016). Furthermore, it clarifies that four theoretical dimensions characterize a responsible innovation process: reflexivity, anticipation inclusion and responsiveness (Stilgoe et al., 2013; Voegtlin and Scherer, 2017). Building on these theoretical foundations we leverage, and advance, recent research on "doing design thinking" (Micheli et al., 2019) by proposing a conceptual framework that explains how multiple stakeholders may work together on a cross-organizational level to solve pressing collective concerns.

Our framework and illustrative project suggest that in order to address grand societal challenges (why), the theoretical dimensions of Responsible innovation (what) can be performed by specific design practices (how) throughout the phases of a design thinking process (when), via the cross-organizational collaboration of various stakeholders (who). In line with Whetten (2016), Table 1 summarizes our main theoretical contribution in terms of the why, what, how, when and who questions. This contribution should be viewed in the acknowledgment that both design thinking and responsible innovation entail a fluid, experimental, iterative and interactive process (Elsbach and Stigliani, 2018; Robaey and Simons, 2015). Therefore, breaking down this process into distinct phases where a specific actor performs a specific practice at a specific point in time, is a conceptual simplification. This is intended to bring more clarity to fundamental dynamics underlying cross-organizational collaboration, but does not fully capture the complexity of reality. Ultimately, we do not exclude that the boundaries between phases and related roles within the process can be blurred. In other words, multiple actors may perform in parallel different phases and practices. For example, in our illustrative project the entrepreneur plays a key role in envisioning the objective, but also leverages his academic background and connections for including relevant stakeholders in the project consortium, while the definition of the idea takes place in parallel with the co-creation of the solution. Another example is related to policy makers, who play a key role upstream of the responsible innovation process, by identifying the problematic situations and consequently framing an innovation problem space through policy directives and related financial mechanisms. This is indeed an essential phase of the process, which takes place before projects with more specific objectives can be envisioned and consequently translated into innovation outputs that address the problematic situation. However, the role of policy makers is not limited to reflecting at the

Table 1. Purpose, theoretical dimensions, practices, phases and driving stakeholders, which characterize the design thinking process in the context of responsible innovation

WHY Purpose of responsible innovation	**WHAT** Theoretical dimension of responsible innovation	**HOW** Practices to perform the dimension	**WHEN** Phase of the process in which it is performed	**WHO** Driving stakeholder in the process phase	**CASE EXAMPLE** Horizon 2020 "Project X"
Grand societal challenges Addressing real problems that are associated to serious consequences	**Reflexivity** Using dialogue to go beyond individual perspectives and jointly reflect on critical issues and their ethical, social and environmental implications	**Framing** Exploring a problematic situation in order to generate different perspectives and identify the variables and boundaries that characterize a problem space	**Discovery phase** Begins with the identification of a problematic situation and eventually leads to a problem space for the innovation project	**Policy makers** Reflect on grand societal challenges by framing addressable innovation problems	**European Commission** Reflect on resource depletion and put forward a strategic framework for the transition toward a circular economy
Grand societal challenges Addressing complex problems that have no single solution with no clear path towards it	**Anticipation** Thinking in a systemic way and foreseeing plausible and desirable outcomes for innovation	**Envisioning** Defining future scenarios and using these as starting points for developing innovative solutions	**Definition phase** Begins with a problem space and eventually leads to a shared objective for the innovation project	**Entrepreneurs** Anticipate solutions for grand societal challenges by envisioning specific innovation objectives	**"Startup A"** Anticipate a solution for resource depletion and focus a project proposal on redesigning the supply chain of water and minerals
Grand societal challenges Addressing collective problems that affect multiple societies across the world	**Inclusion** Involving a broad range of relevant stakeholders and collectively negotiating the objective of innovation while taking all interests into account	**Co-creating** Developing a joint solution that leverages inputs and resources, gives ownership and delivers value to the stakeholders involved	**Development phase** Begins with a project objective and eventually leads to a solution space, where new ideas and concepts are co-created by users and project stakeholders	**Academia** Include relevant stakeholders in the resolution of grand societal challenges by co-creating the innovation solution	**"University B" and "University F"** Include twenty organizations into addressing resource depletion, establishing and managing the consortium of "Project X"
Grand societal challenges Addressing dynamic problems that constantly change and evolve as they are being tackled	**Responsiveness** Considering emerging knowledge and insights and consequently adjusting the shape and direction of innovation	**Prototyping** Building an artifact that can be readily implemented and progressively adjusted over time, acknowledging that new requirements will be found	**Delivery phase** Begins with a solution space and eventually leads to the outcome of the innovation project	**Business firms** Respond to grand societal challenges by prototyping the innovation outcome	**Firms in the "Project X" consortium** Respond to resource depletion and build a demo plant in "Port N"

beginning and at the end of the responsible innovation process. Policy makers are constantly involved in the project by interacting with the other stakeholders, giving feedback, and influencing with anticipatory thinking the definition of the project objectives. These examples point out that academics, entrepreneurs, policy makers and firms need to collaborate closely, often going beyond their typical roles and taking responsibility for communal benefit. Indeed, this idea is hardly compatible with current research on "doing design thinking" (Micheli et al., 2019), and its firm-centric perspective driven by competitive advantage. Nevertheless, through the problematization approach we also propose an alternative way: "doing design thinking" in the context of responsible innovation, emphasizing the need of cross-organizational collaboration on innovation projects and offering concrete examples of practices that could facilitate that at a micro-level.

Ultimately, we hope that connecting to responsible innovation can stimulate design thinking scholars to engage in a more critical reflection on the subject. After the publication of Tim Brown's book "change by design" in 2009, the mainstream understanding of the nature of design thinking from a business perspective has been centered on the criteria of desirability, feasibility and viability (Brown, 2009; Calabretta et al., 2016; Martin, 2010). As mentioned, the purpose of balancing these three criteria is supporting firms to innovate faster driven by their private interest of gaining competitive advantage

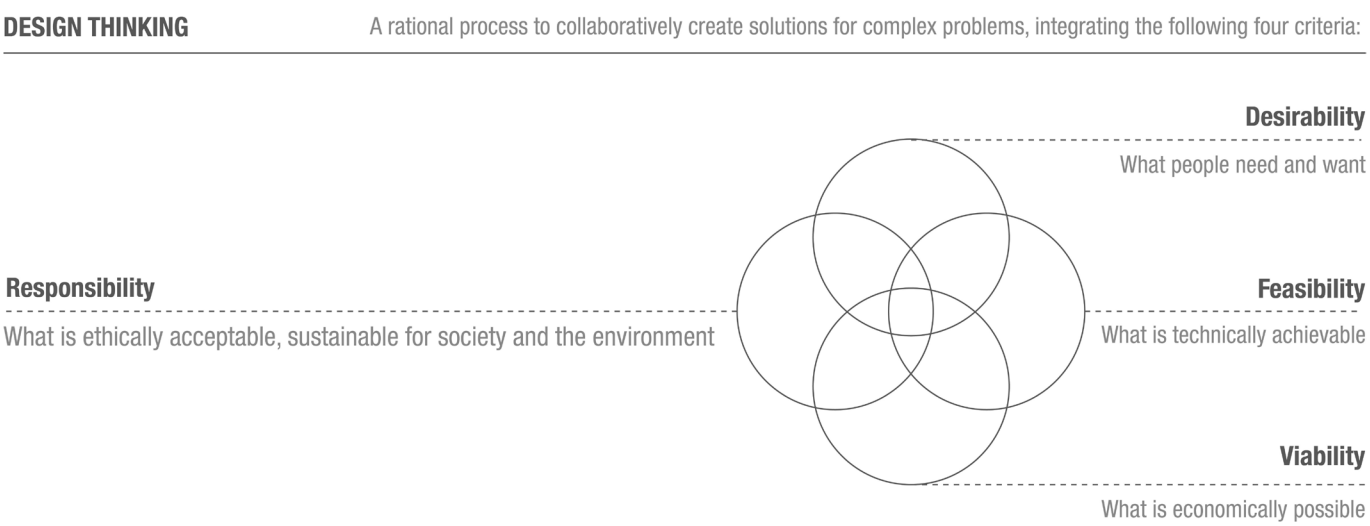

Figure 4. Revisited conceptualization of design thinking and related criteria. Based on: (Brown, 2009; Fuller, 1957; Papanek, 1971; Simon, 1968; Voegtlin and Scherer, 2017) and on the outcomes of this research

(Brown et al., 2014). Unfortunately, and well to often, this neoliberal approach occurs at the expenses of the collective interest (Porter and Kramer, 2011; Yunus et al., 2010) with macroscopic negative effects on society and the environment (Khavul and Bruton, 2013; Whiteman et al., 2013). Conversely, when looking at the origins of design thinking, we see that this approach emerged six decades ago as a rational problem solving process to "change existing situations into preferred ones" (Simon, 1968). The aim of this process was defined in terms of making the world a better place for people to live in, addressing societal needs without running out of critical resources and polluting the natural environment (Fuller, 1957, 1969; Schön and Rein, 1994). This raises an important question on how management research could—or should—frame the nature and purpose of design thinking on its way forward. To this end, this paper leverages the historical roots of design thinking and connects them to management research on responsible innovation. By doing so it explicitly integrates responsibility as a critical—yet forgotten (Fuller, 1957, 1969; Papanek, 1971)—design thinking criteria to assess innovation outcomes, next to desirability, feasibility and viability. In figure 4 we (re)conceptualize and visualize design thinking as an innovation approach based on the integration of these four criteria, providing the foundation for a new evaluative perspective on design-led innovation.

6.1 Managerial implications

"The fact is that in modern society there is no other leadership group but managers. If the managers of our major institutions, and especially of business, do not take responsibility for the common good, no one else can or will" (Drucker, 1973 in Management: Tasks, Responsibilities, Practices).

Business managers have the moral (Drucker, 1973) and political (Scherer and Palazzo, 2011; Scherer et al., 2016) responsibility to play a role in addressing the grand challenges of our time, such as climate change, resource depletion poverty and injustice (George et al., 2016). Besides contributing to theorizing, our framework aims to provide managers with a deeper understanding of how they can play this role. As shown in Figure 3 in the bottom-left quadrant, firms have the capacity to respond to grand challenges by delivering tangible innovation outcomes. These outcomes are embodied by prototypes, artifacts that are gradually implemented and improved (Liedtka, 2015; Schön, 1992). Our illustrative prject shows how the firms within the consortium of "Project X" leverage their technical knowledge, resources and infrastructure to build a demo plant in "Port N" to recover resources from wastewater and address the challenge of resource depletion. This is a highly iterative effort, in which the features of the plant are constantly modified as new knowledge and contingencies emerge. Indeed, business innovation aimed at addressing grand challenges requires such iterative approach (Voegtlin and Scherer, 2017). However, in practice, this may prove problematic, especially in large firms dominated by risk-averse organizational culture (Diaz Lopez et al., 2018). Therefore, the first implication for managers wanting to leverage design thinking in the

context of responsible innovation is putting an active effort in shifting the mindset of their organization toward adopting a trial and error approach based on prototyping.

Furthermore, building on the important statement made by Drucker fixity years ago, our framework shows that the responsibility of innovation does not lie with managers alone, but also with also with other stakeholders, including entrepreneurs, academics and policy makers. This is in line with recent literature maintaining that collaboration is essential for firms to remain relevant (Chesbrough and Appleyard, 2012) while addressing challenges that are disrupting the fundamental rules of competition (Porter and Kramer, 2011) and are too big to be tacked "single-handedly" (Esslinger, 2011). Solutions to these challenges emerge from cross-disciplinary collaborations involving the stakeholder categories mentioned above. As shown in Figure 3 in the top-right quadrant, entrepreneurs are able to anticipate solutions to grand challenges by defining specific innovation objectives. These objectives are based on visions of what a desirable future could look like (Fuller, 1957; Simon, 1968). Our illustrative project shows how the entrepreneur driving forward "Startup A" gave shape to a project proposal aimed redesigning the supply chain of water and minerals by turning wastewater into a valuable resource. Indeed, in a responsible innovation process there is no single designer (Esslinger, 2011; Stilgoe et al., 2013). However, it is also worth considering that entrepreneurs might get closest to this role. Already at the beginning of the past century, Schumpeter argued that entrepreneurs are men of vision who drive progress by introducing new design ideas (Schumpeter, 1912). More recently, and in the context of responsible innovation, it has been noted that new ventures are most likely to come up with sustainable ideas, whereas incumbents have the capacity to implement them (Hockerts and Wüstenhagen, 2010). Thus, the second implication for managers is collaborating with entrepreneurs to empower them in this key role, while building onto their ideas.

Academic institutions can catalyze collaboration between incumbent firms, entrepreneurial ventures and other stakeholders working on responsible innovation toward sustainable development (Trencher et al., 2013). As shown in Figure 3 in the bottom-right quadrant, academia is able to include in the resolution of grand challenges a wide range of stakeholders, who are needed to develop innovation objectives within a solution space. This solution space is shaped over time through the practice of co-creating (Gemser and Perks, 2015; Sanders and Stappers, 2008). Our illustrative project shows how the scientific and interdisciplinary knowledge of "University B" and "University F" is essential to connect key stakeholders (i.e., European Commission, Firm C, Firm D, Firm E, "Port N", and others), facilitating the co-creation and management of the consortium of "Project X". This consortium can be seen as a solution space containing the necessary expertise (and resources) to gradually develop further the ideas of the project proposal. Indeed, co-creation, as the expression itself indicates, is a collaborative feat where each stakeholder involved plays an important role (Gemser and Perks,

2015). However, in order to be effective, collaborative co-creation requires identifying, bringing together and coordinating the right set of stakeholder, who have the best available knowledge needed to develop a solution for the problem at hand. Due to their scientific and interdisciplinary knowledge, as well as their focus on societal impact (instead of being driven by profit), Universities are particularly suitable to play this role. Therefore, the third implication for managers is leveraging the connections that their firm has with academic institutions (reinforcing them and / or creating new ones) in order get involved in coalitions that can perform meaningful and cutting-edge innovation.

Finally, considering the moral and epistemic barriers that arise when dealing with grand challenges (Blok and Lemmens, 2015), firms, entrepreneurs and academic institutions are unlikely to undertake this task successfully without any central coordination (Voegtlin and Scherer, 2017). This is where the public sector comes into play. As shown in Figure 3 in the top-left quadrant, policy makers are needed to reflect on grand challenges by discovering the variables and boundaries characterizing an innovation problem space. These variables and boundaries are in fact identified over time through the reflexive practice of framing (Hey et al., 2007; Schön, 1988). Our illustrative project shows how the European Commission steered decades of reflective efforts on resource scarcity, which led to the creation of a policy framework supporting collaborative action to tackle this grand challenge, such as "Project X". Indeed, businesses must become more mindful of the impact of their innovation processes and outcomes on society and the environment. They need to start acting consequently (Scherer and Palazzo, 2011; Voegtlin and Scherer, 2017). However, this effective action cannot happen without interacting with policy makers, who can inform them with their transversal reflective efforts geared towards the resolution of "intractable policy controversies" (i.e., grand challenges) by framing them as addressable problems while taking into consideration the collective interest (Schön and Rein, 1994). Therefore, the last implication for managers is acknowledging the importance of aligning the scope of the innovation process and outcomes with the responsible innovation frameworks traced by policy makers.

6.2 Limitations and future research

By connecting to responsible innovation theorizing, this paper advances current innovation management research on "doing design thinking" (Micheli et al., 2019) beyond the current firm-centric perspective (Micheli et al., 2018). Thus we open a new avenue for research on how design thinking may enable collaborative innovation aimed at solving grand societal and environmental challenges. Our conceptual framework represents exploratory work in this direction.

The first main limitation of this research relates to the fact that our conceptual framework is illustrated ex-post using a single project. Our illustrative project indeed reflects how theory on the application of design thinking in the context of responsible

innovation unfolds in reality. However, in order to increase the validity of the framework, and its generalizability across contexts, more empirical research is needed, which is a major issue also faced by responsible innovation research (Blok and Lemmens, 2015; Klaassen et al., 2017). Therefore, we suggest that future research could leverage our framework as a preliminary theoretical lens for larger studies across multiple responsible innovation projects, with a focus on observing common patterns. This would allow increasing the understanding of how the design thinking process can be applied by multiple organizations collaboratively in order to solve grand challenges.

While starting to shed more clarity on the fundamental dynamics underlying the subject mentioned above, the second main limitation of our research relates to its conceptual simplification of the design thinking process into clear-cut phases, practices and roles. As explained, this simplification is likely to fall short in fully reflecting the fluid and iterative unfolding of events in real situations (Elsbach and Stigliani, 2018; Klaassen et al., 2017; Schön, 1983). We do not exclude that different practices next to those we already identified may be performed in parallel by different stakeholders, who simultaneously leverage design thinking to integrate the four dimensions of responsible innovation. Consequently, we suggest that future research should further explore this process at a micro-level, looking at how it unfolds over time through longitudinal case studies. This would allow understanding in greater detail how design thinking is practiced beyond current firm-centric approaches.

Finally, we encourage future work to build on our efforts to question the current innovation management perspective on design thinking centered around the criteria of desirability, feasibility and viability (Brown, 2009), rediscovering responsibility as a fourth criteria. Doing this would finally reconcile the management research on design thinking with its historical roots (Fuller, 1957, 1969; Simon, 1968) while increasing its relevance in addressing some of the most pressing problems of our times.

NOTES

1. We have made anonymous all sensitive information in the illustrative project, including the project name and the identity of the stakeholders involved.

ACKNOWLEDGEMENTS

This research was funded by the European Commission through the Horizon 2020 research and innovation programme, under grant agreement N° 730390.

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CONCLUSION

CONTRIBUTIONS TO RESEARCH

This section discusses the contributions of this doctoral thesis to scientific research. It is divided into four parts. The first, second and third parts discuss specific contributions within the three fields of scientific research mentioned in the introduction section: sustainable design, sustainable business innovation and design management. Indeed, these fields are located at the intersections of the three main concepts examined in this thesis: design, business and sustainable development. Sustainable design is a field located at the conceptual intersection between design and sustainable development (Ceschin and Gaziulusoy, 2016; Fuller, 1957). The contribution within this field is discussed in the first part of this section. Sustainable business innovation is a field located at the conceptual intersection between business and sustainable development (Adams et al., 2016; Elkington, 1998). The contribution within this field is discussed in the second part of this section. Design management is a field located at the conceptual intersection between design and business (Brown, 2008; Micheli et al., 2019). The contribution within this field is discussed in the third part of this section. Finally, the fourth and last part of this section takes a broader perspective, reiterating the high-level research objective of the PhD project and the main outcomes of each chapter, connecting them to the general contribution of the thesis across the three aforementioned fields.

Contribution to the field of sustainable design

Sustainable design research investigates how to address sustainable development problems through design, intended as an applied discipline, and at the same time as a conceptual process, to create a new solution (Bhamra and Lofthouse, 2016; Simon, 1968).

Extant literature in the field explains that sustainable design theory can provide insights on how to transform products and services, and even entire cities and the socio-economic system (Ceschin and Gaziulusoy, 2016) in the transition toward sustainable development (Gaziulosoy and Oztekin, 2019). However, critical literature also argues that sustainable design theory can be implemented successfully in practice only when it is tied to the business objectives and operations of organizations (Ceschin, 2013; Dobers and Strannegård, 2005; Tukker, 2004). While integrating sustainable design ideas with business considerations is essential to achieve impact (Tukker, 2004, 2015), this aspect has been repeatedly underestimated over time (Manzini and Vezzoli, 2003; Tukker, 2004). To date, most of these ideas do not make it to the market (Tukker, 2015), and there is a critical gap of knowledge on how to apply sustainable design theory in business practice (Pigosso et al., 2013; Vezzoli et al., 2015). Accordingly, this doctoral research project posed the

following research question:

First research question: How is sustainable design theory applied in business practice?

The question was addressed in Chapter I. Specifically the first scientific publication included in this chapter proposed a framework (see Chapter I, Figure 4) that integrates sustainable design theory with important business concepts, clustering it into four literature streams—eco-design, product service system design, sustainable business model design, collaborative ecosystem design—corresponding to four levels of designing for business innovation. The framework comprises a set of themes—the strategic objective of sustainable design, the perspective and terminology of sustainable designers, the key stakeholders, core activities, and main challenges in the sustainable design process—related to the application of sustainable design theory in business practice across the aforementioned four levels. Based on this framework, the publication pinpointed five recommendations to support future work of academics and practitioners in fostering the application of sustainable design theory in business. This publication stressed the importance of grounding the discipline of design into business when addressing sustainable development problems (Dobers and Strannegård, 2005). Going a step further, it showed that the business context surrounding sustainable design is in turn bounded by a wider policy background (Romme and Meijer, 2019), which regulates interactions across organizations collaborating in the transition toward sustainable development. Indeed, collaborative ecosystem design entails pushing multiple organizations to collaborate in the sustainable transformation of entire industries while contributing to economic growth in line with existing policy agendas.

Through this work, the PhD thesis contributes in advancing research in the field of sustainable design. Indeed, considering the business and policy contexts in which sustainable design takes place is essential (Ceschin and Gaziulusoy, 2016). If sustainable design research fails to do so, it may run into the risk of becoming inward oriented, self-referential and therefore useless for addressing societal and environmental challenges, such as climate change, resource depletion, poverty and injustice (Eppinger, 2011; Esslinger, 2011). Accordingly, the PhD thesis contributes by integrating important business and policy concepts into the field of sustainable design, discussing solutions to societal and environmental challenges in terms of innovative products and services within the business models of organizations and policy directives.

Contribution to the field of sustainable business innovation

Sustainable business innovation research investigates how organizations can generate economic value while addressing societal and environmental challenges (Porter and Kramer, 2011; Schaltegger et al., 2012; Scherer and Palazzo, 2011).

Extant literature explains that next to the redesign of industrial products and processes, sustainable business modeling is an important strategic approach in the transition toward sustainable development (Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2016; Stubbs and Cocklin, 2008). Sustainable business models allow expanding the notion of "value" beyond mere economic terms, integrating social and environmental criteria into the objectives and operations of organizations (Boons and Lüdeke-Freund, 2013). However, recent research points out that doing so is not an easy task. It requires an experimental process, in which a sustainable business model is gradually designed adopting a network-centric view that takes into consideration the needs of multiple external stakeholders. These include including users, and more broadly the needs of civil society and the natural environment in which people live in (Bocken et al., 2013; Stubbs and Cocklin, 2008). In addition, research points out that, to make a tangible impact, designing a sustainable business model is not sufficient. Indeed sustainable business models rarely make it to the market, resulting in a critical design implementation-gap (Geissdoerfer et al., 2018; Tukker, 2015). Therefore, organizations need support in navigating this experimental process, which researchers may be able to provide in the form of tools for sustainable business modeling (Bocken et al., 2019; Breuer et al., 2018). Finally, research also emphasizes that sustainable business innovation should not be driven by a single firm, but rather by multiple organizations collaborating within a circular economy (Brown et al., 2019; Konietzko et al., 2020). This poses the challenge on how to apply the experimental process to design the business models encompassing multiple organizations (Brown et al., 2019; Konietzko et al., 2020). In turn, doing so is particularly relevant in the case of eco-industrial clusters (Short et al., 2014), which seek enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials (Ehrenfeld and Gertler, 1997; Massard et al., 2014). As explained in the introduction, the three aforementioned issues result in three knowledge gaps in the field of sustainable business innovation. Accordingly, this doctoral research project posed the following three research questions:

Second research question: How to design a new sustainable business model by integrating the

needs of external stakeholders and users?

Third research question: How to support business organizations in bridging the design-implementation gap through a tool for sustainable business modeling?

Fourth research question: How to design an eco-industrial cluster from a process and business model perspective?

The three research questions were addressed respectively in Chapter II, Chapter III and Chapter IV. Specifically, the second scientific publication included in Chapter II proposed a business model innovation process for sustainable value proposition design (see Chapter II, Figure 5). The proposed process is based on three phases: talking to multiple stakeholders, rethinking sustainability problems in terms of joint business opportunities, testing an innovative product and / or service concept to seize the opportunity. The process is iterative, meaning that testing new concepts allows thinking further about the problem-opportunity fit, while progressively identifying the right set of stakeholders that have to be involved. Each phase is concretely supported by expertise from design practice (see Chapter II, Table 2). Relatedly, the third scientific publication included in Chapter III proposed at tool to bridge the design-implementation gap in sustainable business model innovation: the sustainable business model pilot canvas (see Chapter III, Figure 5). This tool allows experimenting by applying design expertise beyond a focal product, in order to support organizations in planning and executing small-scale pilots of sustainable business models, as a first step into their implementation. This is achieved by carefully planning how to create and deliver the business model concept considering service elements, stakeholder interactions, monetary transactions, and sustainability impacts as well. Finally, the fourth scientific publication included in Chapter IV proposed an industrial symbiosis process to design the business model of eco-industrial clusters (see Chapter IV Figure 7). This embeds relevant circular business model insights into a process dimension based on a sequence of stakeholder activities. The process is based on the iteration of three main steps: defining a shared strategic vision, designing a business model, and finally assessing impact, which in turn informs the continuous (re)definition of the strategic vision over time.

Through this work, the PhD thesis contributes in advancing research in the field of sustainable business innovation. Indeed, conceptualizing and implementing sustainable business models is a long and complex experimental process. Multiple stakeholders and organization must be involved

as a way to find an overlap between economic objectives and sustainability requirements (Bocken et al., 2018; Konietzko et al., 2020). Recent research points out that design theory and practice is highly relevant to inform this experimental process (Geissdoerfer et al., 2016; Keskin et al., 2013). Accordingly, this PhD thesis contributes by integrating theoretical and practical design expertise into the field of sustainable innovation, discussing design as the essence of the experimental process dimension needed to move from abstract speculations to tangible impact upon society and the environment.

Contribution to the field of design management

Design management research investigates how of strategy and innovation can be performed through a design process (Gruber et al., 2015).

Extant literature in the field discusses design in terms of an alternative way of thinking for business organizations engaging in innovation (Brown, 2008). These ideas around "design thinking" have been disseminated through business journals—such as Harvard Business Review (Brown et al., 2014), California Management Review (Pitsis et al., 2020), Academy of Management (Gruber et al., 2015) and the Journal of Product Innovation Management (Micheli et al., 2018)—and rapidly gained traction in the business arena. The bottom-line argument behind design thinking, is that it allows business organizations to innovate faster and better, thus to gain competitive advantage and make an economic impact (Elsbach and Stigliani, 2018; Martin, 2009; Micheli et al., 2019). However, it is now clear that economic impact cannot be pursued at the expense of society and the environment, which might collapse under the stress of reckless growth (Meadows et al., 1972; Rockström et al., 2009). Consequently, responsible innovation research has emerged to discuss how business may uphold their moral and political responsibility in creating a positive economic, societal and environmental impact simultaneously (Scherer and Palazzo, 2011; Scherer et al., 2016). The innovation management discourse on design thinking should take this critical issue more strongly into consideration, especially because human-centered innovation practice has the potential to address the aforementioned societal and environmental problems while transforming the business models of organizations in the transition toward sustainable development (Eppinger, 2011; Esslinger, 2011). Design thinking research on this subject is slowly emerging (Bason and Austin, 2019; Cankurtaran and Beverland, 2020), but it is still very limited. Accordingly, this doctoral research project posed the following research question:

Fifth research question: How can organizations apply design thinking in the context of Responsible Innovation, to collaboratively address societal and environmental challenges?

The question was addressed in Chapter V. Specifically the fifth scientific publication included in this chapter proposed a conceptual framework (see Chapter V, Figure 2) that explains how the four phases—discovery, definition, development, delivery—and four practices—framing, envisioning, co-creating, prototyping—of the design thinking process can be leveraged to operationalize four theoretical dimensions characterizing a responsible innovation paradigm—reflexivity, anticipation, inclusion, responsiveness (Elsbach and Stigliani, 2018; Stilgoe et al., 2013). Consequently, the publication illustrates the conceptual framework through a case study, a European project where design thinking is applied in the context of responsible innovation.

Through this work, the PhD thesis contributes in advancing research in the field of design management. Indeed, extant design thinking literature lacks a theoretical underpinning (Dell'Era et al., 2020; Johansson-Sköldberg et al., 2013). If design thinking research fails to strengthen its conceptual foundations, it may run into the risk of losing its theoretical and practical relevance on the way forward (Gemser and Barczak, 2020). In order to prevent this, it is important to connect it with other innovation management theories (Gemser and Barczak, 2020), while also supporting emerging efforts discussing how this approach can be leveraged to address pressing societal and environmental challenges (Bason and Austin, 2019; Cankurtaran and Beverland, 2020). Accordingly, this PhD thesis contributes by integrating responsible innovation theorizing into the field of design management, discussing the design thinking practices of framing, envisioning, co-creating, and prototyping as key mechanisms to iteratively turn societal and environmental challenges into solutions.

General contribution

The objective of this doctoral research project was to better understand how to work with design, and business, toward sustainable development. As explained, this objective revolves around three main concepts: design, business, and sustainable development. At the intersection of these three concepts there are three fields of scientific research: sustainable design, sustainable business innovation, and design management. The previous paragraphs pinpointed what are the contributions of the PhD thesis within these fields. The three main concepts, the three research fields at their intersection, as well as the three contributions within these, are visualized in Figure II.

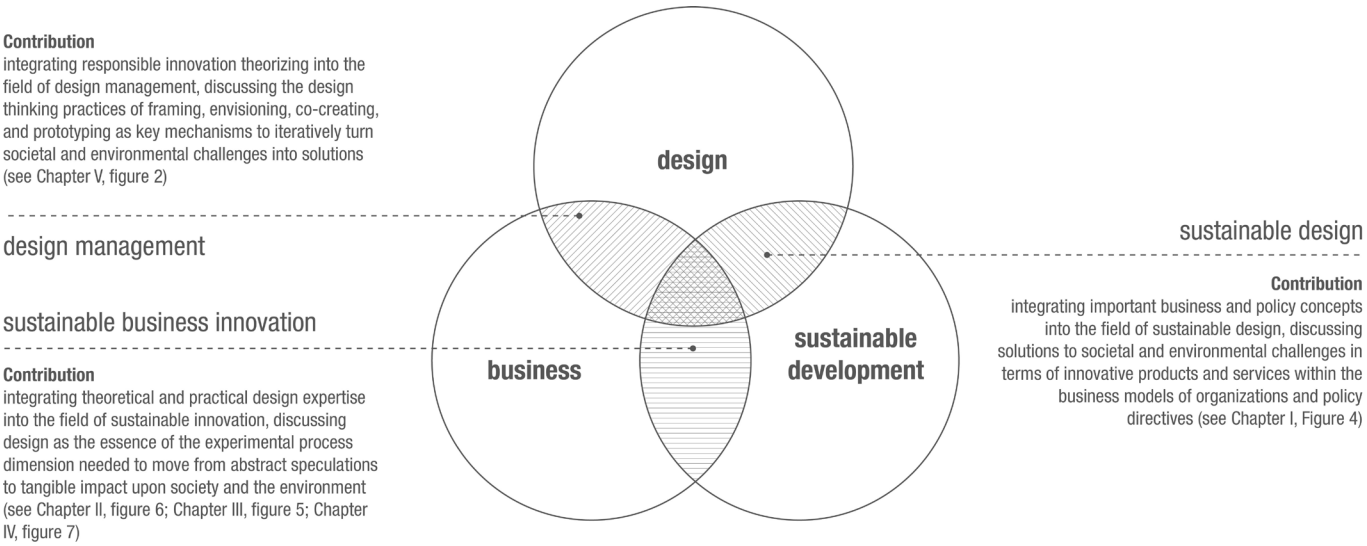

Figure II. Visual representation of the three main concepts and research fields underlying the research objective of this doctoral project. The contributions within these fields are reported as well

The next paragraphs take a broader perspective, elaborating on the general contribution of the doctoral dissertation across the three aforementioned fields. To this end, these three contributions are integrated as a way to inform the original research objective. In the introduction section, a preliminary understanding of what it means to work with design and business toward sustainable development was visualized in Figure I, which is for convenience reported again here. In the figure, design is visualized on the right side as a solution-oriented activity, taking place within a business, which may use it to address the problem of sustainable development, visualized on the left side. This was further clarified with the simple example of a company selling high-quality durable plates, which also aims to provide a supplementary dishwashing service for large events, as a way to exploit a market opportunity around preventing plastic waste and related environmental issues.

Aiming to better understand the variables within this equation, Chapter I clarified that indeed sustainable development requires addressing a set of interrelated societal and environmental problems such as climate change, resource depletion, poverty and injustice (Rockström et al., 2009; United Nations, 2015). These problems are too complex and systemic to be tackled singled

Figure I. Visual representation of working from problem to solution, with design and business toward sustainable development

handedly by individual organizations (Dobers and Strannegård, 2005; Eppinger, 2011; Esslinger, 2011). Going back to the original example, the company willing to provide a dishwashing service to large events as a way to prevent plastic waste and related environmental issues, has to put in place a new business model, and therefore establish interactions with other organizations such as the event organizers, waste management companies and the local government. Importantly, the underlying market opportunity arose due to a strategy recently defined by the European Commission to deal with the problem of plastic waste. Indeed, the Commission established that all single-use plastic products (such as drinking cups) on the EU market must be banned by 2030 (European Commission, 2018a). Therefore, all the activities of the collaborating companies are taking places within this upcoming regulation. Accordingly, Chapter I contributed integrating important business and policy concepts into the field of sustainable design, discussing solutions to societal and environmental challenges in terms of innovative products and services within the business models of organizations and policy directives. To inform the overall research objective, this contribution is visualized in an improved version of Figure I, Figure IIIa: on the left side, sustainable development is the overall problem containing specific environmental and societal challenges; on the right side, the solution may be put forward by multiple organizations doing

business collaboratively to develop products and services within a policy background.

Further exploring the research objective, Chapter II, Chapter III and Chapter IV clarified that establishing collaborative business innovation to solve sustainable development challenges is very difficult because of split incentives, different needs and diverging views across the stakeholders involved (Allee, 2009; Brown et al., 2019; Porter and Kramer, 2011). Therefore experimentation is needed to gradually align cross-organizational action, to find an overlap between economic, societal and environmental goals, and importantly to bridge the gap between new ideas and tangible impact (Geissdoerfer et al., 2018; Konietzko et al., 2020). Going back again to our example, the company may find it relatively easy to hire a design team able to put forward a product and service concept that is in principle desirable for people and clients, technically feasible and economically viable. Nevertheless, launching this concept successfully is a very different story. Multiple design iterations will be necessary in terms of finding the right material to make sure that the plates will last long enough, establishing a commercial agreement with the supplier of this material, getting permission from the local government to operate at large events and convincing street food sellers, or possibly people buying food, to pay extra for this solution. Going through these design iterations the problem is understood from multiple perspectives and

Figure IIIa. Visual representation of working from problem to solution, with design and business toward sustainable development, revisited according to the outcomes of Chapter I

accordingly redefined while advancing toward a shared and tangible solution. This example makes it very clear that this experimental process is basically a sequence of design iterations. In fact, design is not taking place inside the company but rather across organizations negotiating the best way forward to innovate sustainably. Accordingly, Chapter II, III and IV contributed integrating theoretical and practical design expertise into the field of sustainable innovation, discussing design as the essence of the experimental process dimension needed to move from abstract speculations to tangible impact upon society and the environment. To inform the overall research objective, this contribution is visualized in an improved version of Figure IIIa, Figure IIIb: in the middle, design is visualized as the iterative process to address the problem by gradually informing the solution.

Finally, zooming into more detail, Chapter V clarified that the design process to gradually turn innovation problems into desirable, feasible and viable solutions can be conceptually understood as an iterative sequence of practices: framing, envisioning, co-creating and prototyping (Elsbach and Stigliani, 2018; Gruber et al., 2015). Companies can leverage these practices not only to gain competitive advantage and grow economically, but also to innovate more responsibly in the transition toward sustainable development. Our example is again suitable to illustrate this. As explained, the design process to create and commercialize the plates and the supplementary service

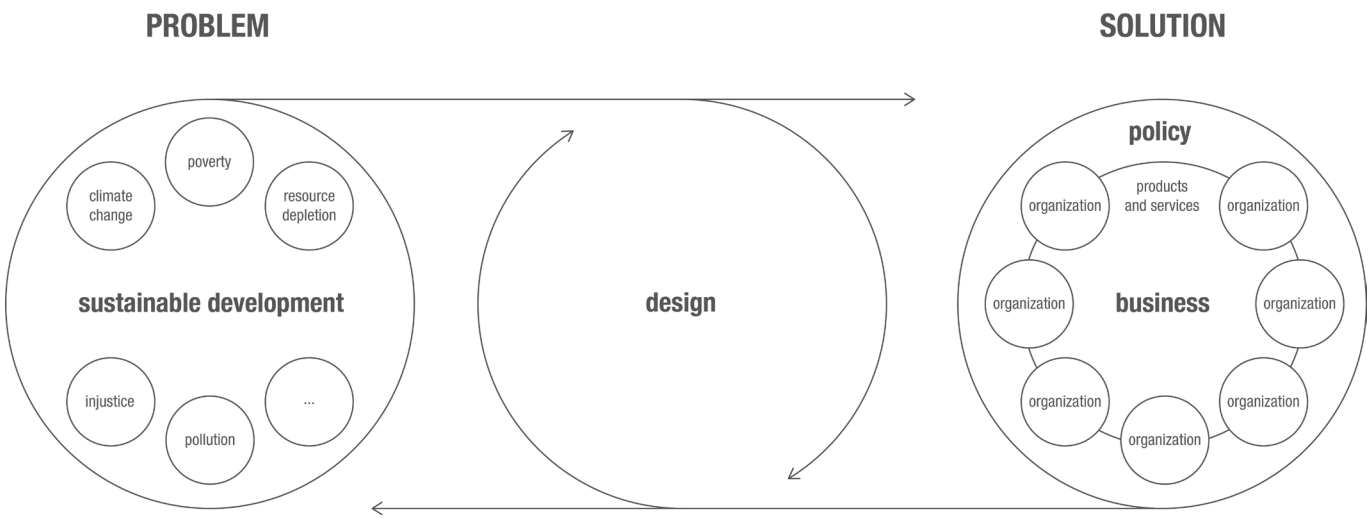

Figure IIIb. Visual representation of working from problem to solution, with design and business toward sustainable development, revisited according to the outcomes of Chapter II, III and IV

is iterative and interactive. Throughout this process, multiple organizations and stakeholders will gradually frame and reframe the problem of plastic waste. For example, the European Commission identifies the issue, reflects on it and as a result frames it in terms of a policy that bans single-use plastics. At the same time, the company selling plates, reframes it in terms of a business opportunity. Then, the company anticipates a solution by envisioning the dishwashing service, which is consequently co-created in an inclusive way as material suppliers, user needs and local-government regulations determine all its attributes. Finally, in order to respond to the challenge of plastic waste, the solution is prototyped, tested and refined over time. For example this may occur when the company realizes that the selected material is not durable enough and has to be changed. In line with this example, Chapter V contributed integrating responsible innovation theorizing into the field of design management, discussing the design thinking practices of framing, envisioning, co-creating, and prototyping as key mechanisms to iteratively turn societal and environmental challenges into solutions. To inform the overall research objective, this contribution is visualized in an improved version of Figure IIIb, Figure IIIc: the iterative design process unfolds through the aforementioned practices.

Figure IIIc visually summarizes the general contribution of the PhD thesis. In line with MacInnis (2011), the conceptual contribution of this figure lies in delineating the main variables and their relationships that may be considered when working with design, business, and importantly with policy, moving from problem to solution in the transition toward sustainable development.

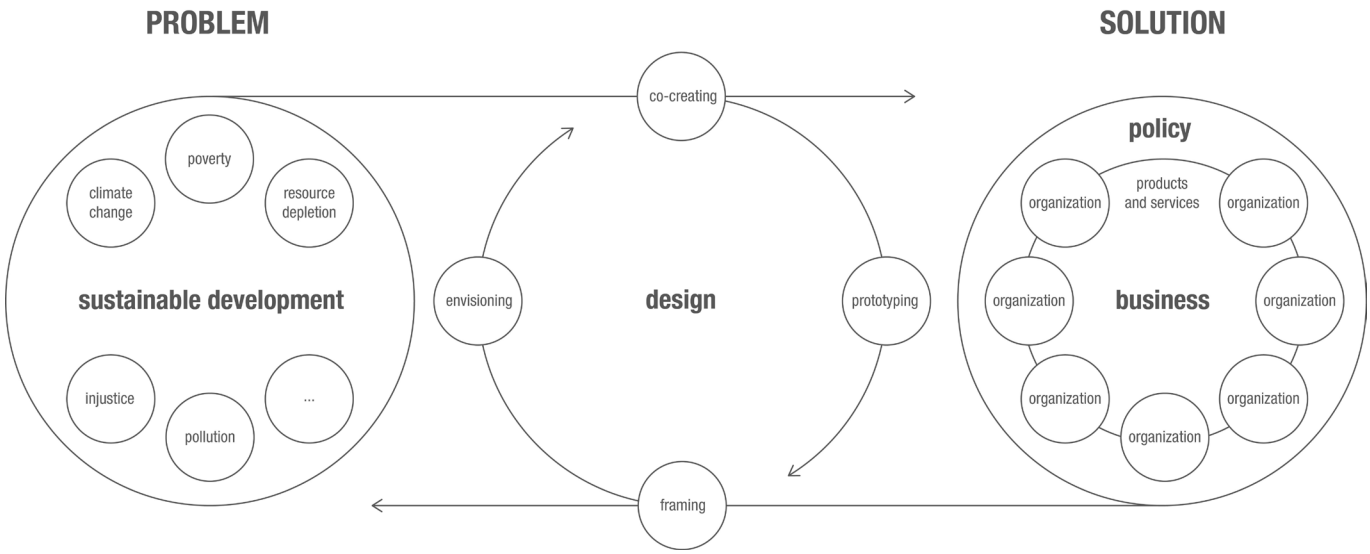

Figure IIIc. Visual representation of working from problem to solution, with design and business toward sustainable development, revisited according to the outcomes of Chapter V

IMPLICATIONS FOR PRACTICE

This section builds onto the contributions to research discussed in the previous one, in particular by elaborating on the implications of Figure IIIc for practice. The intention here is not to make any strong claim, but rather to put forward a few ideas that might be useful to start relevant conversations with different stakeholders, about the role of design in the collaborative transition toward sustainable development. Accordingly, the section is divided into four parts. The first part addresses designers. The second part addresses business managers. The third part addresses policy makers. The fourth part addresses academics.

To designers

Years ago, when I began my studies in industrial design at Politecnico di Milano, I met an inspiring professor who said that we can, and should, use our profile, expertise and skills to become active agents of change in the transition toward sustainable development. In this instance I use the word "we", to express that I am a designer as well: this was my training and the starting point of my professional development. With those of us who are interested in playing this role of change agents, I would like to share a few thoughts on what we could do concretely. Starting off, I must say that bearing the title of designer, although it may sound cool, could also make it quite difficult to work in a position where it is possible to shape the change. Design is a vague word. There is no clear-cut definition of what it means exactly (Archer, 1979; Kimbell, 2011, 2012). Relatedly, there is no consensus on what a designer can or cannot do (Dell' Era et al., 2020; Magistretti et al., 2019). This explains why our title is often preceded by another word that specifies our professional role. For example, "industrial designers", or "product designers", are traditionally related to a supporting role in the integration of technical, functional and aesthetic requirements when developing new industrial products. When product development also takes into considerations sustainability requirements, industrial designers may also play a role by supporting life cycle analysis or devising creative solutions, such as modular designs, to reduce the environmental impact of specific products (Brezet and van Hemel, 1997; McDonough and Braungart, 2002). Another example relates to the title of "graphic designers", and more recently "user experience designers" or "service designers", which is often related to the creation of visual material and digital artifacts such as web pages and smartphone applications. Again, these efforts might support sustainability goals but the designer's contribution will most likely consist in executing a brief that was already defined by somebody sitting higher up in some kind of command chain. Newer titles, such as "strategic designer" or even "policy designer" are starting to emerge in recent years (Calabretta et al., 2016; Vaz and Prendeville, 2019), with the aim of

lifting ourselves upwards in organizational hierarchies (Micheli et al., 2018). This is to some extent happening as we speak, nevertheless slowly: too slowly, if we want to contribute in a more meaningful way to the sustainability transition, which must happen relatively now, in order to avoid inconvenient consequences (Rockström et al., 2009).

Based on my limited experience working as a researcher and as a practitioner in this space, I am convinced that there is something we can do right now to contribute to this effort, which goes way beyond merely executing predefined briefs. Specifically, we can question these briefs and propose new approaches, creative yet rational ways of thinking and doing, to address complex sustainable development problems, trying out new things and gradually learning from mistakes (Fuller, 1957; Papanek, 1971; Schön and Rein, 1994; Simon, 1968). But in doing so, we must become more aware of our own strengths and weaknesses. If we want to be taken seriously we should not pretend to be experts in something that other professionals are already able to do. On the contrary, we must believe in the relevance and potential of our general specialism (Brown, 2008; Calabretta et al., 2016; Chamberlain et al., 2012). In particular, as visualized in Figure IIIc, we should try to bring together people across business organizations and the public sector to inform collectively defined solutions through a collaborative design process. As experts of this process, our role lies in leveraging the practices of framing, envisioning, co-creating and prototyping, to make it tangible and concrete. In order to do so effectively, there are in my opinions four things we have to take into consideration.

To begin, we must in the first place "want" to do all this. In other words, internalize the ambition of having objectives that are broader than those traditionally associated to our profile, making ourselves available to apply our expertise of design practices beyond execution, in more strategic positions dealing with business and policy matters (Manzini, 2009; Vaz and Prendeville, 2019). Without this ambition we will not be able to go very far as change agents. Secondly, to support this ambition and apply the practices at a higher organizational level, we must learn to talk with the people we want to work with. We must learn new "disciplinary languages", meaning the terminologies that different professional profiles use (Calabretta et al., 2017; Micheli et al., 2018) when they talk about issues related to innovation and sustainable development. For example, we must understand what the manager of a multinational company means when he or she talks about the revenue model for the new CSR project, as well as having a clue about all the stuff that the policy makers write inside circular economy reports and regulations. If we are able to understand, then we will be able to translate and facilitate communication across stakeholders. The next step,

the third thing we can do, is to go deeper than language, learning how these different stakeholders think, and adopt their perspective on the problems at hand (Calabretta and Gemser, 2015; Micheli et al., 2018). For example, working from multiple perspectives entails understanding how different departments and organizations see issues related to sustainable innovation, and then connect their different viewpoints to propose something that they can all agree upon. Fourth, we must learn to do what they do. Just a little bit is good enough to start with. We do not need to replace them after all, but to work with them we must be able to handle the collaboration and this entails going out of the comfort zone and continuously learn to execute new activities and tasks, in a similar way that an entrepreneur would do (Halme et al., 2012; Keskin et al., 2013; York et al., 2016). Fifth, and last, we must be aware at all times that this will not come for free. As already mentioned, the desk with the title "business designer" or "policy designer" engraved in it does not really exist yet (Calabretta et al., 2016; Vaz and Prendeville, 2019). As we are trying at the same time to create the desk and sit behind it as change agents, we will be constantly challenged by other professional profiles to legitimate ourselves. It is not easy, but we have the training and skills to do it.

To business managers

Throughout my studies, doctoral research and professional experiences across industry and academia, I had the opportunity to work with different business organizations, ranging from startups to multinational companies. Startups are small and flexible (Ries, 2011, 2017). Therefore, their approach to sustainable innovation is fast, dynamic (Hockerts and Wüstenhagen, 2010). Entrepreneurs working in this space are often young and personally driven to make a change (Akemu et al., 2016; York et al., 2016). They are able to use this drive and biological energy to generate, implement and test new ideas relatively quickly, following an approach that is conceptually not too distant from a design process (Keskin, 2015; Markman et al., 2016; Sarasvathy, 2008). However, acquiring the financial resources needed to execute these activities and scale them up to create a tangible impact may often be challenging (Hockerts and Wüstenhagen, 2010). Larger organizations are quite different. They have more resources and capabilities to get sustainable business implemented (Hockerts and Wüstenhagen, 2010). But at the same time, they are also burdened by their own structure and by a risk-averse culture, which often results in reactive approach when it comes changing their objectives and operations to become more sustainable (van Tulder et al., 2013). Observing the slow process through which these large organizations engage with sustainable innovation made me realize how fragmented they are. I sometimes had the strange impression that the organization does not exist: there are only many

individuals dwelling in the same space, using their position and "political influence" to push certain ideas and topics up the corporate agenda. Indeed, managers have a great responsibility in pushing the right stuff upwards in this agenda, to promote a positive change (Drucker, 1973). If you are a manager who is doing—or wanting to do—this, it is to you that I am talking to now.

I have two suggestions that may help you to trigger and shape sustainable change inside your organization. As visualized in figure IIIc, the first suggestion is collaborating externally with other organizations and entrepreneurs, as a way to collectively pursue a more responsible innovation paradigm toward sustainable development (George et al., 2016; van der Hoven et al., 2014). Figure IIIc also highlights the need of collaborating with the public sector and policy makers (Asveld et al., 2017; Mazzucato, 2018). They define regulatory frameworks that determine what your company can or cannot do. Plus, these frameworks, such as the Circular Economy Action Plan encompassed by the recent European Green Deal, are associated to abundant funding for sustainability research and innovation (European Commission, 2018b, 2019, 2020). Take initiative, and get your company engaged with Circular Economy European projects: it is a good way to gain long term competitive advantage while reducing the risk entailed in sustainable and collaborative innovation (Talmar et al., 2018). In doing so, please do not be opportunistic, just getting involved to acquire funding without really committing to the underlying goals. This happens sometimes, and it isn't cool because those are public money coming from the pockets of European citizens, including yours. The second suggestion is hiring designers and empowering them to use their expertise in catalyzing the aforementioned collaborations. It is crucial to acknowledge that designers are not just good for sketching products or putting together website wireframes (Brown and Martin, 2015; Liedtka and Ogilvie, 2012). They were trained to do more, including thinking strategically about sustainable innovation (Manzini, 2009). If you will involve them in the strategic decisions concerning sustainable innovation, they may help you not only to better collaborate with external stakeholders but also to exploit business opportunities while at it: finding a balance between what people need, what is technically achievable, what is economically possible, as well as what is ethically, socially and environmentally acceptable (Brown, 2009; Windahl et al., 2020). Specifically, they might play a role in this by performing the design practices shown in figure IIIc: framing sustainable innovation problems from novel and shared points of view, envisioning creative solutions, leading the co-creation process itself, and prototyping as a way to make outcomes tangible (Bocken et al., 2019; Schuit et al., 2017). Going a step further, you might consider learning to think like a designer yourself, with the goal of becoming more creative and entrepreneurial to breach corporate conventions and silos, an essential condition for sustainable

innovation (Brown and Martin, 2015; Porter and Kramer, 2011; Yunus et al., 2010).

To policy makers

As a designer I have worked in business but not in policy making. I believe that direct experience is essential to have sensible opinions on something. Therefore, I am not in the position to provide policy makers with any specific recommendation on what they could or should do better within the policy making process. Nevertheless, in these doctoral years, discussing and engaging in circular economy projects, I had the chance to get in contact with policy makers and the regulatory frameworks they define at the European Commission. Based on this limited experience, I understood that these frameworks are very important because they determine the rules of the playing field within which organizations operate and collaborate. Indeed, and in line with Figure IIIc, the European Green Deal explicitly calls for establishing cross-organizational collaboration as a way to make sustainable and circular innovation possible (European Commission, 2019). Importantly, I understood that the definition of policy frameworks such as the Green Deal happens within a long process, in which so called "working groups"—formed by public officers, scientist and industry experts—discuss and negotiate the content of new policies. Considering that this process, on which I know little about, involves iteration, participation and co-creation (Von Schomberg, 2011), it was natural for me to associate it to my knowledge of the design process. Reading some scientific literature on the subject I found out that indeed, policies can be understood as human artifacts embedding the solution to a complex problem (Schön and Rein, 1994). Policies—just like products and services—represent the outcome of a design process (Asveld et al., 2017; Romme and Meijer, 2019). Specifically, this outcome is a set of norms and regulations for framing "intractable controversies" that have no single, right or wrong answer, from an arbitrary point of view that is ethically acceptable and functional for action (Schön and Rein, 1994). Nevertheless, it is essential to acknowledge that in a moving world, such arbitrary point of view must be dynamic too. To remain relevant, policies must evolve over time through a continuous process of reflecting in action (Schön and Rein, 1994; Stilgoe et al., 2013). With the aim of making the policy making process more dynamic and design-driven, policy design labs are already emerging all over Europe (Vaz and Prendeville, 2019). Based on these considerations, my message to policy makers is aligned with the message for business managers: be open to design as a holistic and experimental approach to treat sustainable innovation frameworks, such as the Green Deal itself, as prototypes that can be adjusted over time to tackle the paradoxes and controversies of society (Rittel and Webber, 1973; Schön and Rein, 1994).

To academics

As an academic, I feel I should say something about this, and while at it I am going to use again the word "we", just like I did when addressing designers. We can be change agents as well. I will just say my personal opinion about it. This is what happens—at least in the social sciences, within the branch of the field of sustainable innovation that I am familiar with. We investigate dynamics and processes at the intersection of economics, technology, sociology and ecology. To do so, we spend most of our time reading about the ideas of other academics and propose new ideas based on their premises, and on empirical evidence. What we say tends to be normative, meaning that it aims to provide different stakeholders—often business organizations—with prescriptive guidance on what they should do to reduce their negative impacts, and foster a positive change toward sustainable development. A good example of this is provided by the frameworks proposed in the five chapters, and by Figure IIIc presented in the previous section as the overarching contribution of this PhD thesis. Now that my PhD project is finished, I ask myself: "What is the value of this figure, which took me nearly three years to develop?" And more in general: "What is the value of the multitude of similar figures that academics like me, all over the world, spend their time refining over and over, in great and then greater detail?" Many times, as I struggled with this theoretical exercise in the aseptic environment of the ivory tower, I have been thinking that all these words and neat figures are useless, because they are ultimately too distant from the real problems going on outside the window. And even worse, they are published in such a format that is poorly accessible for the people that work outside the ivory tower. I am not going to lie: there is a part of me that still thinks that all these academic papers about sustainable innovation are useless. But then, there is another part of me who believes that they will make a difference, because altogether they have the potential to influence how people and organizations see things, and therefore to influence what they do. Nevertheless, in order to actually realize their potential, is it crucial to disseminate them more effectively, getting out of the ivory tower and engaging with reality. As academics, we should not get lost in solitary and self-referential theoretical lucubration. A lot more effort should be put into constantly engaging on a personal level with designers, business managers and policy makers driven to foster the sustainability transition. We must use their work, their problems, needs and priorities as raw material to co-define our ideas with them, while being aware that we ultimately share the same objective. The only thing that differs is the hat that we wear. It's a dialogue. Even more importantly, we must engage with our students. This is where the greatest potential to have an impact lies, right before our eyes, and yet most of us forget about it to run after a meaningless citation score. Students will soon enter the workforce and we are

going to work side-by-side. They are also the people that will be most affected by unsustainable development and at the same time the most open to listen to what we say. It's hard to change the frame of mind of a sixty-five years-old person that grew up during the economic boom, but we can educate the younger generation to think in a different way, while listening to them and learning about their priorities as well. Again, it's a dialogue. And I believe that this dialogue, more than some pedantic academic papers, represents the engine of the cultural shift that we need to realize a sustainable development.

FINAL NOTES

Limitations and future research

This PhD thesis represents the outcome of my efforts to coherently structure my own understanding and learning gained by reading, and working on several projects, about design, business, and to a more limited extent policy, for sustainable development.

The first and the fifth scientific publications resulted from a primarily conceptual effort. They are based on reviewing the status quo of literature found respectively in the fields of sustainable design and design management, using respectively snowballing (Wohlin, 2014) and problematization methods (Alvesson and Sandberg, 2011). This was functional to inductively derive the proposed conceptual frameworks (see Chapter I, Figure 4 and Chapter V, Figure 2). From a theoretical standpoint, these frameworks may be considered valid, nonetheless due to the support of the external academic reviewers who informed the publication of the first article, as we all as the support of those who are still informing the fifth one, which is currently under review. However, next to the theoretical validity of the proposed frameworks, it is also important to consider their practical relevance. To this end, the framework in the first scientific publication was discussed within qualitative interviews (Patton, 2002) with a limited number of designers and business managers, in order to provide initial yet informed recommendations for practice. On the other hand, the managerial implications of the framework in the fifth publications were not based on any discussion with practitioners, and therefore have to be considered purely speculative. Both in the case of the first and fifth publication, additional work is required to validate the practical relevance of the proposed frameworks and implications. To address this first limitation of the PhD thesis, future research may focus on this critical aspect by discussing these frameworks and initial implications with an extensive number of practitioners across organizations and sectors, as a way to incorporate their inputs and corroborate relevance for practice. Doing so is simultaneously important to gain empirical inputs for inductively advancing theoretical knowledge in the fields of sustainable design and design management.

The second, third and fourth scientific publications are the result of primarily empirical efforts, aiming to inform the field of sustainable business innovation. They are based respectively on research-through-design (Stappers, 2007; Zimmerman et al., 2007), design science (Grenha Teixeira et al., 2017; Peffers et al., 2007) and case study research (Yin, 2017) methods. The application of these methods often entailed engaging with the subject not only as a researcher but also as a designer, entrepreneur and innovation consultant. Sometimes the boundary between

these roles was blurred, which was challenging but at the same gave me the opportunity to develop and refine ideas while keeping the feet grounded into practice, instead of getting lost in abstract speculations disconnected from reality. Overall this allowed deriving, with an inductive approach in qualitative data collection and analysis (Silverman, 2013), two processes (see Chapter II, Figure 5 and Chapter IV, Figure 7) and a tool (see Chapter III, Figure 5) to concretely guide organizations throughout their sustainable innovation efforts. However, it is important to mention that these studies are exploratory. Given the relatively limited number of projects and cases on which the outcomes are based, additional work is required to generalize their validity. To address this second limitation of this PhD thesis, future research may focus on this aspect by leveraging the proposed processes and tools across multiple case studies in different industry sectors. Importantly, longitudinal cases would be beneficial to objectively evaluate the benefits of applying these processes and tool, as well as quantifying the resulting impact against societal and environmental problems. This is a critical issue that was not examined by this research and remains under-addressed in the field of sustainable business innovation.

Next steps

I started this journey years ago, when I discovered that working with design toward sustainable development requires breaching outside the design bubble and understand business. In these doctoral years, I have learned that around business there is policy, which largely determines the rules of the game in the transition toward sustainable development. Now, I am curious to better understand how policy making works, and this is what I am going to be doing on my way forward.

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